



Five-pointed star lattice sutures for fixation of patella transverse fractures: a clinical study

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Abstract

Introduction Fixation of displaced patella fractures with metal implants may be associated with implant failure, post-operative pain, and high re-operation rate. This study reports preliminary clinical results of using five-pointed star lattice sutures for the management of patella transverse fractures.

Methods A five-pointed star lattice suture configuration was produced intraoperatively, and 25 patients with patella transverse fractures were treated with this newly designed sutures fixation. All patients were followed up until union of the fractures or until further surgical intervention. At a mean of 1.6 years (range 0.8–2.5 years) of follow-up, the notes and plain radiographs of the 25 patients were reviewed. Bostman score was used to evaluate the therapeutic effects.

Results All 25 patients experienced union of the patella fractures, with excellent knee function in 19 patients and good in 6 patients evaluated with Bostman score.

Conclusion The newly designed five-pointed star lattice sutures fixation may be a feasible alternative to metal implants fixation in the management of patella transverse fracture.

Level of evidence Level IV case series.

Keywords Patellar fracture · Lattice sutures · Non-metal implant · Fixation

Introduction

Patella fractures account for approximately 1% of all skeletal injuries [1]. Since patella is an important functional component of the knee extensor mechanisms, patella fractures could lead to obvious pain and secondary knee function impairment [2]. For this reason, the goal of treatment should be focused on achieving the anatomical reduction in both the fractures and the articular surface to alleviate the impairment. The most common types of patella fractures are classified into transverse, vertical, comminuted, marginal, or osteochondral according to fractures pattern [3]. In fractures with non-displacement (1–4 mm), minimal intra-articular

cartilage step-off, and intact extensor mechanism, there is an opportunity of non-surgical treatment [2]. The main indications for surgical treatment include displacement (> 4 mm) and comminuted fractures with a torn extensor retinaculum [2]. Surgical treatments range from patellectomy to reduction in fractures and internal fixation [4]. The conventional method of fixing with a tension band principle mode was firstly introduced by Pauwels in 1935, and the modified tension band wiring technique is the most widely used method [2]. It involves the use of two longitudinal inter-fragment Kirschner wires (K-wires) and a figure-of-eight stainless steel wire looped over the anterior side of the patella [5, 6]. This technique aims to neutralize tension forces applied to the patella through the extensor mechanism and convert tension forces into compression forces [5, 7]. Single or multiple cannulated screws have also been used for fixation of patella fractures to replace tension band wiring technique. Although those techniques above have produced high rates of success, they may be associated with hardware migration and post-operative discomfort [8]. Metal implants are associated with the need of being removed when they cause local tissue irritation [9–11]. For those reasons, non-metal implants for

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fixation of patella fractures have been advocated by different authors and have produced good clinical outcomes; however, there still exist a certain percentage of failures [4, 10, 12, 13]. So it is still necessary for non-metal implants for fixation of patella fractures to be further explored.

On the basis of above procedures for treatment of patella fractures with non-metal implants, we designed five-pointed star lattice sutures in fixing patella transverse fractures with NO. 2-0 ETHIBOND EXCEL suture (Ethicon, Somerville, NJ, USA) and NO. 0-0 polydioxanone sutures (Ethicon, Somerville, NJ, USA). This current clinical study reported 25 cases of patella transverse fractures treated with utilizing five-pointed star lattice sutures for fixation.

