PRINCIPLES AND CLINICAL APPLICATION OF TENSION BAND WIRING

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Pauwels, in Germany, was the first to describe the tension band principle in orthopedic surgery for the treatment of non-union. Commonly used by engineers, it enables tensile forces to be counteracted and converted into compressive forces [1]. Examples of tension band wiring are all around us, in sailing boats, cranes or the construction of bridges. Every loaded bone has a side that is under tension and one that is under compression. These sides change with the various phases of locomotion and their location on the bone varies according to load and muscle pull. There is seldom one side that is constantly under tension: the lateral surface of the proximal and midshaft femur is under tension during weight bearing. The AO method advises always placing plates on the tension side. The tension band principle can be applied in orthopaedic surgery using either plates or metallic wires.

Tension band wiring is a useful technique for stabilizing bone fragments that are subject to unidirectional tension due to the pull of muscles, tendons or ligaments. A constant tension side seldom exists on the outer aspects of bony protuberances, so tension band wiring is mainly used in the treatment of avulsion fractures. The tension band wire counters the tension created during locomotion by the tendon or ligament that inserts on the bone fragment. These loads are converted into dynamic (cyclic) compression at the fracture site.

A combination of orthopedic and Kirchner wires is used. The theory is that the Kirchner wires stabilize the fracture site against rotation and anchor the orthopedic wire that acts as a tension band. Because wire does not easily stretch under tension, it directly counters the distraction forces created during locomotion. Some fragments of bone are too small for the insertion of two intramedullary pins.

A typical example is the transverse or short oblique fracture of the olecranon. After anatomical reduction, a small hole is drilled transversally through the shaft of the ulna, distal to the fracture site. The distance between the drill hole and the fracture site is equal to the distance between the fracture and pin insertion sites. An orthopedic wire (0.8mm – 1.25 mm) is inserted through this hole. Two Kirschner wires are then inserted at the caudo-proximal aspect of the olecranon process and driven distally into the ulna. The ends of the orthopedic wire are wrapped around the two Kirschner wires in a figure of eight pattern, and tightened on each side before being cut and bent over. The two pins are bent at 90 degrees using the same technique.

Alternatively, an AO wire loop and wire tightening can be used. Where feasible, it is preferable to place the wire under, rather than over, the soft tissue structures (the triceps tendon in this case). External coaptation is not usually required.

A model can be used to demonstrate the role of the triceps muscle and its antagonistic biceps muscle, and is useful in helping to understand the limits of the technique.

This model demonstrates that the tension band technique using wire is well adapted when the action of the biceps muscle is negligible, as is the case for the olecranon up to the level of the axis of rotation of the elbow. Further distally, the biceps exerts a stronger action and it is preferable, from a biomechanical point of view, to use a laterally placed plate.

The tension band technique is frequently used in the treatment of apophyseal fractures or following osteotomies enabling a wider surgical approach to a joint [2].

APPLICATIONS

- **Fractures and Osteotomy of the olecranon process.** Simple fractures of the olecranon respond well to this method. Often only one Kirshner wire can be placed in cats and small dogs. The approach via osteotomy is classically used in fractures of the distal extremity of the humerus (Y-fracture). However, a retrospective study has shown a surprisingly high complication rate following osteotomy [3]. The latter should therefore be performed with care.

- **Fractures and Osteotomy of the greater trochanter.** Isolated fractures are exceptional. More often, they form part of multifragmentary fractures of the proximal extremity of the femur. An approach via osteotomy is sometimes used during the surgical repair of acetabular fractures. However, tension band wire-fixation is not ideal for repositioning the greater trochanter after a total hip replacement.

- **Fractures and Osteotomy of the acromion process.** By reflecting the body of the deltoideus muscle, this osteotomy gives an approach to the anterior part of the shoulder joint for fracture repair. It is particularly useful in fractures involving the supraglenoid tubercle. This fracture may also be fixed using a tension wire, since the tubercle is subjected to the traction of the proximal tendon of the biceps muscle.

- **Fractures and Osteotomy of the greater tubercle.** By adding this osteotomy to the previous one, we obtain a very wide approach to the scapulohumeral joint. This enables the treatment of multifragmentary fractures of the joint, such as in fractures of the neck of scapula.

- **Fractures and Osteotomy of the tibial tuberosity.** The technique gives a very high recovery rate for these fractures. The vast majority of affected animals are still growing, and the compression created by the tension band often causes modification of tibial crest anatomy. This is due to the compression exerted by the tension band on the growth plate. However, there do not seem to be any clinical consequences. In the case of highly fragmented fractures of the distal extremity of the femur, an approach via tibial crest osteotomy may be performed. This gives very wide access to the joint by enabling the reflection of the extensor apparatus.

- **Fractures and Osteotomy of the medial malleolus.** Uni or bi-malleolar fractures are often fixed using tension bands, but in general, it is only possible to implant one pin. In certain fractures and in some cases of osteochondritis dissecans of the ridge of the talus, an osteotomy may be performed to obtain a wide articular approach.

- **Fractures of the patella.** This is the classic example of the use of tension wiring in man. This type of fracture is much rarer in the dog or cat. When the
fracture is transverse, it is treated with a tension band. The cerclage wire attaches to the single pin both proximally and distally.

- **Fractures of the calcaneus.** The tension wire antagonizes the traction of the Achilles tendon. The calcaneus is a very hard bone and it is vital to cool the pin with irrigation during implantation, to avoid postoperative thermal necrosis.

- **Thoracolumbar vertebral fractures.** A method combining segmentary pins with the application of a tension band on the spinous processes has recently been proposed [4]. Analysis of the results shows that the method can be applied to small or medium sized dogs and cats.

This method is based on the premise that flexion is the dominant movement in the small animal spine, and that the dorsal aspect of the spine is the traction side. The method employs the tension band principle and is therefore a dynamic fixation. A dorsal approach is made over six spinous processes but limited to exposing just the laminae.

A Kirschner wire (1.6 mm in dogs and 1.25 mm in cats) is inserted through the dorsal lamina adjacent to the affected spinal segment. The K-wire is bent into a U shape and adapted along the dorsal laminae between the articular and spinous processes. It is held in position with a cerclage wire placed in the spinous process of the next caudal vertebra on the opposite side of the affected segment of the spine. The fracture / dislocation is reduced and stabilized using a figure of eight wire. This wire is inserted into the lamina at the base of the spinous process of both the cranial and caudal vertebrae of the affected segment. The wire is tightened bilaterally around the U-shaped K-wire. In this technique, the figure of eight wire, acting as a tension band, neutralizes the distracting forces and the U-shaped K-wire, acting as a splint, neutralizes the torsional forces [5].

REFERENCES