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"Tension band wiring first"—an easy, fast and reproducible technique to reduce patellar fractures, a retrospective comparative study with traditional reduction technique

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Abstract

Objective To evaluate intraoperative and early postoperative clinical outcomes using the "tension band wiring first technique" to reduce C type patellar fractures.

Methods Sixty-four patients with C type fractures were enrolled in this study. Thirty-four patients underwent open reduction and internal fixation (ORIF) surgeries using the traditional reduction technique by pointed clamps (TRT group). The other thirty patients received the patellar fracture reduction using the "Tension band wiring first technique" (TBWFT group). All patellar fractures were treated with a cable tension band and a cerclage cable. The duration of intraoperative procedure and X-ray exposure times were recorded. All patients were followed up at 1, 3, 6, and 12 months. Bone union time was recorded. The articular surface steps of the patellas were measured. After surgery, range of motion (ROM) of the knee, and complications were evaluated, and patellar function was evaluated using the Lysholm knee scores and Böstman scores.

Results When compared to TRT group, the "Tension band wiring first technique" significantly reduced the intraoperative time and X-ray exposure times and tended to reduce the articular surface steps, though without statistical significance. In the two groups, there was no significant difference in bone union time, ROM, complications and patellar function.

Conclusion The utilization of "Tension band wiring first technique" proved to be a straightforward, expeditious, and reproducible technique for reducing patellar fracture in comparison to the conventional reduction technique utilizing pointed clamps. Further studies are required to ensure the generalizability of these findings to additional patient populations at other institutions.

Keywords Patellar fractures, "Tension band wiring first technique", Articular reduction

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Introduction

The patella is the largest sesamoid bone in the body, and it is the key component of the knee extensor mechanism for quadriceps leverage [1]. Fractures of the patella account for approximately 1% of all skeletal fractures and can disrupt extensor function and damage the articular surface of the patellofemoral joint [2]. Consequently, patella fractures can lead to a variable of amounts of long-term extensor weakness, range of motion limitations, increased incidence of osteoarthritis, and chronic pain. According to modern theory and practice, operative treatment is recommended for displaced patellar fractures in order to restore the continuity of the extensor mechanism of the knee and to anatomically reduce the patellar articular surface [3].

In order to achieve an outstanding operative treatment, reduction is of paramount importance [4–6]. For patellar fractures, traditional reduction techniques depend on pointed clamps. This technique may be suitable and convenient for patellar fractures of type C1 and C2. However, it often requires multiple reduction attempts, which can result in time-consuming in comminuted patellar fractures or C3 type fractures, especially when without opening the articular surface [7]. As recommended by the AO foundation, the technique of tension band is the most common method for the fixation of patellar fractures. The tension band principle is capable of converting distractive forces into compressive forces during muscular contraction and weight-bearing [8, 9].We initially proposed that a tension band with a figure-of-eight sharpness that was perpendicular to the main fracture line be applied prior to fracture reduction (we have designated it as the "Tension band wiring first technique"). During the tightening process of the tension band, it reduced the distance between the fracture segments. Additionally, the patella was pulled up closely to the underneath of the tension band, thereby facilitating the reduction of the patellar articular surface indirectly.

Therefore, we aimed to compare the "Tension band wiring first technique" with the traditional reduction technique using pointed clamps in the ORIF of patellar fractures. We hypothesized that "Tension band wiring first technique" was an easy, efficient and precise technique to reduce patellar fractures. Furthermore, we also disclosed bone union time, knee function and post-operative complications.

Patients and methods.

This retrospective study was approved by the Ethics Committee of the Second Affiliated Hospital of Soochow University (approved number: 2020-H-161) and performed in compliance with the Helsinki Declaration. Informed written consent was obtained from all individual participants and is available from the corresponding author upon reasonable request.

