Treatment of Patellar Fracture With Kirschner Wire Tension Band With Absorbable Sutures

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Abstract

Study design

Retrospective cohort study

Objective

Tension band wiring is considered the standard treatment for patella fractures. However, it is limited for fractures with marginal involvement, comminution, and osteoporotic bone. Our experience indicates that these limitations can be overcome with the technique of Kirschner wire combined with absorbable suture. We evaluated the radiographic and clinical outcomes in patients with patella fracture treated with this new technology.

Methods

We enrolled 32 patients who underwent the new technology for patella fracture at our hospital between 2018 and 2019. Fracture classification and surgical options were reviewed. Numerical Rating Scale (NRS), Levack score system, WOMAC test form of pain, stiffness and function, and knee joint range of motion (ROM) were applied for functional evaluation.

Results

32 patients were followed up for an average follow-up time of 13 months (11 to 24 months). All fractures were unioned, no wound infection, Kirschner wire exposure and second displacement of fracture fragment was found. None of the patients had knee stiffness, and the range of motion of the knee was 125.6° (110-135). The average NRS for knee pain was 7.5 (6-9) preinjury and 0.5 (0-2) at the last follow-up. Knee joint function recovered well, excellent and good rate was 93.75% (30/32). The average Levack score was 10.0 (6-12), which included twenty evaluations of “excellent” and twelve of “good”. WOMAC averaged 22.5 (14 - 38).

Conclusion

The combination of Kirschner wire and absorbable suture for patella fractures is simple and clinically satisfactory, restores knee function well, and is a worthy orthopedic method.

Introduction

Patellar fracture is relatively common, the incidence of 0.5% - 1.5%[1]. The surgical treatment of patella fractures mainly includes traditional and modified tension bands, hollow screw titanium cables, plate fixation and other surgical methods [2] [3]. Among these methods, the Kirschner wire tension band fixation method is simple and reliable, and it is still the most commonly used method for the treatment of patella fractures[3-5] . However, the Kirschner wire tension band technique also has many complications, such as
the loosening of the Kirschner wire, the interference of the wire on the soft tissue, and the displacement of the fracture end, especially the comminuted patella fracture or the osteoporotic patella fracture. The above risks are higher. And it is prone to serious consequences such as failure of internal fixation and nonunion of fractures [6-8]. In view of the limitations of traditional tension band technology, we use Kirschner wire combined with absorbable suture tension band technology to treat patella fractures. This surgical method is simple to operate and reliable, especially suitable for comminuted patella fractures. This study aims to evaluate the clinical effect of Kirschner wire combined with absorbable suture tension band technology in the treatment of patella fractures.

Data And Methods

This was a retrospective observational cohort study, and the present study was approved by the institutional review board. The medical records and radiographs of patients who presented with patella fracture from January 2018 to December 2019 in our institution was reviewed. The inclusion criteria were as follows: patella fracture, surgical treatment with Kirschner wire combined with absorbable suture tension band technology, and patient age 18 years. The exclusion criteria were patients with less than 11 months of follow-up and periprosthetic fracture. Out of the initial 78 patella fractures that were screened during the period, 32 patients (17 male and 15 female) were included in this study with an average age of 58.6 (range, 19-84) years. The average follow up was 13.0 (range, 11-24) months.

The X-ray or CT imaging results of all patients before and after the operation were collected, and the preoperative X-ray or CT results were classified according to the AO/OTA standard. Collect and record all postoperative clinical data and complications. Numerical Rating Scale (NRS) score, Levack score system, WOMAC test form of pain, stiffness and function, and knee joint range of motion (ROM) were applied for functional evaluation.

