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Technical Paper

Understanding the Basic Principles and Biomechanics of Patellar Modified Tension Band Wiring Surgery: Are we on a Monotonous Path for Fixing Transverse Patellar Fractures?

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Fractures of patella constitute up to 1% of all skeletal injuries with 70-80% of these having a transverse fracture pattern in adults with the absolute indication for surgical treatment being an extensor mechanism disruption [1-4,7]. The aim of surgical treatment in patella fracture is anatomical reduction, restoration of articular congruity, preserving patellar bone stock, and repairing the extensor mechanism. The modified tension band wiring (TBW) technique, which converts the tensile forces generated by the knee extensor into compressive forces at the joint line, has been widely acknowledged as the optimum treatment for displaced transverse patellar fractures due to its biomechanical superiority and economical benefits [1-3,6,7].

Understanding the biomechanics of patello-femoral joint

Extensor apparatus functions to keep the body erect and overcome the force of gravity. The patella being link in the quadriceps system provides two important biomechanical functions (Figure 1a). First, it transfers the tensile forces produced by the quadriceps to the patellar ligament. Second, the patella elevates the knee extensor mechanism's lever arm significantly from the axis of knee flexion-extension [5,8-10].

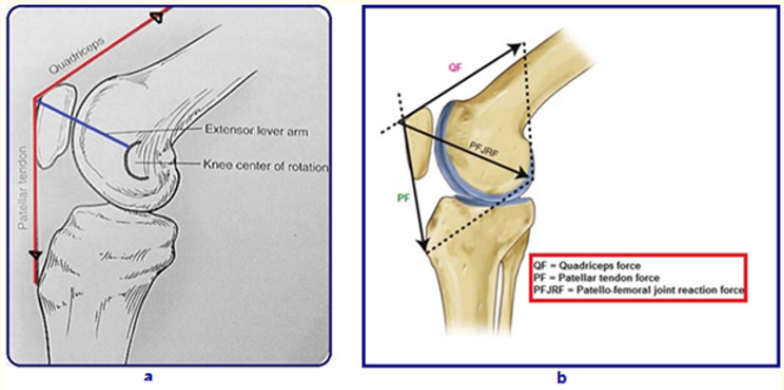

Figure 1: Biomechanics of patella-femoral joint.

The patella transmits a significant loading force from the quadriceps contraction when the knee is extended. However, when the knee is flexed, the patella is subjected to a compressive force against the distal condyles of the femur, known as the patellofemoral joint reactive force, which causes a 3-point bending configuration in the patella (Figure 1b).

The patella is under significant biomechanical compressive load during activity in 45-60° knee flexion, the forces are three times the body weight, whereas in full flexion the forces are over four to seven times the body weight. This bending load results in tension at the anterior surface of the patella.[5, 10] Due to the magnitude of tension, three-point bending stress, and compressive forces that oc-

cur on the posterior surface of the patella in a loaded flexed knee, displaced transverse patellar fractures are prevalent and pose a significant impact on the efficacy of various treatment methods for these fractures.

Principle of tension band wire fixation

The tension band wiring concept was introduced to orthopaedics by Freidrich Pauwel in1935 and was applied in the internal fixation of an eccentrically loaded bone. An eccentrically loaded bone was found to have both a tension side and a compression side (Figure 2). It has a typical stress distribution, with compression on the concave side and tension on the convex side [2,6,11,12].

Principle

The tension band construct works on the principle of converting tension (distracting forces) into compression (compressive forces) at the articular side (opposite cortex) of the fracture.

To restore load-bearing capacity to an eccentrically loaded fractured bone, the tensile forces must be absorbed by the tension band wire, and the bone itself must withstand axial pressure (Figure 2). Therefore, inter-fragmental compression occurs when the device is pre-tightened being under tension [2,6,12].