A total of sixty-four patients who experienced AO/ATO C type patellar fracture from January 2021 to June 2023 were enrolled in this study. The patellar fracture segments of thirty-four patients were reduced by traditional technique using pointed clamps (TRT group) during the reduction process, the other thirty patients were treated by "Tension band wiring first technique"(TBWFT group) during the reduction process. All patellar fractures were ultimately fixed by cable tension band and cerclage cable.

The inclusion criteria were as follows: (1) A unilateral closed, displaced patellar fracture that involves the patellar articular surface with an articular step-off greater than 2 mm; fractures involving multiple fragments and/or a separation of the fragments of greater than 3 mm). (2) Over 18 years of age, with an almost normal knee joint function before fracture. The exclusion criteria were as follows: open fractures, multiple fractures, multiple traumas, peripheral neural damage, or mental disorders.

Surgical techniques.

All operations were conducted by Peng Jia. The patient was placed in supine position on a radiolucent table with a tourniquet on the proximal thigh. A longitudinal incision was made between the proximal and the distal border of the patella. The fracture site and condition of the bilateral aponeuroses and joint capsule were evaluated, and the intra-articular hematoma was removed. The articular cavity was rinsed. For some comminuted patellar fractures or some C3 type fractures, small fracture fragments needed reduction first and were fixed by 1.2–1.5 mm K-wires. The major fracture fragments of the patients in the TBWFT group were reduced by a figure-of-eight sharped tension band that was applied perpendicularly to the main fracture line and through the soft tissue, using 18-gauge stainless sternal steel wire. As the sternal steel wire was gradually tightened, patellar fracture fragments were pulled to the underneath of the wire and the articular surface of the patellar was reduced automatically. If there were multiple fracture fragments and one tension band could not reduce the remaining fragments, then another figure-of-eight sharped tension band could be applied until all the main fracture fragment got reduced (as shown in Fig. 1). When the lateral or medial retinaculum was injured, the reduction of the articular surface could be monitored and confirmed by placing the surgeon's finger through the opened medial or lateral patellar retinaculum and directly palpating the patella's undersurface. The congruity of the patellar articular surface was ultimately verified using an image intensifier. Once articular congruence was achieved, the knee was placed in 40° flexion and two parallel 2.0-mm

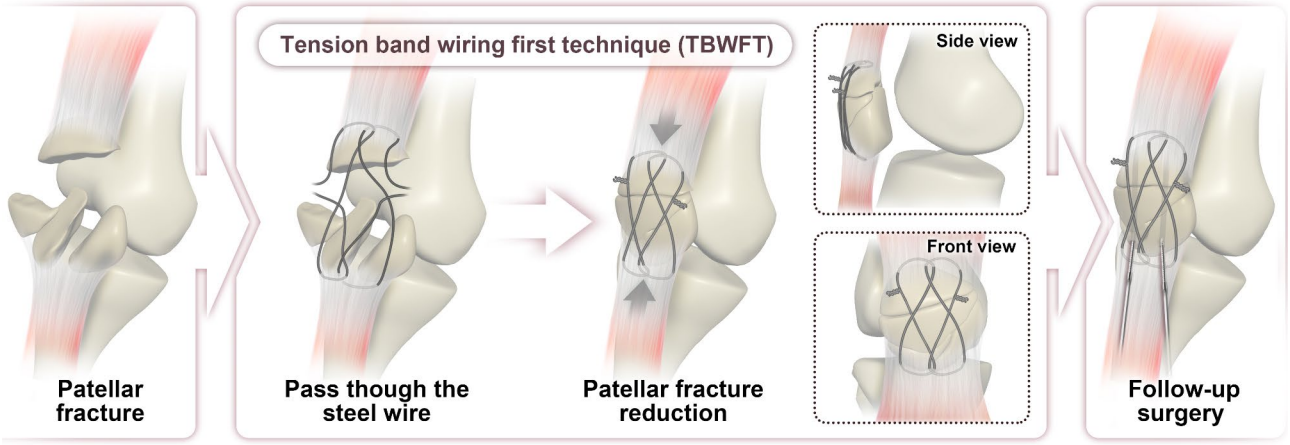

Fig. 1 Illustration of the application of the "Tension band wiring first technique" to reduce C type patellar fractures

