How To Fix Fractures Online 'Mini Series'

Session 3: Getting the Most Out of Intramedullary Pins and Orthopaedic Wire

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Getting the most out of Intramedullary Pins and Orthopaedic Wire

Intramedullary pins (IM pins) are a simple method of internal fixation that are ***only*** indicated in simple fractures of the humerus, femur and tibia with a high fracture assessment score. They are most commonly used in combination with cerclage wire.

IM pins and wire are also the technique most commonly associated with fracture complications such as non-union and osteomyelitis.

The main reason for this high incidence of fracture complication with IM pins is that they are **commonly used in inappropriate situations**.

IM pins are available in 1.6mm – 6mm diameter and lengths of 22.5-30cm. Several different tips or points (chisel, trocar, threaded trocar) are available on one or both ends. **There is no advantage in using a threaded IM pin.** Plain trocar point IM pins are the easiest to place and are recommended.

Pin placement can be either **normograde** (pin advanced from one end of the bone in one direction only) or **retrograde** (pin is driven from the fracture site through one end of the bone and then driven back into the opposite end of the bone). **Normograde insertion is preferred** as it reduces the chance of injuring the adjacent joint and important soft tissue structures.

Retrograde insertion is contraindicated in tibial fractures.

Biomechanics of IM pins

Of the four main fracture forces (compression, rotation, bending and tension) that may potentially act on a repaired fracture (and that must be counteracted for fracture healing to occur) **IM pins can only counteract bending forces**.

IM pins are not "fixed" to the bone by screws and rely on frictional contact with the bone which is limited. Their biomechanical disadvantages are:

- **Poor resistance to compression forces**
  - Pins are ineffective in neutralising compressive forces of any great magnitude. (they are unsuitable for large dogs, fractures with comminution or a fracture gap)
- **Poor resistance to rotation forces**
  - Pins are ineffective in neutralising rotational forces

IM pins are contraindicated as the primary method of repair in comminuted fractures or fractures where rotational and compressive forces will be significant.

IM pins can only counteract bending forces. They are ineffective at neutralising compression or rotational forces.

How can you increase the resistance of IM pins to compression and rotational forces?

