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RESEARCH

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A comparative study on the efficacy of kirschner wire tension band combined with anchor cross-suture internal fixation versus partial patellectomy in the treatment of comminuted inferior pole patellar fractures

Siyu Duan[1], Rongda Xu[1], Hanfei Liu[3], Ming Sun[1], Hairui Liang[3] and Zhencun Cai[1,2*]

Abstract

Objective The treatment of comminuted inferior pole patellar fractures has long posed a challenge for orthopedic surgeons. This study aims to compare the biomechanical stability and clinical efficacy of Kirschner wire tension band combined with anchor cross-suture fixation versus traditional partial patellectomy in the treatment of comminuted inferior pole patellar fractures.

Methods A retrospective analysis was conducted on 14 patients who underwent Kirschner wire tension band combined with anchor cross-suture fixation (Group A) in our department of orthopedics from September 2020 to April 2022. Additionally, we matched 14 patients with similar baseline characteristics who received inferior pole patellectomy combined with patellar tendon repair (Group B). The two groups were compared in terms of operative time, intraoperative blood loss, postoperative complications, and at the final follow-up, knee range of motion (ROM), visual analogue scale (VAS) score, Bostman knee function score, peak knee torque, and Insall-Salvati (IS) ratio.

Results All patients were followed up for more than 12 months. At the final follow-up, Group A showed significantly better outcomes than Group B in terms of knee range of motion (ROM), Bostman knee function score, knee VAS score, and average peak knee torque, with statistically significant differences ($P < 0.05$), indicating faster postoperative recovery and better clinical results in Group A. The IS ratio of the injured knee in Group B was 0.71 ± 0.66, less than 0.8, suggesting a decrease in patellar height. There were no significant differences between the two groups in terms of operative time, intraoperative blood loss, or incision length ($P > 0.05$). In Group A, one patient experienced complications from hardware irritation, while in Group B, one patient had postoperative knee pain, and two patients experienced knee extension weakness after cast removal and rehabilitation.

Conclusion Kirschner wire tension band combined with anchor cross-suture fixation for the treatment of inferior pole patellar fractures yields satisfactory results. This technique provides reliable fixation, restores the original extensor mechanism, promotes early postoperative rehabilitation, and reduces the incidence of complications, making it suitable for clinical application and widespread use.

*Correspondence:
Zhencun Cai
sychczc@163.com
Full list of author information is available at the end of the article

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Keywords Inferior pole patellar fracture, Tension band, Suture anchor, Internal fixation, Partial patellectomy

Introduction

Comminuted fractures of the inferior pole of the patella are relatively rare, accounting for approximately 9.3% to 22.4% of patellar fractures, and are commonly seen in cases of direct trauma or in patients with osteoporosis [1, 2]. Clinical studies have shown that when the knee joint is flexed at angles between 45° and 60°, the stress on the patella can reach 4 to 5 times the body weight. As the attachment point for the patellar tendon, the inferior pole bears the greatest tensile stress, making it particularly susceptible to fractures [3, 4]. Comminuted fractures of the inferior pole of the patella often result in significant loss of patellar height and dysfunction of the extensor mechanism. Conservative treatment, requiring prolonged immobilization and often leading to poor fracture reduction, frequently results in suboptimal recovery of knee joint function. Therefore, early surgical intervention is generally recommended in clinical practice. However, due to the anatomical characteristics of the inferior pole of the patella and the comminuted nature of these fractures, achieving anatomical reduction and stable fixation presents considerable challenges [5].

The traditional surgical methods for comminuted fractures of the inferior pole of the patella primarily include partial patellectomy and Kirschner wire tension band fixation [6, 7]. Although these methods can provide a certain degree of fixation strength, some patients experience fixation failure or recurrence after surgery, limiting early rehabilitation. In recent years, novel techniques such as cerclage wire, screws, anchors, sutures, and double-button plate fixation have been introduced into clinical practice [2, 3, 8–12]. However, these approaches have limitations in terms of fixation strength, surgical complexity, and general applicability. Currently, there is no consensus on the optimal treatment strategy for comminuted inferior pole patellar fractures [13]. In clinical practice, we have found that Kirschner wire tension band combined with anchor cross-suture fixation effectively provides fracture stability for the treatment of comminuted inferior pole patellar fractures, ensuring early rehabilitation while offering the advantages of simplicity and ease of operation. This study aims to evaluate the clinical efficacy of this novel treatment method, with the goal of providing more scientific evidence for surgical options in inferior pole patellar fractures. The hypothesis of this study is that compared to traditional partial patellectomy, Kirschner wire tension band combined with anchor cross-suture fixation can significantly improve postoperative knee function scores and reduce the incidence of complications.

