Technique Report

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Tension band tendon-approximating cerclage for surgical fixation of patellar fractures: a novel surgical technique

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Abstract Patellar fractures are potentially debilitating injuries due to loss of extensor mechanism function, resulting in an inability to extend the leg. Traditionally, these fractures have been surgically managed with open reduction and internal fixation using a tension band construct. This can be performed with K-wires or cannulated screws with suture or cable as the tension band. Plate osteosynthesis is another option that is increasing in popularity. Incorporating the tension band construct converts tensile force into a healing-compatible compressive force. However, these techniques often fail when used for comminuted patellar fractures. There is also a high reoperation rate due to metal implant discomfort. Reoperation rates have been reported as high as 41% for K-wires and 23% for cannulated screws. A more optimal technique would provide adequate reduction and strong fixation without the risk of implant irritation that can apply to all/most fracture types. We report a new technique that implements a multistrand, long-chain, ultra–high-molecular weight, polyethylene core suture material with a braided jacket of polyester (FiberWire) without the need for any associated plates, K-wires, or cannulated screws. The suture is woven to create a tension band tendon-approximating cerclage construct that incorporates the proximal and distal bone fragments as well as the patellar and quadriceps tendons. This technique can be used for both simple and comminuted fractures and provides optimal fixation strength while minimizing the complications associated with metal implants. The efficacy of this technique may lend to future studies including biomechanical and retrospective analyses.

Keywords: patella, fracture, knee, suture, tension, band, cerclage, construct, tendon, approximating, technique, surgery

1. Introduction

Patellar fractures most often occur by direct trauma to the knee or when the extensor force exceeds the tensile strength of the knee. This compromises the extensor mechanism of the leg and leads to the classic physical examination finding of failure to extend the leg against gravity. One study of 707 patellar fractures determined that the most common mechanism of injury is by direct trauma (65%) and the most common fracture pattern is a simple 2-part division.[1] High-energy vehicular trauma has been found to be the most common cause of injury by far.[2,3] The fracture morphology is highly related to the mechanism of injury; direct trauma often causes comminution, whereas failure in tension often leads to transverse fractures.[4] In addition, the majority of patellar fractures are closed, with some studies citing only 7% of patellar fractures as open.[2,5] Open patellar fractures are associated with other injuries, most notably other fractures, in approximately 80% of cases.[6]

The definitive treatment generally begins with the decision of operative versus nonoperative treatment. This takes into account the status of the extensor mechanism, fracture morphology, and the degree of displacement. Only approximately one-third of patellar fractures require surgical intervention.[7,8] Specifically, nonoperative criteria include no extensor mechanism disruption and <2 mm displacement or <3 mm separation of fracture fragments.

Current surgical management typically relies on open reduction and internal fixation of the patella. This often proves challenging, as the patella is frequently put under very high tensile loads; thus, a very strong construct is needed. One common technique is the implementation of an anterior figure eight tension band. This construct is ideal because it converts the tensile force into a compressive force. The tension band is historically created by inserting either 2 parallel 0.062 K-wires or 2 cannulated lag screws across the fracture lines and then using an 18 G wire placed in figure eight fashion over the anterior surface of the patella.

Another technique that does not implement the tension band construct is the plate osteosynthesis method. With this method, a plate is placed over the reduced fracture line and is then attached by screws. This technique is not commonly used, as the plate is often uncomfortable because it is very close to the skin surface.

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The authors have developed a new technique for patellar fractures. It uses a FiberWire suture with no K-wires, lag screws, or plates to create a tension band, tendon-approximating cerclage construct (TB-TAC). This technique is very versatile, as it does not require the placement of additional metal implants and can be used for a variety of fracture patterns, including those which are comminuted and would be otherwise difficult to reduce. In this study, we will describe how to successfully implement this technique. This study was approved as a non human subject determination by the local IRB review board.

2. Technique

Our technique is unique because it uses a multistrand, long-chain, ultra–high-molecular weight, polyethylene core suture material with a braided jacket of polyester (FiberWire), but no associated K-wires or cannulated screws. FiberWire has a very high tensile strength and is ideally suited in cases that require very high-strength constructs, such as patellar fractures.