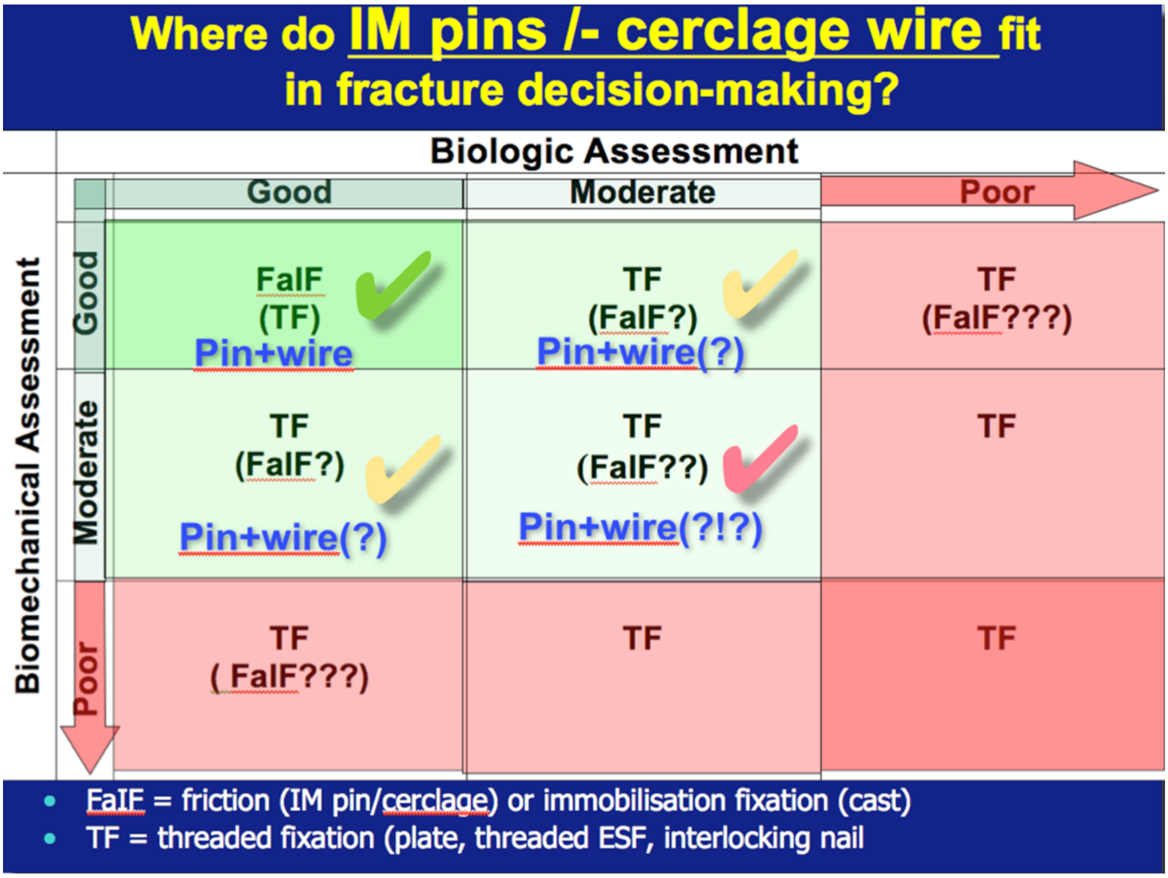
In long oblique or spiral fractures *effective* placement of cerclage wires will **increase the resistance of an IM pin to compression and rotation**. As cerclage wires rely on friction produced by interfragmentary compression they also can **only neutralise forces of low magnitude.**

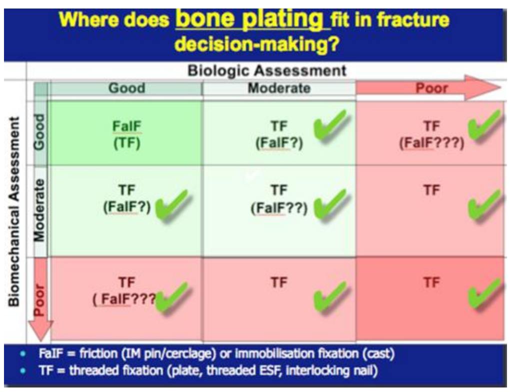
Cerclage wires rely on friction to maintain interfragmentary compression so, like IM pins, must be considered "light weight" from a fracture biomechanics perspective.

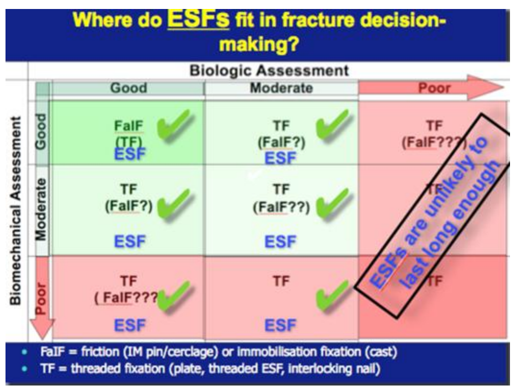
Biology of IM pins

A potential advantage of IM pins is that they can be placed closed thereby not disrupting the blood supply to the fracture site. However most IM pins are placed by an open approach, thereby losing this potential advantage. The concurrent use of cerclage wire with IM pins can significantly disrupt soft tissue (and thereby blood supply) in the area of the fracture. This needs to be considered in fracture assessment of individual cases.

Decision-making with IM pins and wire







Principles of application of IM pins

- Properly assess fractures so that IM pins are not used in inappropriate situations.