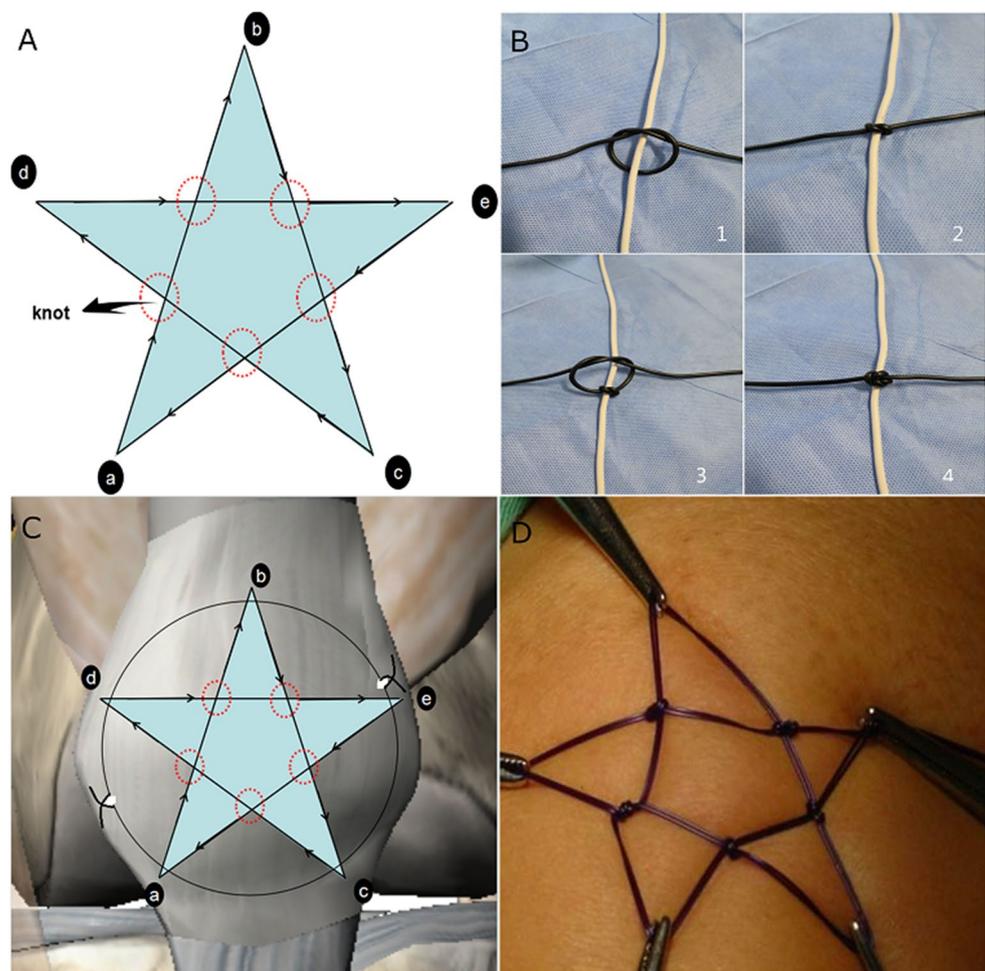
Methods

This clinical study was carried out at Jiangxi Provincial People's Hospital, Nanchang, China. Informed consent has been obtained from all the patients before the procedure. This study was approved by the Ethics Committee of Jiangxi Provincial People's Hospital. All study methods were in

accordance with the Declaration of Helsinki. Patients were included in this study if aged between 18 and 65 years and diagnosed with patella transverse fractures. A total of 25 cases diagnosed with patella transverse fractures were finally included in this study. Of the 25 cases, there were 9 males and 16 females. The age ranged from 21 to 65 years old (average 42.25 years). In eighteen cases injuries were caused by a tumble, and 7 cases were by road traffic accidents. All cases were unable to do active extension after injury, and fracture fragments were significantly displaced. It was about 5 h–7 days from injury to surgery.