Surgical technique (Fig. 1, 2)

The patient was placed in the supine position, continued epidural anesthesia, a thigh tourniquet was applied and inflated to 350mmHg, and the anterior median longitudinal incision approach of patella was selected. The periosteum and aponeurosis of the innermost layer were not cut along the incision, and the tissue was removed to both sides to expose the extension of the supporting zone. If the expansion part is broken, the patella fracture site can be explored from the fracture site. If the expansion part is complete, the longitudinal small incision can be made for exposure exploration according to the fracture site needed to be explored. First, the patellar fracture was reduced under direct vision, and the patellar fracture was temporarily fixed and stabilized with the point reduction forceps. For the fractures that could not be temporarily fixed and stabilized, the prepatellar fascia could be repaired with the No. 1 absorbable line (PGA, 2000127, shanghai, China) (Fig. 2, c-A). After fracture reduction was confirmed by C-arm fluoroscopy machine (Siemens, Germany), Kirschner wire (φ2mm) was used to fix the fracture block perpendicular to the fracture line as far as possible according to the position of the bone block, and the Kirschner wire passed through the contralateral cortical surface of the bone (Fig. 2, d). It is easier to bend
the upper end of Kirschner wire by using stainless steel suction tube or hollow sleeve with diameter of 3-4mm (Fig. 2, e-B). Then pull the Kirschner wire down to make as much contact as possible with the bone surface. Then bend the lower end of the Kirschner wire in the same way. The position and length of the Kirschner wire were determined by C-arm fluoroscopy machine, and the effect of fracture reduction and fixation was confirmed (Fig. 2, h). The excess Kirschner wires were cut off, the tail was reserved for about 5mm, and rotated inward 45° to avoid the stimulation of soft tissue by the stump of the Kirschner wires (Fig. 2, f). Second, The No. 1 absorbable suture line (PGA, 2000127, shanghai, China) was used to perform continuous suture along the dilated quadriceps femoris (Fig. 2, C/D). The starting point was the intersection of the upper edge of patella about 5mm upward and the tangent of the lateral edge of the quadriceps femoris tendon (Fig. 1 A/B), and the end point of the intersection of the lower edge of patella about 5mm downward and the tangent of the lateral edge of the patellar ligament (Fig. 1 C/D). Arc suture was performed along the starting and ending points, and the back and forth suture was performed once each. The medial and lateral suture methods of dilatation are the same. Third, knee flexion and extension test (Fig. 2, g). The knee joint was passively extended and flexion test to check no loosening or fracture of sutures. The position of Kirschner wire was determined by C-arm fluoroscopy machine again (Fig. 2, i/j), and the effect of fracture reduction and fixation was confirmed. After irrigation and hemostasis, suture layer by layer.

Postoperative management

There was no use of hinged knee brace or other external fixation. The isometric contraction exercise of quadriceps femoris muscle was allowed one-day post-operation (Fig. 3, a). The second day after surgery (Fig. 3, b), the knee joint flexion and extension exercises were performed with the assistance of continuous passive motion (CPM). On the third day after the operation, the patients were encouraged to get out of bed and walk on crutches (Fig. 3, c). Two weeks after the operation, the active function exercise of the knee joint was strengthened (Fig. 3, d). About 4 weeks postoperatively, vigorous active flexion and extension movements can be performed without the aid of instruments (Fig. 3, e).

Results

A total of 32 patients with patellar fracture were screened and included in the study. All cases were closed fracture and were treated by Kirschner wire combined with absorbable suture technology. The baseline characteristics of all patients were shown in Table 1.

The clinical outcomes were shown in Table 2. All patients had fracture unioned. There was no wound infection, Kirschner Wire exposure and second displacement of fracture fragmen. Kirschner wire loosening happened in two case at six months post-operation. None of the patients had knee stiffness, and the range of motion of the knee was 125.6° (110 - 135). The average NRS score for knee pain was 7.5 (6-9) preinjury and 0.5 (0-2) at the last follow-up. Knee joint function recovered well, excellent and good rate was 93.75% (30/32). The average Levack score was 10.0 (6-12), which included twenty evaluations of “excellent” and twelve of “good”. WOMAC averaged 22.5 (14 - 38).
Discussion

Patellar articular surface displacement of more than 2mm or comminuted patellar fractures require surgical treatment. The purpose of surgery is to restore the patellar articular surface flatness, early recovery of knee movement and rapid recovery [9]. There are many surgical methods to treat patella fracture, including TBW, braided polyester suture[10], interfragmentary screw fixation[11], staple technique with tension band wiring[12], titanium-mesh[6], tightrope fixation[13], and cannulated screws[3]. Techniques of internal fixation using stainless steel wire, such as the modified tension band method, are widely used. However, symptoms and complications related to the stainless steel wire are not uncommon after this technique[5]. The incidence of complications related to wire loops was 47%; furthermore, 1/4 had associated symptoms and required wire removal[9].