  IM pins are suitable for relatively simple fractures **with a high fracture assessment score where:**

  1. **Rotation and axial compression are not major factors**
  2. **The overall load is low**
  3. **The fracture biology is high**

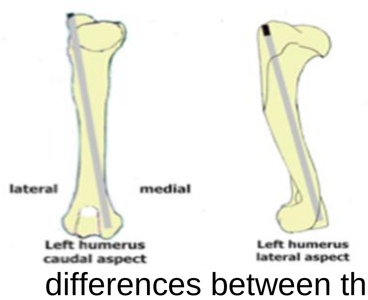
  Interdigitating transverse fractures and long oblique or spiral fractures in small to medium sized young animals that will be appropriately managed postoperatively are usually suitable for IM pin and/or wire combinations (transverse fractures are not suitable for cerclage wire – see the section on cerclage wire).

  Fractures with a low fracture assessment score such as open fractures or comminuted fractures are unsuitable for IM pinning

- **Pin size should be approximately 70-80% the size of the (femoral) medullary canal**.

  This is a compromise between biomechanics and biology. Larger pins provide greater resistance to bending yet may delay reformation of the medullary artery.

  Tibial IM pins should be only 50-60% the medullary diameter at its narrowest point. This is to allow the pin to bend during its normograde introduction into the tibial plateau, which is necessary to avoid articular damage to the stifle joint.



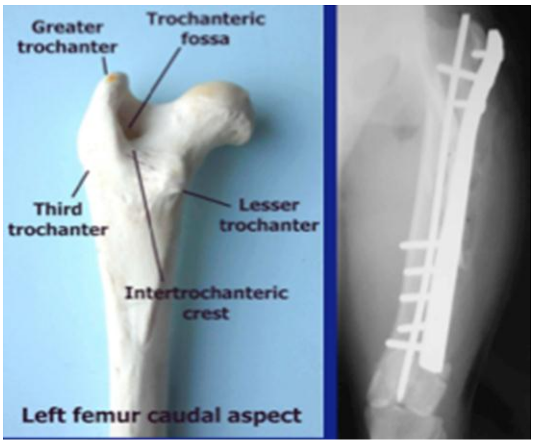
  Humeral pins need to be seated into the medial epicondylar ridge. Unlike the femur the cancellous bone in the humerus is very distal – to engage it you must be distal to the supracondylar foramen and have the pin seated in the medial epicondylar ridge. **This means that it is not possible to place a 70-80% medullary diameter pin in the humerus**. Because of this it is important to recognize the anatomic differences between the femur and the humerus and the impact this has on stability.
  There are very few fractures that are suitable for repair with an IM pin +/- cerclage as the primary method of fixation.

- **Ensure the pin is seated as deeply as possible into the distal cancellous bone**.

Pins should be embedded as far as possible into the metaphyseal cancellous bone as possible to maximise pin – bone contact. They must not penetrate the cortical / articular bone. Pins that have been driven too far and have penetrated the cortical or articular bone distally should be removed and some other form of stabilisation used. If they are just withdrawn back into the bone they will <u>always</u> migrate back through the hole and cause problems.
Remember that the tibia and humerus have very “short” distal canceloous bone segments. Ensure that you:

- Have a second pin of the same length to “measure” the depth of pin penetration.
- remember that humeral pins need to be seated in the medial epicondylar ridge
- remember that the talocrural joint is proximal to the distal end of the tibia

- **Cut the end of the pin protruding from the bone as short as possible** that will still allow subsequent retrieval. This will decrease postoperative morbidity/**seroma** formation. For femoral fractures placing the pin normograde allows the pin to be cut shorter than with retrograde pin placement