Clinical data and methods

Study design

This study is a retrospective case–control study, including 28 patients with comminuted inferior pole patellar fractures who were admitted to the Affiliated Central Hospital of Shenyang Medical College from September 2020 to April 2022. The study adheres to the principles of the Declaration of Helsinki and has been approved by the Ethics Committee of the Affiliated Central Hospital of Shenyang Medical College (Ethics No. 2020020). All patients provided written informed consent.

Inclusion and exclusion criteria

Inclusion criteria:

1. Normal knee function prior to injury, with a unilateral closed patellar fracture.
2. Fracture located in the inferior pole of the patella, with comminuted fragments ≥ 3.
3. Surgery performed within 7 days of injury.

Exclusion criteria:

1. Other fractures in the same limb.
2. Severe osteoporosis or other conditions affecting normal knee joint function.
3. Open fractures.
4. Patients with preoperative contraindications for surgery (including but not limited to the following conditions: poor general health, inability to tolerate anesthesia or surgery; severe osteoporosis; presence of local or systemic infections that may lead to postoperative infectious arthritis; and patients with complex knee joint injuries, particularly those with anterior and posterior cruciate ligament injuries).
5. Lost to follow-up.

Demographic characteristics

According to the inclusion and exclusion criteria, a total of 28 patients were included and divided into Group A (Anchor group, 14 cases) and Group B (Patellectomy group, 14 cases). All patients had closed fractures, classified as AO type 34-A1, and underwent surgery 2 to 7 days after the injury. There were no significant differences between the two groups in terms of age, gender, fracture side, length of hospital stay, time from injury to surgery, and follow-up duration ($P > 0.05$), indicating that the two groups were comparable. See 1 for details.

Preoperative preparation

After admission, all patients underwent preoperative X-ray and 3D CT examinations. The injured lower limb was temporarily immobilized with a plaster cast at 0° extension to alleviate pain, and the affected limb was elevated. Preoperative medications included routine pain relief and anticoagulants. After excluding contraindications for surgery, the procedure was carried out. All patients were administered a single dose of antibiotic prophylaxis 30 min before surgery, with cefazolin sodium routinely used as the preventive antibiotic to reduce the risk of postoperative infection. For patients allergic to cephalosporins, clindamycin was used as an alternative. The surgery was performed by a chief surgeon with 20 years of clinical experience, proficient in various internal fixation techniques, ensuring the procedure proceeded smoothly. The anchors used in the surgery were provided by Smith & Nephew (Product Name: Smith & Nephew FAST-FIX, Manufacturer: Smith & Nephew, headquartered in London, UK) to ensure the quality and reliability of the internal fixation materials.

Surgical Procedure

After the patient is under general or lumbar anesthesia, they are placed in the supine position. A pneumatic tourniquet is applied to the upper thigh of the affected limb. The limb is then disinfected with iodine. After completing the hemostasis, a straight incision is made anterior to the knee joint. The incision is carried out layer by layer through the skin, subcutaneous tissue, and fascia. The edges of the incision are retracted to expose the comminuted bone fragments of the inferior pole of the patella. The area is irrigated with saline, and the soft tissue and blood clots at the fracture site are cleaned. The joint cavity is also irrigated.

Table 1 Baseline demographic characteristics of patients

	Group A(n=14)	Group B(n=14)	P
Age, years	43.29±11.10	46.00±13.00	0.557
Gender, n			0.704
Male	5	7	
Female	9	7	
Fracture side, n			0.706
Left	6	8	
Right	8	6	
Length of hospital stay, days	5.64±1.15	5,57±1.16	0.868
Time from injury to surgery, days	3.71±1.20	4.07±1.49	0.492
Follow-up time, months	16.14±1.66	17.21±1.63	0.096

(Group A) (Kirschner Wire Tension Band Combined with Anchor Cross-Suture Internal Fixation): Reduction is assessed using X-rays, the fracture is realigned, and joint surface integrity is restored. The patella is stabilized with a patella reduction clamp or towel clamp. During the procedure, care is taken to avoid detaching the prepatellar fascia and periosteum to prevent separation of the fracture fragments. Two parallel Kirschner wires (2.0 mm in diameter) are drilled from the superior pole to the inferior pole of the patella. Steel wire is threaded through the ends of the Kirschner wires, forming a longitudinal figure-eight tension band on the anterior side of the patella. Then, the stainless steel wire is tightened using Kirschner forceps, and the upper ends of the Kirschner wires are bent above the patella to prevent loosening and detachment. Under C-arm fluoroscopy, after confirming satisfactory reduction of the fracture fragments, a single anchor is inserted perpendicular to the cross-section of the proximal patellar fracture fragment (Fig. 1a). The anchor is embedded into the patellar body. The tail-suture cross-suture method is then used to secure the comminuted fragments of the inferior pole patellar fracture and the patellar tendon (Figs. 1b, d). The knee joint is flexed and extended to ensure fracture stability and proper tension of the patellar tendon. A final C-arm fluoroscopy is performed to confirm good alignment of the fracture ends (Fig. 1c). The surgical area is irrigated with saline, and the incision is closed layer by layer. (Fig. 1).