In recent years, the treatment of patella fractures with non-metallic internal fixation materials has attracted more and more attention from clinical researchers. Current studies have shown that non-metallic materials are used to treat olecranon fractures, proximal humeral fractures, and Achilles tendon ruptures, and have achieved good therapeutic effects[14-17]. Researchers have found that non-metallic materials have a significantly reduced repulsion response to the human body, and have less irritation to surrounding soft tissues. More importantly, studies have confirmed that there is no significant difference in mechanical properties between non-metallic materials and metal internal fixation materials[10]. For patella fractures, studies have also shown that non-metallic internal fixation materials can also achieve good therapeutic effects, but there are many limitations in indications, and external fixation devices such as plasters and braces are required for postoperative fixation [18, 19]. The traditional and classic Kirschner wire tension band technique for the treatment of patella fractures, because it conforms to the mechanical properties of the patellofemoral joint, early knee joint functional exercises can be performed, but the wire tension band stimulates the surrounding soft tissues, and there is a risk of wire breakage[6, 20]. However, there is no relevant research on the use of non-metallic materials instead of steel wire and ordinary Kirschner wire as a tension band system for the treatment of patella fractures.

Through this study, we found that the use of absorbable sutures combined with Kirschner wires to treat patella fractures can achieve a good therapeutic effect. First, this technique can be well applied to various types of patella fractures. During the operation, the number of Kirschner wires and the direction of the Kirschner wires can be increased to achieve firm fixation. Moreover, studies have confirmed that for patellar fractures, the mechanical properties of Kirschner wire cross fixation are similar to that of parallel fixation, and there is no significant difference in fracture end displacement [21]. For severe comminuted fractures, compression fixation of the fracture fragment can be performed from the periphery by means of an absorbable suture hemlock. Second, this technique can not only play the role of Kirschner wire tension band, but also reduce the stimulation of steel wire tension band to the surrounding soft tissue, with fewer postoperative complications. Third, the technology is firmly fixed and can achieve rapid recovery to the greatest extent. In this study, all patients did not need to place drainage tubes after surgery, and immediately performed knee flexion and extension exercises with continuous passive motion (CPM) and assistance on the first day after surgery. The patients were guided to walk on the ground
within 1 week after surgery without the assistance of crutches or braces, and basically returned to normal walking 4 weeks after surgery. Fourthly, there were few postoperative complications with this technique. Only 2 patients (2/32) had Kirschner wire loosening within 6 months after surgery, but the fracture was completely healed and the Kirschner wire was removed in advance.

In this study, absorbable sutures were used instead of traditional steel wires, which significantly reduced the complications caused by irritation and fracture of steel wires. Studies have confirmed that the strength of absorbable sutures can replace steel wire and Kirschner wire to form a tension band system [10]. In this study, we also improved the suture method of absorbable sutures. The absorbable suture is further strengthened by an arc suture along both sides of the patella using a hemlock suture, and the suture is repeated twice. During the operation, attention should be paid to the selection of the starting and ending points of the arc suture on both sides. It is suggested that the intersection point of the horizontal line of about 5mm upward of the upper edge of the patella and the tangent line of the lateral edge of the quadriceps femoris tendon should be the starting point, and the intersection point of the horizontal line of about 5mm downward of the lower edge of the patella and the tangent line of the lateral edge of the patellar ligament should be the end point. Of course, the starting and ending points can be interchanged. If intraoperative rupture or tear of prepatellar fascia is found, absorbable sutures can also be used for repair. It is recommended to repair before the implantation of the Kirschner wire, because this can make the position of the crushed fracture block relatively stable and facilitate the implantation of the Kirschner wire.