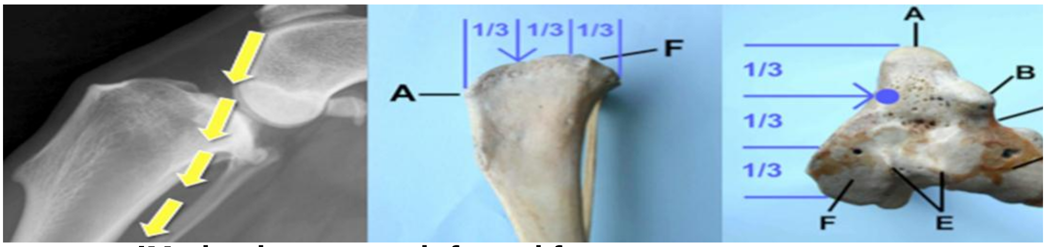
- **Retrograde or normograde placement of IM pins?**

  Normograde or retrograde placement of pins is possible in the humerus and femur but tibial pins must be placed normograde. **Retrograde tibial pins will penetrate the stifle joint and cause significant joint damage.**

  During retrograde placement of femoral pins it is important to extend the hip and adduct the stifle joint to prevent damage to the sciatic nerve. **Normograde placement of femoral pins is preferred.**

Do not place tibial pins retrograde. This will damage the stifle joint.

Tibial pins *must* be placed normograde.



- **Do not use IM pins in open or infected fractures**

- **Do not use IM pins in the radius**.

IM pinning is not suitable in the radius due to:

- **A high incidence of complications (>80%)**
- The articular damage that is caused to the carpus if the pin is left protruding
- The craniocaudal compression of the radius means that the medullary canal is too small to place a large enough pin to achieve effective stability without significantly compromising medullary revascularisation
- The cranial bow of the radius complicates pin placement

How can you "reinforce" an IM pin

The most effective way to reinforce IM pins is to **not use them in inappropriate fractures in the first place**. That is, if an IM pin needs reinforcing it is probably not the correct method of fracture fixation in the first place. Bone plates, interlocking nails and external skeletal fixator (ESF) should be considered in these instances.

If however an IM pin has been placed and needs to be reinforced there are two options:

- Apply an ESF
  ESFs provide rotational and axial stability and additional resistance to bending loads.

- Remove the IM pin and replace it with some other form of more appropriate fixation

What about stack pinning?

Stack pinning (the use of more than one IM pin) used to be recommended as a means of increasing the resistance to rotational forces. Recent work however would suggest that this technique is **not biomechanically effective**. The use of two pins does not provide increased resistance to rotation. The use of multiple pins (>2) only provides a slight increase in rotational stability.

What about reinforcing the IM pin with external coaptation (splints or casts)?

Casts and splints should **not** be used to reinforce intramedullary pins. The added weight of the cast can produce a **fulcrum effect which increases the bending force on the fracture site** and is likely to increase the risk of complications**.**

What about using IM pins to "reinforce" other methods of fracture fixation?

The inherent resistance of IM pins to bending loads provides useful advantage when they are used in combination with bone plates and ESFs.

- **Plate – Rod combinations**
  The use of a smaller than normal diameter IM pin (35-40% of narrowest medullary diameter) in combination with a bone plate:
  - Increases the resistance of the plate to bending forces
    - IM pin diameters of 40% increased plate-rod stiffness in an osteotomy model by 40%
  - Increase fatigue life of the plate

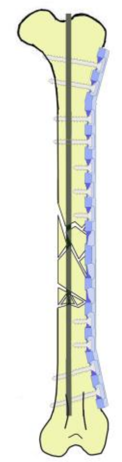
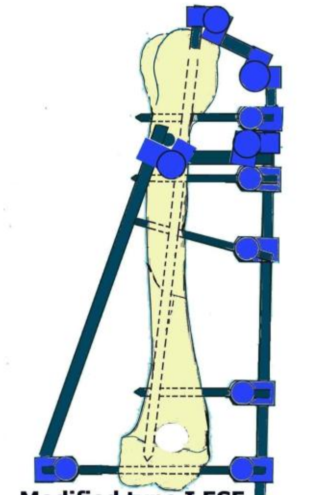


Plate-rod comminuted femoral facture

    - a 50% diameter IM pin has been shown to “infinitely” increase plate life in an osteotomy model
- Is particularly useful in highly comminuted fractures.