K-wires were passed through fracture fragments in a distal-to-proximal direction. The fractures were checked under an image intensifier. After that, a 1.3 mm-diameter titanium cable (Zimmer, USA) was passed around the K-wires under the quadriceps tendon and patellar tendon to form a figure-of-eight loop, and the titanium cable was tightened to form the tension band. The titanium cable was then fixed by a corresponding crimp, and the excess titanium cable was cut off. Furthermore, cerclage titanium cable was used to enhance the fixation strength. In the end, the final operation results were checked by the image intensifier. For the patients in the TRT group, pointed clamps were utilized to reduce the major fracture fragments. Other operation steps were the similar to the TBWFT group.

Postoperative treatment.

Patients underwent postoperative antimicrobial prophylaxis for 24 h. The patient's knee was immobilized in a brace for a duration of 3 weeks. Functional exercises, encompassing static quadriceps exercises and straight leg raising were initiated on day one postoperatively. As tolerated, partial weight-bearing on crutches was initiated. Progressive knee joint flexion and extension were initiated three weeks postoperatively, performed three times daily with an adjustable brace. Within eight weeks, the injured knee should regain the same flexion-extension range as the healthy one.

Surgical time (min) was recorded routinely from the beginning of the skin incision to the closure of the wound. Intro-operative X-ray exposure times were also recorded. All patients underwent follow-up at 1, 3, 6 and 12 months and underwent X-ray examination to evaluate the healing progress. Bone union time was recorded. Fracture healing was defined as the absence of local pain or tenderness, walking without help, and evidence of trabecular bone across the fracture line. At the last follow-up, patellar articular surface steps were measured on the lateral radiographic view on the lateral radiographic view. ROM and complications were also noted during the last follow-up. The knee function was evaluated using Lysholm knee scores and Böstman scores.

Table 1 Demographic characteristics for patients in two groups

	TRT group	TBWFT group	*P*
Case(n)	34	30	
Age(y)	56.03 ± 15.64	53.57 ± 18.11	0.561
BMI (kg/m^2)	23.23 ± 3.47	22.99 ± 3.66	0.799
Gender (male/female)	22/12	19/11	0.909
Injured mechanism (Accident/fall down from standing height)	4/30	2/28	0.485
Hypertension(%)	41.2	33.3	0.518
Diabetes mellitus(%)	17.6	16.6	0.917
AO/ATO type classification C1/C2/C3(n)	12/10/12	11/9/10	0.986

Statistical analysis

The statistical software SPSS 19.0 was used for analysis. The measurement data were presented as mean ± SD, and the disparity between the groups was analyzed using an independent sample t-test for continuous variables. The categorical variables were analyzed using the Chi-square (χ^2) test. A value of $P<0.05$ was considered statistically significant.

Results

According to Table 1, a total of 64 patients were enrolled in the study, comprising 34 patients in the TRT group and 30 patients in the TBWFT group. There were no statistically significant differences in patients' basic information, including age, BMI, gender, injured mechanism, comorbidities, and patellar fracture AO/ATO type classification between the two groups.

The short-time clinical indicators were shown in Table 2. It was found that TBWFT significantly reduced the operation time compared to the TRT group (63.1±9.44 min vs. 78.61±11.76 min, $P<0.05$), and that the reduction process was the critical factor that contributed to the operation time. During the entire operation, our trauma and orthopedic team underwent a minimum of three X-ray exposures. The initial exposure was conducted to assess the reduction of patellar fractures, the second to assess the position of K-wires, and the third to assess the position of titanium cable and the outcomes of the operation. In most cases, it was the malreduction that demanded additional X-ray exposure. It was demonstrated that TBWFT significantly reduced the X-ray exposure times from 4.32±0.94 (TRT group) to 3.5±0.57 ($P<0.05$). Another potential advantage of TBWFT was that it appeared to result in enhanced reduction. The articular surface of the TBWFT group was 0.14±0.12 mm, while that of the TRT group was 0.21±0.16 mm. However, there was no statistically difference between the two groups ($P>0.05$).