In this technique, ordinary Kirschner wires are still used. The diameter of the Kirschner wires is selected according to the patient's physical condition. Generally, the diameter of the Kirschner wires is 2.0 or 2.5mm. During the operation, the patella can be temporarily fixed with point-like reduction forceps, and then the prepatellar fascia can be repaired. Finally, two parallel Kirschner wires can be inserted longitudinally perpendicular to the fracture line. If there are more fractures, a third Kirschner wire can also be inserted horizontally perpendicular to the direction of fracture line. Both ends of the Kirschner wire are bent and cut off about 5mm from the tail end. The hollow stainless sleeve (such as suction tube or hollow screw driver) with a diameter of 3-4mm is recommended to bend the Kirschner wire so that it is bent as close to the bone surface as possible.

Of course, there are also shortcomings in this study, such as a small sample size, no comparative study with other internal fixation techniques for patella fractures, and whether different specifications of absorbable sutures have an impact on the fixation effect. In addition, this technology still needs to be further proved in theoretical research. These are also the directions we will focus on in the next step.

Conclusions

In general, the Kirschner wire tension band with absorbable sutures can effectively fix various types of patellar fractures, and can avoid the common loosening of internal fixation and pain caused by internal
fixation. It is a reliable clinical fixation method. In addition, the Kirschner wire tension band fixation technique with absorbable sutures may also be considered in other fracture sites.

**Abbreviations**

CPM: continuous passive motion, NRS: Numerical Rating Scale, ROM: range of motion.

**Declarations**

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Not applicable.

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No funding was obtained for this study.

**Availability of data and materials**

Not applicable.

**Ethics approval and consent to participate**

This study was performed following the Declaration of Helsinki principles and was conducted according to the National Ethic Guidelines Statement. Informed consent to participate was obtained from all participants.

**Consent for publication**

Not applicable.

**Conflict of interest**

The authors declare that they have no conflict of interest.

**References**

1. Lotke, P. and M. Ecker, *Transverse fractures of the patella*. Clinical orthopaedics and related research, 1981(158): p. 180-4.

2. Schuett, D., M. Hake, C. Mauffrey, E. Hammerberg, P. Stahel, and D. Hak, *Current Treatment Strategies for Patella Fractures*. Orthopedics, 2015. 38(6): p. 377-84.

3. Zderic, I., K. Stoffel, C. Sommer, D. Höntzsch, and B. Gueorguiev, *Biomechanical evaluation of the tension band wiring principle. A comparison between two different techniques for transverse patella fracture fixation*. Injury, 2017. 48(8): p. 1749-57.
4. Bartoníček, J. and S. Rammelt, *Early history of operative treatment of patellar fractures*. International orthopaedics, 2015. 39(11): p. 2303-8.

5. Hung, L.K., K.M. Chan, Y.N. Chow, and P.C. Leung, *Fractured patella: operative treatment using the tension band principle*. Injury, 1985. 16(5): p. 343-7.

6. Dickens, A., C. Salas, L. Rise, C. Murray-Krezan, M. Taha, T. DeCoster, et al., *Titanium mesh as a low-profile alternative for tension-band augmentation in patella fracture fixation: A biomechanical study*. Injury, 2015. 46(6): p. 1001-6.

7. Smith, S., K. Cramer, D. Karges, J. Watson, and B. Moed, *Early complications in the operative treatment of patella fractures*. Journal of orthopaedic trauma, 1997. 11(3): p. 183-7.

8. Matthews, B., K. Hazratwala, and S. Barroso-Rosa, *Comminuted Patella Fracture in Elderly Patients: A Systematic Review and Case Report*. Geriatric orthopaedic surgery & rehabilitation, 2017. 8(3): p. 135-144.

9. Carpenter, J., R. Kasman, and L. Matthews, *Fractures of the patella*. Instructional course lectures, 1994. 43: p. 97-108.

10. Patel, V., B. Parks, Y. Wang, F. Ebert, and R. Jinnah, *Fixation of patella fractures with braided polyester suture: a biomechanical study*. Injury, 2000. 31(1): p. 1-6.

11. Dargel, J., S. Gick, K. Mader, J. Koebke, and D. Pennig, *Biomechanical comparison of tension band- and interfragmentary screw fixation with a new implant in transverse patella fractures*. Injury, 2010. 41(2): p. 156-60.