The anterior transverse arc incision (convex to the distal) was used to expose the fractured patella. We cleaned the blood clot, reduced the fractures, and fixed the fracture mass temporarily with towel forceps. We located the sutures on the surface of knee, and five points were marked with an aseptic marker pen, according to the size of the patella. A five-pointed star lattice was weaved with double NO. 0-0 polydioxanone sutures (PDS) in vitro (Fig. 1d). Intraoperatively, five-pointed star lattice can be weaved before or after exposing the fractured patella. The aim was to make the suture lattice suitable for the patella. Diagrammatic sketch

Fig. 1 **a** Diagrammatic sketch showed PDS began from point a, to b, c, d, e and ended in point a. Square knot was marked with red circle. **b** When two lines came across, square knot was made with the later line. **c** Diagrammatic sketch showed five-pointed star lattice was put on the front surface of the patella, and two semi-circular sutures around the patella edge were made with NO. 2-0 ETHIBOND EXCEL sutures. Each ethibond suture was used to make half purse string suture around the patella and went through five points of the star lattice. **d** Intraoperative photograph showed the weaving procession of five-pointed star lattice



(Fig. 1a) showed PDS began from point a, to b, c, d, e and ended in point a. Vessel forceps was used to fix five points (Fig. 1d). When two lines came across, square knot was made with the later line (Fig. 1b). The tail sutures of the PDS were retained after made surgical knot.

Five-pointed star lattice was put on the front surface of the patella, and two semi-circular sutures around the patella edge were made with NO. 2-0 ETHIBOND EXCEL sutures (Fig. 1c). Each ethibond suture was used to make half purse string suture around the patella and went through five points of the star lattice. The ethibond suture was tightened and knotted when the knee joint flexed at 5°–10°. As a result, five-pointed star lattice was tightly clenched and pressed to the patella, forming a tension band fixation. The ethibond suture produced a centripetal uniform pressure on the patella and made the five-pointed star lattice tensioned which helped to produce a uniform pressure firmly on the patella. The remaining tail sutures of the PDS were also used to make half purse suture around the patella and went through five points of the star lattice. Then we tightened and knotted the remaining tail sutures, forming one more fixation of the patella. By transforming tension into pressure, five-pointed star lattice sutures formed tension band fixation and prevented the patella fracture opening.

Here, we concluded some experience from the procedure. PDS II suture is absorbable and can provide wound support for approximately 60 days. ETHIBOND EXCEL suture is a non-absorbable, braided, sterile surgical suture composed of Poly (ethylene terephthalate). The PDS suture has a good expansion characteristic, and when it reaches the maximum pulling force, it is 3 times as long as the original one. Therefore, the five-pointed star lattice should be smaller than the patella during the operation in diameter. However, the five-pointed star lattice should not too small; its five points would be located in the front of the patella when it is tightened. The ethibond suture would also be at the anterior patella border and reduce the extrusion pressure of the patella. As there was no reference about the specific ratio, we generally made the five-pointed star lattice less about 3–4 mm than patella in the diameter, in order to reach patella diameter when PDS suture stretched. The position of the five points of the five-pointed star lattice can be adjusted according to the fracture position of the patella. If there were small displaced fracture fragments, complement sutures can be used between grids and grids, or between grids and the ethibond suture to strengthen network density, in order to ensure the fixation stability.

After the operation, the knee should be pressure dressing to reduce the effusion and adhesion of the joint cavity with thick cotton pads. An approximately 20-cm plaster was used to fix the knee behind it to prevent the knee flexing. On the first day after surgery, the patients were instructed to perform isometric contractions of the musculi quadriceps

femoris. On the third day after surgery, the patients were encouraged to stand and walk on the ground without walking sticks to make the knee joint move slightly, which help to make the patellofemoral joint to fit. After post-operative 2 weeks, the sutures on the surface of skin were removed as well as the plaster. The patients were instructed to gradually practise knee flexion and extension actively and walk without walking sticks. The patients were followed up regularly until union of the fractures or until further surgical intervention was performed. The notes and X-rays of them were carefully preserved and reviewed. Bostman score (Table 1, [14]) was used to evaluated the therapeutic effects.