In this technique, a longitudinal incision is made over the patella, which exposes the patellar fracture, the adjacent anterior knee capsule and patellar retinaculum, quadriceps tendon, and patellar tendon. Fracture fragments are identified, and any hematoma is evacuated. Preliminary reduction can be achieved by manipulation and held in place with Weber clamps with the leg in the extended position.

A #5 FiberWire suture is then used to create a pattern around the patella, which approximates the patellar and quadriceps tendons (Fig. 1). The suture starts at the lateral patellar tendon site with 3 Krackow locking sutures placed caudad. Three more Krackow locking sutures are placed cephalad at the medial patellar tendon site. The placement of sutures then continues in a cephalad direction through the capsule passing deep at the fracture site, leaving anterior suture loops at the 2 and 4 o'clock positions (Figs. 1 and 2). Three Krackow locking sutures are then placed on both sides of the quadriceps tendon, first moving cephalad on the medial side and then passing caudad on the lateral side. The suture is then passed deep at the fracture site, leaving anterior suture loops at the 10 and 8 o'clock positions. The cerclage is finished by tying the ends together. In doing so, 4 loops are made that serve as a scaffold for the tension band construct at the 2, 4, 8, and 10 o'clock positions (Figs. 1–3).

Another #5 FiberWire suture without needle is used to make the anterior figure eight tension band. The suture is woven under and over each corner of the cerclage and then pulled taught to properly reduce the fracture. The tension band has 4 points of cerclage attachment at the 2, 4, 8, and 10 o'clock positions (Fig. 3). The ends of the figure eight are then hand-tied together and tightened to provide adequate reduction. Both knots are positioned either laterally or medially so as to reduce post-operative midline irritation (Fig. 4). The knee is flexed and extended to assess for range of motion, and then, the fascia and skin are closed (Fig. 5). Radiographs taken preoperatively, immediately postoperatively, and 5 months postoperatively in 1 patient treated with the TB-TAC technique demonstrate good and consistent reduction (Fig. 6).

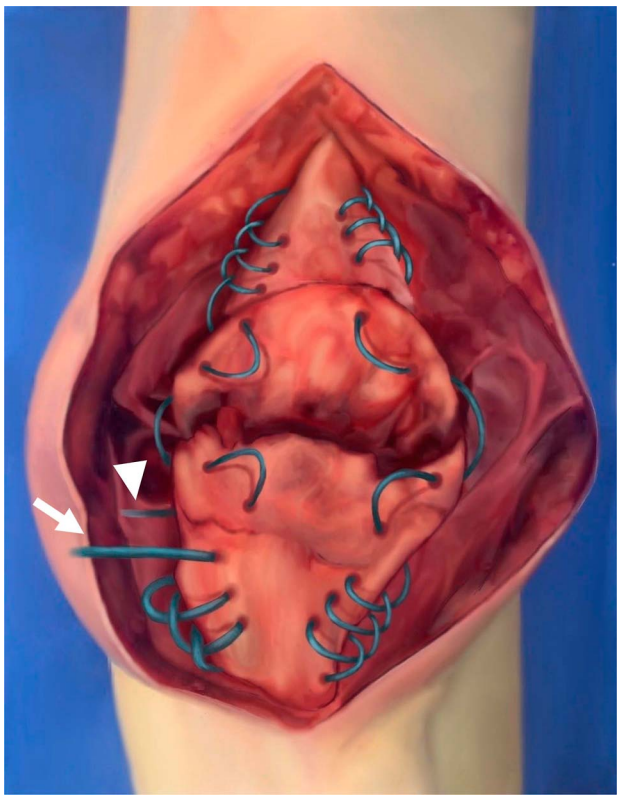

Figure 1. Cerclage suture diagram demonstrating the suture passing beneath the fracture line and 4 loops that function as a scaffold for the tension band. The Krackow sutures are used on the medial and lateral borders of the patellar and quadriceps tendons.