All the patellar fractures of all patients enrolled were healed successfully. The mean healing time was 10.29±1.75 weeks for TRT group, compared to 9.83±1.53 weeks for TBWFT group ($P>0.05$). Furthermore, there was no significant difference in range of knee motion, Böstman scores, or Lysholm knee scores between the two groups at the last follow-up. The representative cases were shown in Figs. 2 and 3.

Table 2 Short-term clinical indicators

	TRT group	TBWFT group	*P*
Operation time (min)	78.61±11.76	63.1±9.44	0.000
X-Ray exposure times (n)	4.32±0.94	3.5±0.57	0.000
Articular surface steps (mm)	0.21±0.16	0.14±0.12	0.055
Healing time (weeks)	10.29±1.75	9.83±1.53	0.27
Range of motion(°)	135.88±4.4	135.5±4.99	0.747
Böstman scores	28.09±1.54	28.27±1.44	0.635
Lysholm knee scores	95.15±2.35	95.63±2.22	0.400

Postoperative complications were observed in 3 patients in the TRT group and there were also 3 patients in the TBWFT group that suffered from postoperative complications ($P>0.05$). The soft tissue irritation was mainly caused by K-wire migration, which was resolved by removing the K-wire after the fracture healed. Nevertheless, there was no significant disparity observed between the two groups, despite the presence of an average of an additional 1.8 wires in patients belonging to the