Results

All of 25 cases were followed up with a mean of 1.6 years (range 0.8–2.5 years), and all cases got patella fractures union. No complications like infection, dislocation, or breakage of implants were observed post-operatively during the whole follow-up periods. Meanwhile, Bostman score [14] indicated that the post-operative knee function was excellent in 19 patients and good in six patients. A typical case is shown in Fig. 2.

Discussion

A few biomechanical studies have studied different fixation techniques for patella fractures [1, 15, 16], of which the modified tension band wiring technique is the most commonly used method for almost all fracture types [2]. Cannulated screws combined with anterior tension wiring have become a common alternative, because it was certified to provide higher load-bearing capacity and greater stability [17]. Metal implants may be associated with hardware migration, post-operative discomfort, and re-operation for removing the implants [18]. Other fixation materials, like titanium–nickel shape-memory alloy (Ti-Ni SMA) fixation, may produce good osteosynthesis effect [19], but some patients complained of anterior patella discomfort sense, and Ti-Ni SMA is more expensive and requires second operation to remove the implant.

Patel et al. [4] conducted a biomechanical study with the longitudinal anterior band (Lotke) technique and demonstrated that the quality of fixation for braided polyester suture for displaced transverse patella fractures was comparable to stainless steel wire. Gosal et al. [20] presented clinical outcomes of patellar fracture fixation using metal wire and non-absorbable polyester (5 Ethibond), which indicated non-absorbable polyester appears to compare favourably with the use of metallic wire to fix patellar fractures. The relative risk of re-operation in the metal group is six times

Table 1 Bostman clinical grading scale [14]

Variable	Points (maximal 30)
Range of motion	
Full extension and range of motion (ROM) > 120° or within 10° of normal side	6
Full extension, ROM 90°–120°	3
Unable to full extension, ROM < 90°	0
Pain	
None or minimal on exertion	6
Moderate on exertion	3
In daily activities	0
Work	
Original job	4
Different job	2
Cannot work	0
Atrophy, difference of circumference of thighs 10 cm proximal to the patella	
< 12 mm	4
12–25 mm	2
> 25 mm	0
Ambulation assistance	
None	4
Walking stick part time	2
Walking stick all time	0
Effusion	
None	2
Reported to be present	1
Present	0
Giving way	
No	2
Sometimes	1
In daily life	0
Stairclimbing	
Normal	2
Disturbing	1
Disabling	0

Total score results: 30–28 points, excellent; 27–20 points, good; < 20 points, unsatisfactory [14]

than that in the non-absorbable polyester group, and the risk of infection in the metal group is also higher [20]. Wright et al. [21] performed materials testing on 18-gauge stainless steel wire and repeated samples of No. 5 FiberWire suture and then used for tension band fixation on a novel transverse patellar fracture model, which demonstrated FiberWire is a potentially superior alternative to stainless steel wire in tension band fixation of transverse patella fractures. Camarda et al. [22] systematically reviewed literature and concluded

that non-metallic fixation treating patella fracture had a 90% success rate and a 10% failure rate. Non-metallic fixation has its advantages, including reducing re-operation rate and post-operative pain. Therefore, non-metallic fixation is useful but needed to be improved.

We newly designed five-pointed star lattice sutures in fixing patella fractures with NO. 2-0 ETHIBOND EXCEL suture and NO. 0-0 polydioxanone sutures. In our clinical study, all cases got patella fractures union, and there were no complications like infection, dislocation, or breakage of implants during the whole follow-up periods. Some surgeons may question that will the absorbable PDS fail through time? As we know, bio-absorbable or biodegradable materials have been used for the fixation of displaced patella fractures and have produced good clinical outcomes [23]. Only one operation is needed in using biodegradable implants, for they do not require removal. Besides, all cases got bony union in this study. Furthermore, Bostman score indicated that the post-operative knee function was excellent in 19 patients and good in 6 patients. As a result, it shows that the newly designed five-pointed star lattice sutures fixation may be a feasible alternative to metal implants fixation for treatment of patella transverse fractures.