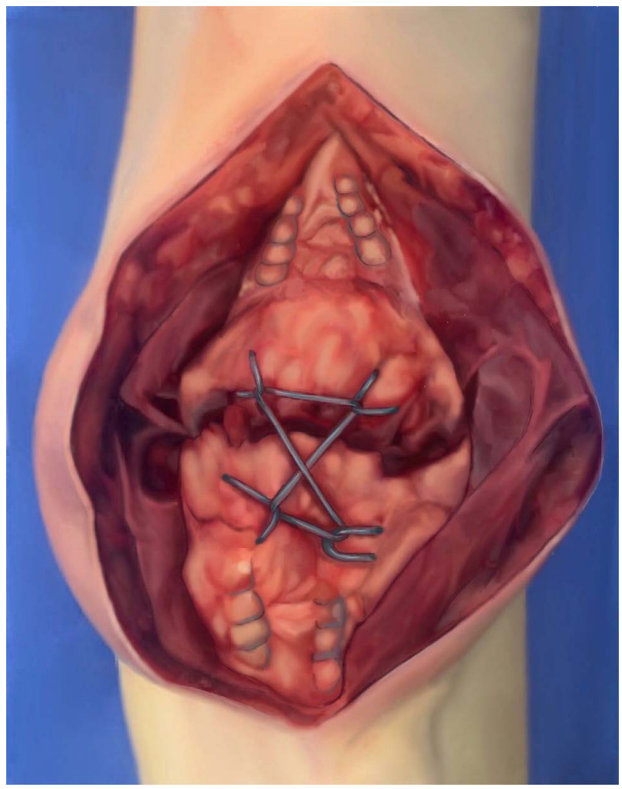

Figure 2. Full construct diagram showing both cerclage and figure-of-eight tension band. The tension band brings the 4 cerclage loops together for fracture reduction.

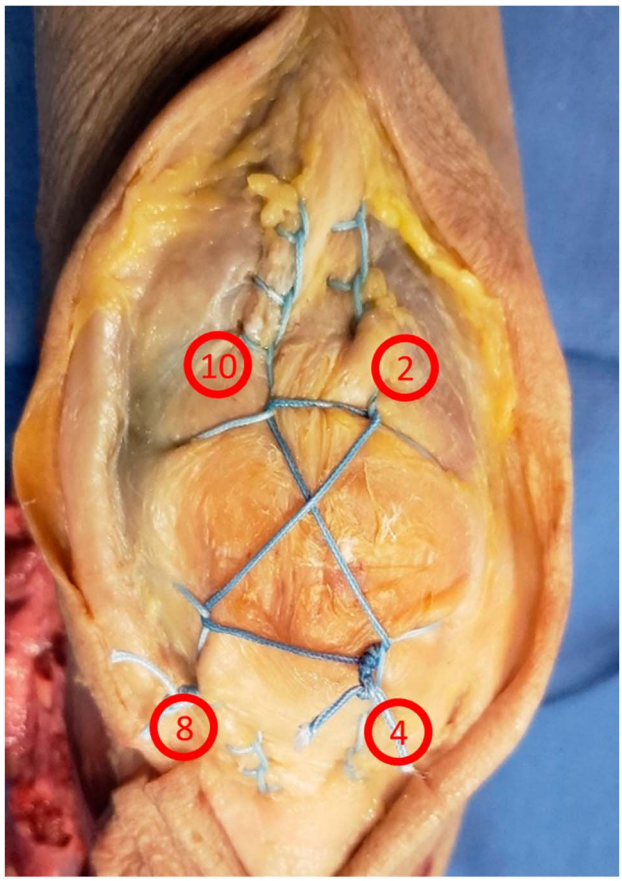

Figure 3. Cadaveric demonstration of novel patellar fracture treatment with numbers indicating the position of cerclage loops as attachment points for figure-of-eight tension band.

Figure 4. Intraoperative view of the completed TB-TAC suture construct in extension demonstrating good reduction.