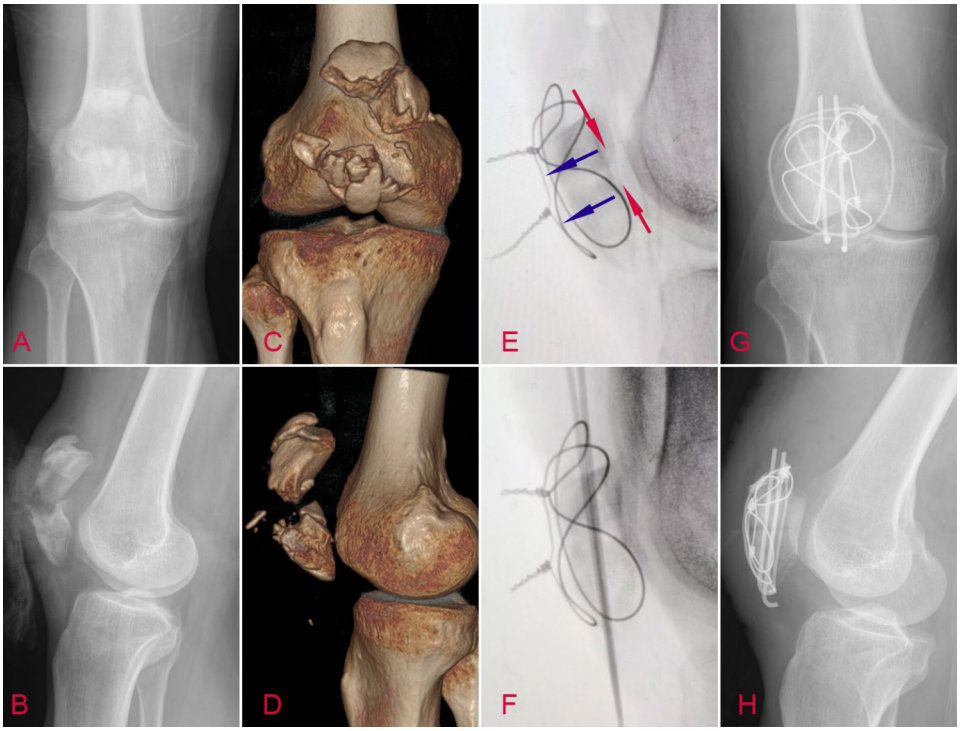

Fig. 2 A 51-year-old male suffered a right patellar fracture (C3) after falling from height. (**A**, **B**): An anterior-posterior and lateral X-ray image of the patellar fracture prepoperation. (**C**, **D**): CT view preoperation. (**E**): Intraoperative key X-Ray picture: two tension band wires were first applied to reduce the fracture segment. The tension band wires decreased the displacement between fracture segments (red arrows) and the upper surface of the patella was strongly pulled to the underneath of the wires. The articular surface was also reduced indirectly (blue arrows). (**F**): Intraoperative key X-Ray picture: 2 parallel 2.0-mm K-wires were passed through fracture fragments in a distal-to-proximal direction. (**G**, **H**): anteroposterior and lateral X-ray images of patellar fracture post-operation

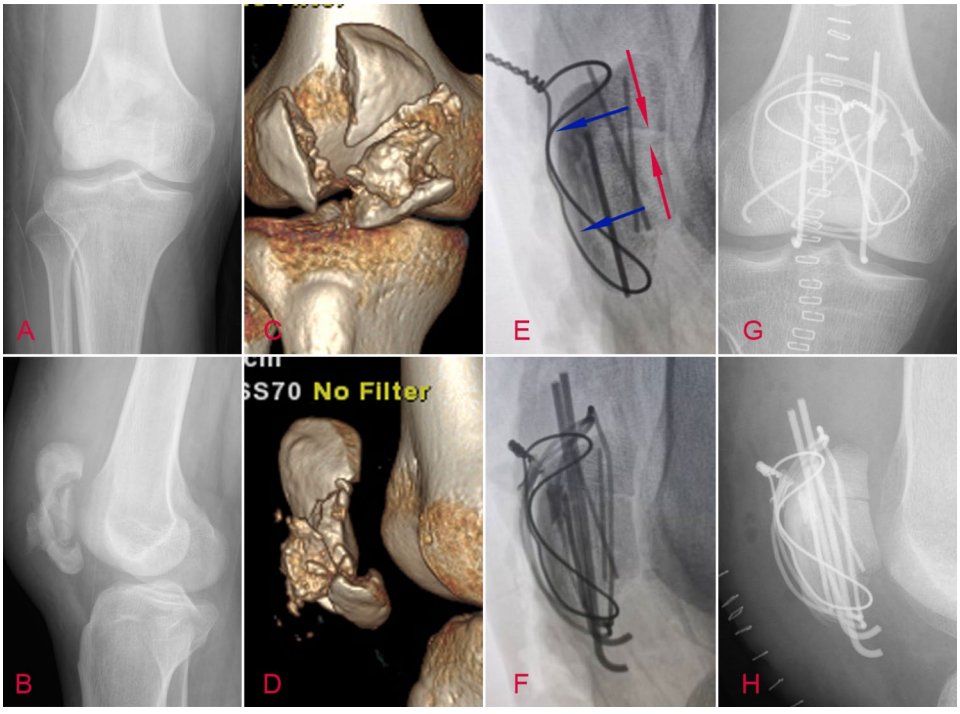

Fig. 3 A 28-year-old male suffered a right patellar fracture (C3) after falling from height. (**A**, **B**): An anterior-posterior and lateral X-ray image of the patellar fracture prepoperation. (**C**, **D**): CT view preoperation. (**E**): Intraoperative key X-Ray picture: small fracture fragments were reduced and were fixed with 1.2 mm and 1.5 mm K-wires. Then tension band wires were applied to reduce the main fracture segment. The tension band wires decreased displacement between fracture segments (red arrows) and upper surface of patella was strongly pulled to the underneath of wires and the articular surface got reduced indirectly (blue arrows).(**F**): Intraoperative key X-Ray picture: two parallel 2.0-mm K-wires were passed through fracture fragments in a distal-to-proximal direction. (**G**, **H**): anteroposterior and lateral X-ray images of the patellar fracture post-operation