Theoretically, the five-pointed star lattice sutures fixation can be suitable for other types of patella fractures; however, it is needed to be affirmed with more clinical studies. Compared to the most commonly used modified tension band wiring fixation [2], we feel that the five-pointed star lattice sutures fixation is simpler and may reduce operation time. More importantly, it has no local tissue irritations and free need of re-operation for removing internal fixation.

Our study also has some limitations. First, it needs more cases to verify the five-pointed star lattice sutures fixation of patella fractures, and it had better comparison with other fixation methods of patella fractures. Second, it is the first reported fixation with this method, and many procedures and measures before or after the surgery were conducted just according to our clinical experiences, and there is no literature to support.

Compared to traditional metal implants in the treatment of patella transverse fractures, the newly designed five-pointed star lattice sutures fixation can also produce good clinical outcomes. It does not require re-operation for removing internal fixation. Our study suggested the newly designed five-pointed star lattice sutures fixation may be a feasible alternative to metal implants fixation in the management of patella transverse fracture, and it requires further research to determine whether the newly designed five-pointed star lattice sutures fixation is suitable for other kinds of patella fractures.

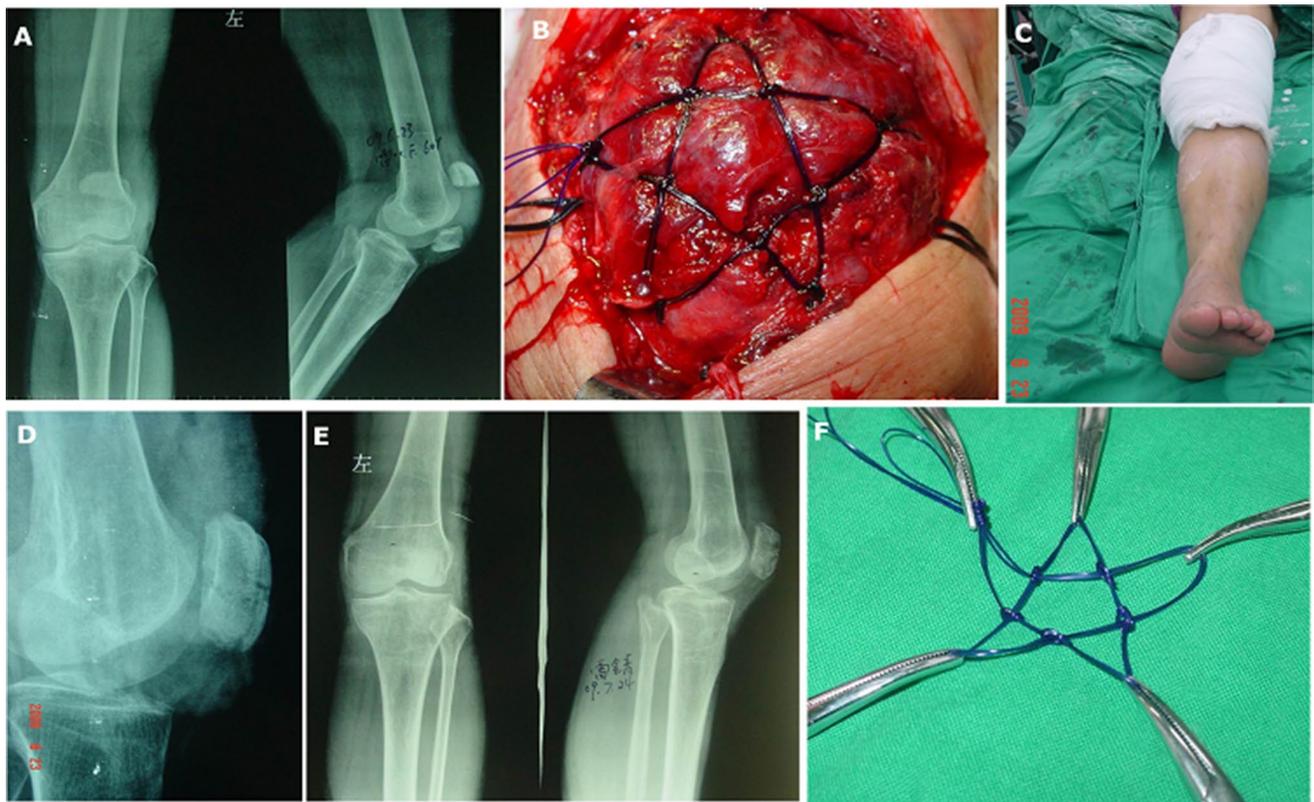


Fig. 2 A 35-year-old man was diagnosed with left patella transverse fracture. **a** Preoperative plain radiographs of knee showed displaced transverse patella fractures. **b** Intraoperative photograph showed five-pointed star lattice sutures fixation for patella transverse fractures. **c** A 20-cm plaster was used to fix the knee behind it to prevent the

knee flexing. **d** X-ray image on the operation day showing the fractures were reduced well. **e** X-ray image at 4 weeks after the operation showing the fracture line disappeared. **f** Intraoperative photograph showed the weaving procession of five-pointed star lattice in this case