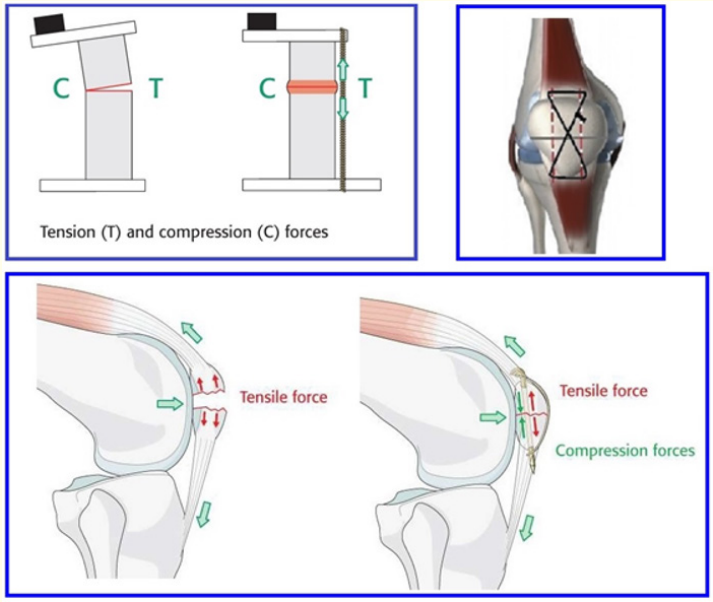

Figure 2: Principle of patellar tension band wiring.

Biomechanical factors

Tension band must be applied on the tension surface of the bone and pre-stressed (pre-tightened) as it keeps the fractured fragments under static compression. When the compressive force increases with movement, it is called a dynamic tension band. Therefore, when the knee is flexed, the increased tensile force is converted to compression force [1-3,6,8,12].

- The construct must be strong enough to withstand tension load.
- To withstand dynamic compressive loads, a strong opposite bone cortex is required.
- To improve congruity and compression, joint movement must be encouraged.

Discussion

There is a remarkable interest among orthopaedic trauma surgeons to learn whether the modified tension band wiring technique in treating displaced transverse patellar can be considered as the gold standard method despite having the most advanced surgical instruments, implants and techniques in this era [1-7,13,18].

Patellar fractures account for a considerable portion of traumatic musculoskeletal injuries, and despite a wide range of suggested

treatments, there is a dearth of evidence-based studies that suggests the best fixation technique [1-3,6-11].

It is surmised that eight to twelve weeks are required for an optimum healing of the fractured patella, with approximately 100,000 cycles of flexion and extension occurring during this time [14,15]. These factors reflect a high demand on any surgical fixation strategy.

Although several similar techniques including hybrid fixation with additional screws, fiber tape, and cerclage wiring have been published, the modified tension band wiring based on AO principles, is the most accepted and commonly utilized method for the treating displaced patella fractures [12]. According to biomechanical studies, an eight-shaped tension band technique offers stability that is superior to circular wire, but it also poses a higher risk of soft tissue irritation due to the prominence of the hardware [16]. To minimize secondary dislocation of the fragments, the tension band construct must be positioned as closely as possible to the bone [17]. K-wires are reported to cause hardware associated symptoms twice as often as cannulated screws [14-17]. The incidence of hardware associated symptoms can be reduced by paying close attention to detail while executing tension band construct, as most soft tissue irritation comes from shattered tension bands or bulky knots in the stainless steel wire [16,18]. It is a historical paradox that even after 145 years and despite having advanced instrumentation and implants, internal fixation of transverse fractures of patella is still associated with a number of complications which generally includes infection, fixation failure, re-fracture, nonunion, osteonecrosis of the proximal fragment, post-traumatic osteoarthritis, loss of knee range of motion, extensor lag, patellar instability, and painful retained hardware [2,3,11,15] Various surgical fixation methods for treating displaced transverse patellar fractures have been described and reported in the literature till now, including plate and screw devices, tension band wiring, hybrid tension band wiring, inter-fragmentary screw fixation, and arthroscopic assisted fiber tape fixation, it is still a matter of debate and treatment modalities continue to evolve with different surgical techniques and implants [1,2,4,5-7,18] Current implantation tech-

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