3. Discussion

The optimal management of patellar fractures should provide adequate reduction and allow for normal healing. Tension band constructs that implement K-wires or cannulated screws greatly advanced treatment toward these goals. These traditional fixation methods have been around since the 1950s and are the gold standard for how patellar fractures are managed. However, these fixation methods have limitations: they are not ideal for comminuted cases and the patella is very superficial, making it prone to implant irritation. This makes it essential for any implant to be flush with the bone surface or completely inside the bone to ensure that implant prominence does not bother the patient postoperatively. K-wires have been found to protrude at times and cause soft-tissue irritation that may hinder knee range of motion and cause pain, particularly when pressure is applied to the protrusion as in kneeling.[9–14] When K-wires are used, they are typically not locked into the tension band construct and may move slightly, leading to decreased stability.[11] In addition, K-wire movement can cause irritation as the sharp ends of the K-wires sometimes stick out past the distal or proximal edges of the patella, particularly during kneeling actions.[9,10,12,14] K-wires are not cannulated and have no thread, so during immobilization when the leg is extended, straight traction from the quadriceps may lead to some loss of reduction.[9,13] Some of these complications have been reduced by implementing a ring that locks the K-wire with the tension band construct to decrease

Figure 5. Intraoperative view of the completed TB-TAC suture construct at approximately 90 degrees of flexion demonstrated good reduction.

Figure 6. Case illustration radiographs. From top to bottom, preoperative, immediate postoperative, and 5 months postoperative lateral (left) and AP (right) radiographs of the described case. Each postoperative radiograph demonstrates good, anatomic reduction without hardware.

movement.[11] Compared with fixation with cannulated screws, the incision needed for K-wire implementation is larger and more dissection is required. This potentially increases infection risk and healing time.[15,16] Although fracture nonunion rates are generally low when K-wires are implemented with tension band constructs, implant irritation is common and other complications are possible, so other surgical methods should be explored.[14,17]

Implementing cannulated screws with tension band construct instead of K-wires was designed to reduce some of the complications associated with K-wires, including implant migration and loss of reduction. This is due to the inherent design of cannulated screws, which have a thread to "hold" the 2 displaced pieces of bone together. This technique is unique in that it can often be performed percutaneously.[18] Percutaneous implementation decreases incision size, potential damage to the extensor, and cosmetic scar.[9,18,19] Studies have demonstrated that this technique results in excellent range of motion and early motion exercise with very low rates of nonunion and loss of reduction.[9,18,19]

Tension band constructs with K-wires and cannulated screws are the 2 most widely used techniques for surgical treatment of patellar fractures, and several studies have compared the 2. Patients treated with K-wires were almost twice as likely to undergo implant removal (37%–41% vs. 21%–23%).[20,21] Infection rates and fixation failure rates were low in both techniques.[20,22] One study found that complication rates overall are also significantly lower when using cannulated screws compared with K-wires (11% vs. 53%).[10] In general, cannulated screws with tension band construct decreased loss of range of motion, blood loss, time to motion exercise, and hospital stays and improved knee functional scores when compared with K-wires with tension band construct.[22,23] Of the 2 most widely used techniques, cannulated screw implementation with tension band construct is certainly the more efficacious method based on complications and outcomes.

At the time of writing, the corresponding author has performed this technique for approximately 21 patients without any instance of hardware failure and 1 case of delayed union. A retrospective analysis of patients treated with TB-TAC by the corresponding author is in progress.

TB-TAC combines a tension band and cerclage pattern that approximates the patellar and quadriceps tendons, which allows use in a diverse range of patella fracture patterns. The tendon approximation offloads the bony structures, the cerclage can capture comminuted fragments, and the tension band construct allows tensile forces to be converted into compressive forces. Most importantly, it incorporates no hardware to minimize the risk of hardware irritation and hopefully decrease the risk of reoperation. Given the known drawbacks of existing techniques, we think TB-TAC is a potentially useful alternative that may mitigate the risks associated with hardware.

4. Conclusions

Current techniques of surgical correction of patellar fractures have very high rates of complication and reoperation primarily due to metal implant irritation. TB-TAC implements a high tensile strength suture in a cerclage, tendon-approximating anterior figure eight suture pattern. This technique brings the quadriceps and patellar tendons together and provides optimal fixation strength while decreasing the risk of complications as it does not incorporate other implants. To further analyze the efficacy of this surgical technique, future studies will include a clinical series, biomechanical analysis, and comparison with preexisting surgical methods.