- **Tied-in external skeletal fixator**

The use of an IM pin left protruding through the skin and then connected or “tied-in” to an ESF is an increasingly common method for repair of humeral fractures that necessitate an ESF. The more rigid ESF configurations such as Type II and Type III frames cannot be applied above the elbow and stifle. Connecting the ESF to the IM pin significantly increases the rigidity, particularly the resistance to bending, of the Type I and modified Type I frames that are applied to the humerus .


Modified type I ESF tied-in to an IM pin

IM pins in combination with cerclage wires are the implant most associated with osteomyelitis and non-union.

IM pins are only suitable for simple fractures.

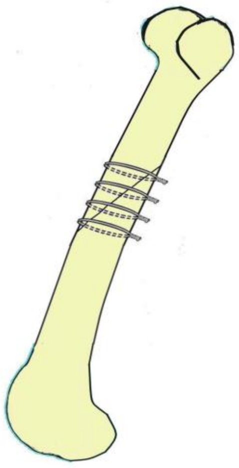
<u>Orthopaedic Wiring</u>

Orthopaedic wire is malleable monofilament stainless steel wire

It can be used as:

- Cerclage wire
- Tension band wire
- Interfragmentary wire

Cerclage wiring



Cerclage wire is a 360^0 circumferential wire placed around
a long oblique fracture to provide additional stability

- It does not provide sufficient stability in itself and is usually used in combination with an intramedullary pin
in combination with an intramedullary pin

- Applied correctly it produces interfragmentary compression and helps neutralise compression and rotational forces produced by weight-bearing. Cerclage wire will not neutralise bending force

- it is unsuitable as the primary means of fracture fixation

- Applied poorly or applied inappropriately to unsuitable fractures are a cause of significant problems

Principles of Cerclage wiring

1. Cerclage wire must be strong enough

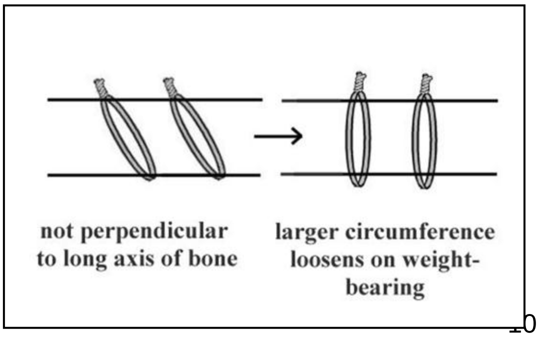
   Orthopaedic wire is available in different sizes or gauges. **One of the most common mistakes is to use too small a gauge of wire.** This will prevent suitable tension being developed and will result in failure of the cerclage wire.

   Recommended sizes are:

   - **22g - tiny animals (<3kg)**
   - **20g - cats / small dogs (<10kg)**
   - **18g - medium dogs (<25kg)**
   - **16g - large dogs (note: 16 gauge wire is very thick and is extremely difficult to work with. The use of cerclage wire in this size dog is not recommended. Alternative methods of achieving interfragmentary compression such as lag screws are preferred in animals >25kg)**

2. Cerclage wires must be perpendicular to the long axis of the bone

Wires that are not placed perpendicular to the long axis of the bone will have a circumference greater than the bone circumference.
On weight-bearing they will inevitably move perpendicular to the bone and loosen quickly.



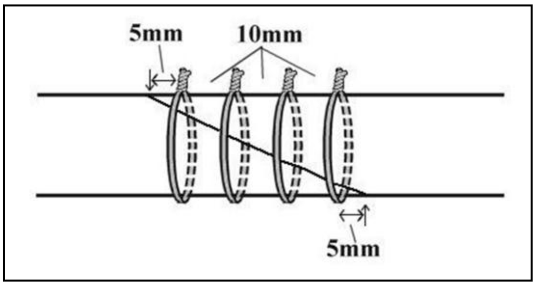
3**.** Cerclage wires must be <u>tight</u> and applied directly against the bone with no soft tissue entrapped

Entrapped soft tissue will become avascular and on necrosis will result in loose wires. Proper placement of cerclage wires necessitates the circumferential elevation of muscle attachments at the point of placement of the cerclage wire. For this reason cerclage wires are by necessity a relatively "non-biological" method of augmenting fracture fixation. Remember to ask the question before placing any implant "is the biomechanical gain worth the biological price?" If not, then alternative methods (such as lag screws or methods of bridging osteosynthesis) should be considered.