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with Review Board of Jiangxi Provincial People's Hospital and with the 1964 Helsinki Declaration and its later amendments. All procedures performed with animals were in accordance with the ethical standards of Jiangxi Provincial People's Hospital on the Use and Care of Animals.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

- Weber MJ, Janecki CJ, McLeod P, Nelson CL, Thompson JA, Weber MJ, Janecki CJ, McLeod P, CFAU-Nelson CCL, Nelson CL (1980) Efficacy of various forms of fixation of transverse fractures of the patella. *J Bone Joint Surg Am* 62:215–220. <https://doi.org/10.2106/00004623-198062020-00007>
- Camarda L, Morello S, Balistreri F, D'Arienzo A, D'Arienzo M (2016) Non-metallic implant for patellar fracture fixation: a systematic review. *Injury* 47(8):1613–1617. <https://doi.org/10.1016/j.injury.2016.05.039>
- Meinberg E, Agel J, Kellam JF, Roberts CS (2017) The fracture and dislocation classification compendium 2017—"nearing the finish line". *Injury* 48(4):793–794. <https://doi.org/10.1097/00005131-200711101-00020>
- Gosal HS, Singh P, Field RE (2001) Clinical experience of patellar fracture fixation using metal wire or non-absorbable polyester—a study of 37 cases. *Injury* 32:129–135. [https://doi.org/10.1016/S0020-1383\(00\)00170-4](https://doi.org/10.1016/S0020-1383(00)00170-4)
- Lefavre KA, O'Brien PJ, Broekhuysse HM, Guy P, Blachut PA (2010) Modified tension band technique for patella fractures. *Orthop Traumatol Surg Res* 96:579–582. <https://doi.org/10.1016/j.otsr.2010.01.014>
- Eggink KM, Jaarsma RL (2011) Mid-term (2–8 years) follow-up of open reduction and internal fixation of patella fractures: does the surgical technique influence the outcome? *Arch Orthop Trauma Surg* 131(3):399–404. <https://doi.org/10.1007/s00402-010-1213-1>
- Gwinner C, Märdian S, Schwabe P, Schaser KD, Krapohl BD, Jung TM (2016) Current concepts review: fractures of the patella. *GMS Interdiscip Plast Reconstr Surg DGPW* 5:Doc01. <https://doi.org/10.3205/iprs000080>
- Choi HR, Min KD, Choi SW, Lee BI (2008) Migration to the popliteal fossa of broken wires from a fixed