Table 3 Postoperative complication

	TRT group	TBWFT group	*P*
Loss of reduction	0	0	
implant breakage	0	0	
soft tissue irritation	2	2	0.897
infection	1	1	0.928
total number of patients with complications	3	3	0.872

TBWFT group. One patient from each group was diagnosed with a superficial infection, which was successfully treated with oral antibiotics. (Shown in Table 3)

Discussion

The patella is a crucial component of the extensor mechanism that aids in knee extension. Patella fractures account for 1% of all fractures and frequently disrupt the extensor mechanism [1]. The surgical treatment aims to repair the extensor mechanism, promote knee function and restores articular congruity to minimize the risk of subsequent knee arthritis [3, 10].

The first and utmost step of patella fractures surgery was reduction, regardless of the kind of devices applied [11, 12]. Traditional reduction technique were relayed using pointed clamps [3, 13]. Nevertheless, there were several limitations and drawbacks during the reduction process using pointed clamps. Firstly, during the reduction process, multiple reduction attempts and intraoperative fluoroscopy may be needed, especially when confronted with a comminuted fracture and without exposing the articular surface. Secondly, it consistently applied the fixation devices after reduction by pointed clamps, and it is possible that a reduction loss may occur during this period. Thirdly, it would be challenging for pointed clamps to effectively secure the fracture segments during reduction of the comminuted fracture [7]. In order to address the aforementioned issues, various reduction strategies were proposed by scholars. Yong and Yin et al. pointed out that a medial parapatellar approach to visualize the patellar articular surface directly was favorable to the surgeries [14, 15]. Gardner et al. believed that a lateral arthrotomy could be used to ensure articular surface congruence and achieve satisfactory clinical results [16]. It has been suggested that due to anatomic and blood supply factors, a lateral arthrotomy may be considered if it is necessary to obtain direct visualization of the articular surface [1]. Nonetheless, the utilization of turn-over reduction techniques is likely to result in an injury to the media/lateral patellar retinaculum, and the lateral incision may pose a potential disadvantage for

potential total knee arthroplasty [1]. Furthermore, these methods still required the use of pointed clamps and could only solve partial problems. Besides direct reduction methods, Chen et al. proposed nice knots as an auxiliary reduction technique for displaced comminuted patellar fractures [17]. Jiang et al. presented a three-dimensional strapping reduction technique for the treatment of patellar fractures [7]. It has been revealed that in comparison to towel clamp reduction, the utilization of three-dimensional strapping reduction in the treatment of patellar fractures offers advantages such as a shorter operation time and fluoroscopy time, improved knee function after surgery, and satisfactory fracture healing.

According to the AO Group, the tension band technique has been a mainstay of surgical treatment of patellar fractures [8, 18]. Two parallel K-wires were placed longitudinally through the center of the patella, while a flexible wire was passed posteriorly to the K-wires and was tensioned anteriorly in a figure-of-8 configuration. It was theoretically designed to convert anterior tensile forces into a compressive force across the articular surface as the knee flexed [9]. The tension band wire was typically applied following the reduction of patellar fracture. We proposed that the tension band wire could be applied prior to reduction and utilized as a reduction tool. During the tightening process of the tension band, the wire decreased the distance of fracture segments until they disappeared. Meanwhile, the upper surface of patellar was strongly pulled to the underneath of wire, and the articular surface could get reduced indirectly without exposed the articular surface directly. Our study demonstrated that TBWFT significantly reduced the operative time and X-ray exposure times compared to the TRT group. Additionally, it tended to decrease the articular steps. There are several major advantages to TBWFT. Firstly, it proved to be a time-saving and straightforward technology, particularly for novices. Secondly, it was unnecessary to open the patellofemoral joint, thereby preventing any further artificial damage to the retinaculum. Thirdly, TBWFT utilized the soft tissue around the patella to reduce fracture segments, which is especially suitable for comminuted patellar fractures and avulsion fractures. Fourthly, in our operation, the final fixation mainly relied on titanium cable. Nonetheless, we retained the tension band wiring both during and subsequent to the operation, thereby minimizing the potential for reduction loss prior to cable application. Furthermore, it provided stronger reduction strength compared to "nice knots" and "three-dimensional strapping reduction method" and it provided with additional fixation strength in the presence of titanium cable.