Non-circular bone (for example the radius, ulna, proximal humerus and proximal tibia**) is not suitable for cerclage wiring** as the wire will not lie directly against **the bone and consequently will have limited effect.**

4. Place cerclage wire 5mm from the fracture line and then spaced every 10mm apart

If cerclage wires are placed closer than 5mm to the transverse part of the fracture line (i.e the "end" of the fracture line), they run a high risk if migrating into the fracture line. The cerclage wire will then act as a "cheesewire" and cut through the callus that is forming thereby preventing or delaying bone healing.



5. Place a minimum of 2 wires

Cerclage wires are only suitable for <u>long</u> oblique fractures whose length is <u>at least twice the diameter</u> of the bone shaft**. If an oblique fracture is not long enough to place at least two cerclage wires (5mm from the fracture line and 1cm apart) then it is not appropriate for cerclaging.** Placement of a single wire is <u>contraindicated</u> **as it acts as a fulcrum and increases the likelihood of failure by bending forces.**

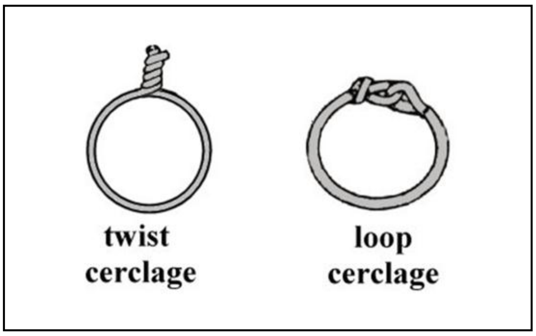
6. In areas where the diaphysis is conical avoid cerclage wires or place in combination with a K wire

Cerclage wires placed on a conical shaft (for example the proximal humerus or proximal tibia) will migrate to the narrower diameter section of shaft and quickly loosen. In areas where the shaft is conical, consideration should be given to a better method of achieving interfragmentary compression such as lag screws, which are effective regardless of variation in shaft diameter.

If cerclage wires are to be placed on a conical diaphysis then some means of preventing wire migration must be used. The recommended method is to place a transverse K wire (Kirschner wire – which is a small stainless steel pin– 0.9 – 2.0mm diameter) through the bone and place the cerclage wire around the bone on the side with the greater circumference. The pin will prevent migration of the wire.

7. There are two methods of placing cerclage wires: wire twist and wire loop

Both methods are effective if done correctly. The wire twist method is the cheaper and most commonly used method however is <u>more difficult to place correctly</u> than the loop method. Developing and maintaining effective wire tension is easier with the loop method.



Double loop cerclage wire has been shown to be biomechanically superior to twist cerclage and …… has also been shown to be easier to place.
I would strongly encourage you to purchase a double loop cerclage tightener and start placing double loop cerclage instead of twist cerclage.

If using the twist cerclage method:

- **Do <u>not</u> bend the twists over** to lie flush with the bone. While this will cause less soft tissue irritation in the short term **bending the twisted knots causes loss of up to 70 % of the tensile strength of the cerclage loop**. When not bent over the ends are quickly covered in fibrous tissue and provide minimal soft tissue irritation

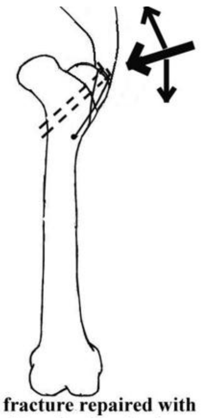
- **Do not cut the twists less than 3 full twists** in length as this will further decrease the tensile strength up to 20%

<u>Tension band wires</u>

Tension band wires are interfragmentary wires used as a tension band to convert axial tension force (i.e distraction) into a compressive force.