- patellar fracture. *Knee* 15(6):491–493. <https://doi.org/10.1016/j.knee.2008.06.005>
9. Berg EE (1997) Open reduction internal fixation of displaced transverse patella fractures with figure-eight wiring through parallel cannulated compression screws. *J Orthop Trauma* 11(8):573–576. <https://doi.org/10.1097/00005131-199711000-00005>
 10. Yotsumoto T, Nishikawa U, Ryoke K, Nozaki K, Uchio Y (2009) Tension band fixation for treatment of patellar fracture: novel technique using a braided polyblend sutures and ring pins. *Injury* 40(7):713–717. <https://doi.org/10.1016/j.injury.2008.10.032>
 11. Wu CC, Tai CL, Chen WJ (2001) Patellar tension band wiring: a revised technique. *Arch Orthop Trauma Surg* 121(1–2):12–16. <https://doi.org/10.1007/s004020000183>
 12. Chen CH, Huang HY, Wu T, Lin J (2013) Transosseous suturing of patellar fractures with braided polyester—a prospective cohort with a matched historical control study. *Injury* 44(10):1309–1313. <https://doi.org/10.1016/j.injury.2013.06.024>
 13. Qi L, Chang C, Xin T, Xing PF, Tianfu Y, Gang Z (2011) Double fixation of displaced patella fractures using bioabsorbable cannulated lag screws and braided polyester suture tension bands. *Injury* 42(10):1116–1120. <https://doi.org/10.1016/j.injury.2011.01.025>
 14. Böstman O, Kiviluoto O, Nirhamo J (1981) Comminuted displaced fractures of the patella. *Injury* 13(3):196–202. [https://doi.org/10.1016/0020-1383\(81\)90238-2](https://doi.org/10.1016/0020-1383(81)90238-2)
 15. Kakazu R, Archdeacon MT (2016) Surgical management of patellar fractures. *Orthop Clin North Am* 47(1):77–83. <https://doi.org/10.1016/j.joc.2015.08.010>
 16. Scilaris TA, Grantham JL, Prayson MJ, Marshall MP, Hamilton JJ, Williams JL (1998) Biomechanical comparison of fixation methods in transverse patella fractures. *J Orthop Trauma* 12(5):356–359. <https://doi.org/10.1097/00005131-199806000-00011>
 17. Benjamin J, Bried J, Dohm M, McMurtry M (1987) Biomechanical evaluation of various forms of fixation of transverse patellar fractures. *J Orthop Trauma* 1(3):219–222. <https://doi.org/10.1097/00005131-198701030-00004>
 18. Baran O, Manisali M, Cecen B (2009) Anatomical and biomechanical evaluation of the tension band technique in patellar fractures. *Int Orthop* 33(4):1113–1117. <https://doi.org/10.1007/s00264-008-0602-3>
 19. Hao W, Zhou L, Sun Y, Shi P, Liu H, Wang X (2015) Treatment of patella fracture by claw-like shape memory alloy. *Arch Orthop Trauma Surg* 135(7):943–951. <https://doi.org/10.1007/s00402-015-2241-7>
 20. Wright PB, Kosmopoulos V, Coté RE, Tayag TJ, Nana AD (2009) FiberWire is superior in strength to stainless steel wire for tension band fixation of transverse patellar fractures. *Injury* 40:1200–1203
 21. Patel VR, Parks BG, Wang Y, Ebert FR, Jinnah RH (2000) Fixation of patella fractures with braided polyester suture: a biomechanical study. *Injury* 31(1):1–6
 22. Camarda L, Morello S, Balistreri F, D’Arienzo A, D’Arienzo M (2016) Non-metallic implant for patellar fracture fixation: a systematic review. *Injury* 47:1613–1617. <https://doi.org/10.1016/j.injury.2016.05.039>
 23. Heusinkveld MH, den Hamer A, Traa WA, Oomen PJ, Maffulli N (2013) Treatment of transverse patellar fractures: a comparison between metallic and non-metallic implants. *Br Med Bull* 107:69–85. <https://doi.org/10.1093/bmb/ldt013>