The primary advantage of TBWFT was favorable towards reduction. There is no significant difference between the two groups in bone healing time, knee ROM, or knee function. These results further demonstrated that reduction will determine the final clinical results when the same fixation device is applied.

The main complication of the TBWFT and TRT group was soft tissue irritation, which was associated with the application of tension band devices in our surgery [18–20]. However, there was no significant disparity observed between the two groups because we always buried the wire end into soft tissue deep.

This study had several limitations. Firstly, the current study was a short-term retrospective study that involved a limited number of cases from a single institution. It is anticipated that TBWFT will be implemented in other institutions and that a more considerable number of cases will be enrolled. Secondly, there may exist the possibility that TBWFT would display more advantages in treatment of comminuted patellar fractures or C3 type fractures. Therefore, future research might focus on enrolling more cases with C3 type fractures. Thirdly, it was imperative to conclude the biomechanical analysis to evaluate the strength imparted by the supplementary tension band wire. Fourthly, it is reasonable to investigate the utilization of non-metallic suture-based fixation for the reduction and fixation of patellar fractures in order to mitigate the soft tissue irritation induced by metallic implants [21–23].

Conclusion

In conclusion, compared to TRT, TBWFT decreased operative time and X-Ray exposure times. Consequently, TBWFT may be regarded as a straightforward, expeditious, and reproducible technique for reducing C type patellar fractures.

Acknowledgements

Not applicable.

Author contributions

Peng Jia and Tao Liu contributed equally to this paper. Peng Jia performed all the surgeries and submitted the manuscript, Tao Liu collected the data and prepared Figs. 2 and 3, Chen Yu analysed the data, Zhihai Fan prepared the Fig. 1 and Haibin Zhou wrote the manuscript. All authors reviewed the manuscript and agreed the manuscript to be published in current version.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Ethics Committee of the Second Affiliated Hospital of Soochow University (approved number: 2020-H-161) and performed in compliance with the Helsinki Declaration. Informed written consent was obtained from all individual participants and is available from the corresponding author upon reasonable request.

Competing interests
The authors declare no competing interests.