They are applicable to any fracture or osteotomy of a traction apophysis
(i.e. where the pull of a tendon or ligament's origin or insertion results in distraction. e.g. the olecranon – triceps tendon, greater trochanter – gluteal tendon, tibial tuberosity – quadriceps tendon etc).

The tension band wire is placed as a **figure of 8 wire** spanning the fracture or osteotomy site and "pulling" in the opposite direction to the pull of the tendon or
ligament. On weight-bearing the resulting sum of these opposite vectors produces a dynamic compression force on the fracture line which effectively stabilises the fracture.



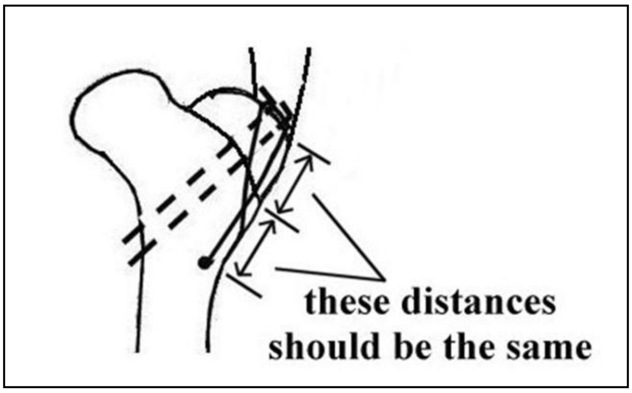
avulsion fracture repaired with

Principles of tension band wires

1. Use 2 K wires (Kirschner wires) to maintain reduction and to prevent rotation of the fracture or osteotomy fragment and to anchor the tension band wire around

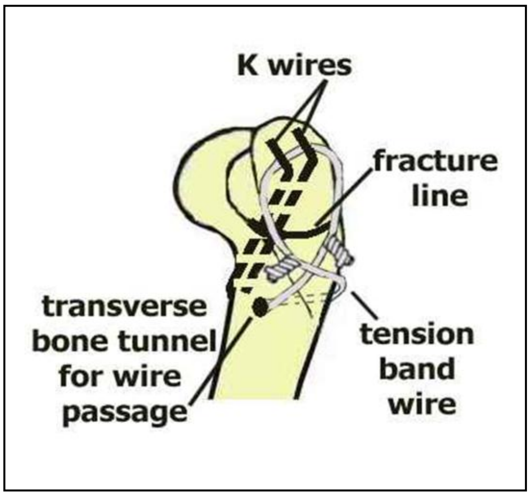
   The K wires should be:
   - ***Perpendicular to the fx line***
   - ***Parallel to each other***
   - Long enough to penetrate the far cortex

2. The drill hole in the bone shaft should ideally be the same distance from the fracture line as the size of the fracture fragment



3. Avoid having soft tissue interposed between the tension band wire and the K wires as this will lead to soft tissue necrosis and loosening

4. **The tension band wire should be a figure of 8 and comprise two wires and two knots for maximum biomechanical advantage**



5. Unlike cerclage wires tension band wires do not need to be overtightened

The static tension in the tension band wire does not directly compress the fracture. It is the force of weight-bearing pulling in an opposite direction to the tension band wire that results in a dynamic compressive force. Tension band wires should be firm but not excessively tight.

Interfragmentary wires

An interfragmentary wire is a piece of orthopaedic wire crossing a fracture line to connect two adjacent pieces of bone. It is anchored in holes drilled in each of the bone fragments.

Twisting the wire exerts limited interfragmentary compression. This used to be a commonly used method of providing adjunctive support in fracture repair however has **little to recommend its use today** except in certain mandibular fractures. It is a method that provides little biomechanical advantage and should be avoided in diaphyseal fractures.