12. Schnabel, B., M. Scharf, K. Schwieger, M. Windolf, B. Pol, V. Braunstein, et al., *Biomechanical comparison of a new staple technique with tension band wiring for transverse patella fractures*. Clinical biomechanics (Bristol, Avon), 2009. 24(10): p. 855-9.

13. Han, F., C. Pearce, D. Ng, A. Ramruttun, D. Chong, D. Murphy, et al., *A double button adjustable loop device is biomechanically equivalent to tension band wire in the fixation of transverse patellar fractures-A cadaveric study*. Injury, 2017. 48(2): p. 270-76.

14. Peeters, I., A. Depover, A. Van Tongel, and L. De Wilde, *A review of metallic and non-metallic cerclage in orthopaedic surgery: Is there still a place for metallic cerclage?* Injury, 2019. 50(10): p. 1627-33.

15. Ren, G., Z. Zhang, P. Han, T. Chen, P. Li, and X. Wei, *[Meta-analysis of clinical effects between non-metallic materials and metallic materials by internal fixation for patellar fracture]*. Zhongguo gu shang = China journal of orthopaedics and traumatology, 2018. 31(10): p. 927-32.

16. Camarda, L., S. Morello, F. Balistreri, A. D’Arienzo, and M. D’Arienzo, *Non-metallic implant for patellar fracture fixation: A systematic review*. Injury, 2016. 47(8): p. 1613-7.

17. Traa, W., P. Oomen, A. den Hamer, M. Heusinkveld, and N. Maffulli, *Biomechanical studies on transverse olecranon and patellar fractures: a systematic review with the development of a new scoring method*. British medical bulletin, 2013. 108: p. 131-57.

18. Kim, K.-S., D.-W. Suh, S.-E. Park, J.-H. Ji, Y.-H. Han, and J.-H. Kim, *Suture anchor fixation of comminuted inferior pole patella fracture-novel technique: suture bridge anchor fixation technique*. Archives of Orthopaedic and Trauma Surgery, 2020. 3(6): p. 71-5.
19. Dong, Z., F. Liu, Y. Pan, S. Wu, and C. Luo, *Clinical analysis of an anchor nail combined with a titanium cable in the treatment of lower patella fractures*. The Journal of international medical research, 2020. 48(4): p. 1-8.

20. Matthews, B., K. Hazratwala, and S. Barroso-Rosa, *Comminuted Patella Fracture in Elderly Patients: A Systematic Review and Case Report*. Geriatric orthopaedic surgery & rehabilitation, 2017. 8(3): p. 135-44.

21. Lenihan, J., S. Ramos-Pascual, P. Silvestros, P. Beak, A. Miles, and A. Trompeter, *Novel techniques demonstrate superior fixation of simple transverse patella fractures - A biomechanical study*. Injury, 2020. 51(6): p. 1288-93.

Tables

Tables 1 and 2 are not available with this version.

Figures
Figure 1

Schematic diagram of operation. A/B. Absorbable suture starting point. C/D. Absorbable suture ending point.
Figure 2

Surgical procedure. a. Three-dimensional reconstruction computed tomography image. b. Clear the clot. c. Repair the prepatellar fascia. d. Kirschner wire implantation. e. Bend the Kirschner wire. f. Continuously suture along the quadriceps dilation. I, j. Intraoperative C-arm fluoroscopy.

Figure 3

Postoperative rehabilitation. a. Knee flexion and extension exercises in bed. b. The knee joint exercises was performed with the assistance of CPM. c. The patient got out of bed and walked. d. Two weeks after
surgery, the suture was removed and the knee joint was strengthened. e. The knee flexion and extension function of the patient returned to normal 4 weeks after operation.

**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.

- Case1Surgicalvideo1.mp4
- Case1Surgicalvideo2.mp4
- Case2Surgicalvideo1.mp4
- Case2Surgicalvideo2.mp4
- Day7aftersurgery.mp4
- Thefirstdayaftersurgery.mp4
- Theseconddayaftersurgery.mp4
- Thethirddayaftersurgery.mp4
- case2Surgicalprocedure.tif