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References

1. Howatt J, Liew AS, Wilkin G. Patellar fractures: anatomy, mechanics, and Surgical Management. J Bone Joint Surg Am. 2021;103(23):2237–46.
2. Larsen P, Court-Brown CM, Vedel JO, Vistrup S, Elsoe R. Incidence and epidemiology of patellar fractures. Orthopedics. 2016;39(6):e1154–8.
3. Kakazu R, Archdeacon MT. Surgical Management of Patellar fractures. Orthop Clin North Am. 2016;47(1):77–83.
4. Rau Y, Huynh T, Frosch KH, Schultz C, Schulz AP. Developments in the epidemiology and surgical management of patella fractures in Germany. BMC Musculoskelet Disord. 2023;24(1):83.
5. Zhou M, Jia X, Cao Z, Ma Y, Wang Y, Wang P, Kang Y, Luo J, Wu Y, Rui Y. Treatment of inferior Pole patella fracture using Krackow suturing combined with the suture bridge technique. Arch Orthop Trauma Surg. 2022;143(6):2973–80.
6. Cho J-W, Kim J, Cho W-T, Gujjar PH, Oh C-W, Oh J-K. Comminuted inferior Pole fracture of patella can be successfully treated with rim-plate-augmented separate vertical wiring. Arch Orthop Trauma Surg. 2017;138(2):195–202.
7. Jiang W, Li Y, Kotian RN, Lin B, Zhang X. A novel three-dimensional strapping reduction for the treatment of patellar fractures. J Orthop Surg Res. 2019;14(1):249.
8. Hambright DS, Walley KC, Hall A, Appleton PT, Rodriguez EK. Revisiting Tension Band fixation for difficult patellar fractures. J Orthop Trauma. 2017;31(2):e66–72.
9. Hsu K-L, Chang W-L, Yang C-Y, Yeh M-L, Chang C-W. Factors affecting the outcomes of modified tension band wiring techniques in transverse patellar fractures. Injury. 2017;48(12):2800–6.
10. Lazaro LE, Wellman DS, Sauro G, Pardee NC, Berkes MB, Little MTM, Nguyen JT, Helfet DL, Lorich DG. Outcomes after operative fixation of complete articular patellar fractures: Assessment of Functional Impairment. J Bone Joint Surg Am. 2013;95(14):e96–91.
11. Brusalis CM, Gruskay JA, Bornes TD, Langhans MT, Ricci WM. Open reduction and internal fixation of Patella fracture with contoured dorsal plating. J Orthop Trauma. 2021;35(2):S34–5.
12. Siljander MP, Harwin SF, Vara AD, Koueiter DM, Wiater BP, Wiater PJ. Novel anterior plating technique for Patella fracture fixation. Orthopedics. 2017;40(4):e739–43.
13. Meng D, Xu P, Shen D, Chen Y, Zhu C, Hou C, Lin H, Ouyang Y. A clinical comparison study of three different methods for treatment of transverse patellar fractures. J Orthop Sci. 2019;24(1):142–6.
14. Yin Q-d, Wang J-b, Gu S-j, Wu Y-w. Rui Y-j: clinical observation of C3-type patellar fractures treated by operation methods with or without a turned-over patella. Injury. 2019;50(4):966–72.
15. Yoon Y-C, Sim J-A, Hong J-H. Surgery of patellar fractures using a medial parapatellar approach. J Orthop Surg (Hong Kong). 2017;25(2):230949901771937.
16. Gardner MJ, Griffith MH, Lawrence BD, Lorich DG. Complete exposure of the articular surface for fixation of patellar fractures. J Orthop Trauma. 2005;19(2):118–23.
17. Chen M, Jin X, Fryhofer GW, Zhou W, Yang S, Liu G, Xia T. The application of the nice knots as an auxiliary reduction technique in displaced comminuted patellar fractures. Injury. 2020;51(2):466–72.
18. Hoshino CM, Tran W, Tiberi JV, Black MH, Li BH, Gold SM, Navarro RA. Complications following Tension-Band fixation of patellar fractures with cannulated screws compared with Kirschner Wires. J Bone Joint Surg Am. 2013;95(7):653–9.
19. Zhu X-z, Huang T-l, Zhu H-y, Bao B-b, Gao T, Li X-w, Lin J-q, Zheng X-Y. 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(1):60.
20. Neumann-Langen MV, Sontheimer V, Näscher J, Izadpanah K, Schmal H, Kubosch EJ. Incidence of postoperative complications in patellar fractures related to different methods of osteosynthesis procedures - a retrospective cohort study. BMC Musculoskelet Disord. 2023;24(1):871.
21. Heusinkveld MH, den Hamer A, Traa WA, Oomen PJ, Maffulli N. Treatment of transverse patellar fractures: a comparison between metallic and non-metallic implants. Br Med Bull. 2013;107:69–85.
22. Traa WA, Oomen PJ, den Hamer A, Heusinkveld MH, Maffulli N. Biomechanical studies on transverse olecranon and patellar fractures: a systematic review with the development of a new scoring method. Br Med Bull. 2013;108:131–57.
23. Trinchese GF, Cipollaro L, Calabrese E, Maffulli N. Platelet-Rich plasma, mesenchymal stem cell, and non-metallic suture-based fixation technique in a patellar fracture Nonunion: a technical note and systematic review. Clin Orthop Surg. 2021;13(3):344–51.

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