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References

1. Nummi J. Fracture of the patella. A clinical study of 707 patellar fractures. *Ann Chir Gynaecol Fenn Suppl*. 1971;179:1–85.
2. Torchia ME, Lewallen DG. Open fractures of the patella. *J Orthop Trauma*. 1996;10:403–409.
3. Wild M, Windolf J, Flohé S. Fractures of the patella. *Unfallchirurg*. 2010; 113:401–411. quiz 412.
4. Carpenter JE, Kasman R, Matthews LS. Fractures of the patella. *Instr Course Lect*. 1994;43:97–108.
5. Gwinner C, Märdian S, Schwabe P, et al. Current concepts review: fractures of the patella. *GMS Interdiscip Plast Reconstr Surg DGPW*. 2016;5:Doc01.

6. Catalano JB, Iannacone WM, Marczyk S, et al. Open fractures of the patella: long-term functional outcome. *J Trauma*. 1995;39:439–444.
7. Boström A. Fracture of the patella. A study of 422 patellar fractures. *Acta Orthop Scand Suppl*. 1972;143:1–80.
8. Egol K, Howard D, Monroy A, et al. Patella fracture fixation with suture and wire: you reap what you sew. *Iowa Orthop J*. 2014;34:63–67.
9. Khan I, Dar MY, Rashid S, et al. Internal fixation of transverse patella fractures using cannulated cancellous screws with anterior tension band wiring. *Malays Orthop J*. 2016;10:21–26.
10. Lin T, Liu J, Xiao B, et al. Comparison of the outcomes of cannulated screws vs. modified tension band wiring fixation techniques in the management of mildly displaced patellar fractures. *BMC Musculoskelet Disord*. 2015;16:282.
11. Kyung MG, Lee SH, Kim MB. Complications related to implant fixation of patellar fractures: comparison of ring pins versus bent K-wires. *J Knee Surg*. 2017;30:560–564.
12. Choi HR, Min KD, Choi SW, et al. Migration to the popliteal fossa of broken wires from a fixed patellar fracture. *Knee*. 2008;15:491–493.
13. Biddau F, Fioriti M, Benelli G. Migration of a broken cerclage wire from the patella into the heart. A case report. *J Bone Joint Surg Am*. 2006;88: 2057–2059.
14. Petrie J, Sassoon A, Langford J. Complications of patellar fracture repair: treatment and results. *J Knee Surg*. 2013;26:309–312.
15. Tian Y, Zhou F, Ji H, et al. Cannulated screw and cable are superior to modified tension band in the treatment of transverse patella fractures. *Clin Orthop Relat Res*. 2011;469:3429–3435.
16. Wardak MI, Siawash AR, Hayda R. Fixation of patella fractures with a minimally invasive tensioned wire method: compressive external fixation. *J Trauma Acute Care Surg*. 2012;72:1393–1398.
17. Zhang Y, Xu Z, Zhong W, et al. Efficacy of K-wire tension band fixation compared with other alternatives for patella fractures: a meta-analysis. *J Orthop Surg Res*. 2018;13:226.
18. Cho JH. Percutaneous cannulated screws with tension band wiring technique in patella fractures. *Knee Surg Relat Res*. 2013;25:215–219.
19. Malik M, Halwai MA. Open reduction and internal fixation of patellar fractures with tension band wiring through cannulated screws. *J Knee Surg*. 2014;27:377–382.
20. Hoshino CM, Tran W, Tiberi JV, et al. Complications following tension-band fixation of patellar fractures with cannulated screws compared with Kirschner wires. *J Bone Joint Surg Am*. 2013;95:653–659.
21. Zhu XZ, Huang TL, Zhu HY, et al. A retrospective cohort study on prevalence of postoperative complications in comminuted patellar fractures: comparisons among stabilized with Cannulated-Screw, Kirschner-Wire, or Ring-Pin Tension Bands. *BMC Musculoskelet Disord*. 2021;22:60.
22. Liu C, Ren H, Wan C, et al. Comparison of the therapeutic effects of tension band with cannulated screw and tension band with kirschner wire on patella fracture. *Comput Math Methods Med*. 2020;2020:4065978.
23. Tan H, Dai P, Yuan Y. Clinical results of treatment using a modified K-wire tension band versus a cannulated screw tension band in transverse patella fractures: a strobe-compliant retrospective observational study. *Med Baltim*. 2016;95:e4992.