(Group B) (Partial Patellectomy): Partial patellectomy and patellar tendon repair (PP) were performed using standard techniques [7]. During the surgery, the comminuted bone fragments of the inferior pole of the patella were first excised, taking care to avoid excessive damage to the prepatellar fascia. Next, we reshaped the ends of the patella. Then, using Kirschner wires, we drilled parallel holes at equal intervals approximately 1.5 cm from the edge of the patellar fracture or right next to the cartilage surface of the fracture site (Fig. 2a). Subsequently, high-strength, non-absorbable sutures were passed through the patellar tendon, and the sutures were tightened and secured through the bone holes in the patella to ensure firm contact between the patellar tendon and the bone surface (Fig. 2b, c). Postoperatively, we mobilized the joint to check the stability of the fixation, then sutured the prepatellar fascia and joint capsule, closing the incision layer by layer. This technique ensures the precision and consistency of the surgery. A plaster cast was applied

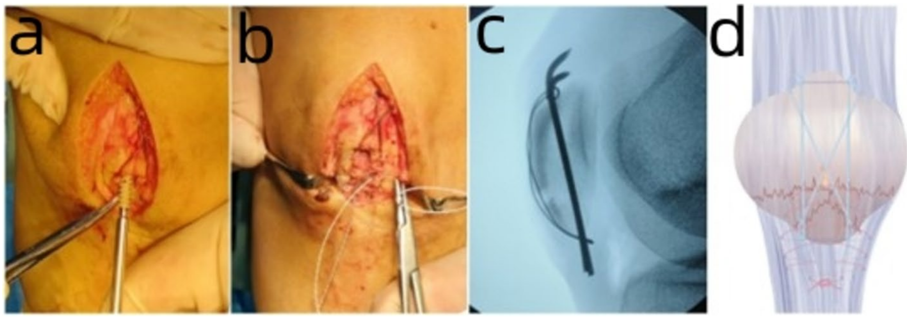

Fig. 1 **a** Insertion of the suture anchor perpendicular to the cross-section of the proximal patellar fracture fragment. **b** Cross-suturing with suture anchor to fix the inferior pole patellar fracture fragments and the patellar tendon. **c** Intraoperative C-arm fluoroscopy showing the reduction of the inferior pole patellar fracture, with the anchor not visible. d. Diagram of the cross-suture technique with suture-anchor for inferior pole patellar fracture

for 6 weeks, during which active quadriceps muscle strengthening exercises were conducted. After 6 weeks, the plaster cast was removed, and external fixation was discontinued. (Fig. 2).

Postoperative management

Postoperatively, both groups of patients received a single dose of antibiotics within 24 h to prevent infection, along with routine pain management and anticoagulation therapy [14, 15]. On the first postoperative day, an X-ray of the knee joint in both anteroposterior and lateral views was taken to evaluate fracture reduction and internal fixation. The surgical incision was dressed every 2–3 days to monitor healing, and the sutures were removed at the incision site two weeks after surgery.

Patients in Group A did not require plaster external fixation. After the postoperative day 1 X-ray examination of the knee joint in both anteroposterior and lateral views, isometric contractions of the quadriceps, straight leg raises, knee flexion exercises, and ankle joint functional exercises were initiated. On postoperative day 3, patients were allowed to bear light weight under protection with crutches and gradually began knee flexion exercises. Full range of knee joint movement was initiated at 4 weeks postoperatively, and gradual full-weight bearing training without assistance was carried out until full knee flexion and normal function were restored.

Patients in Group B were kept in full knee extension and immobilized with a long leg cast for 6 weeks postoperatively. During this period, patients were required to strengthen quadriceps muscle training and were allowed partial weight-bearing with crutches. After the cast was removed, knee flexion exercises were gradually initiated based on the follow-up X-ray findings, and patients were guided to restore full range of knee motion. Starting from the 7th week postoperatively, patients gradually discontinued the use of assistive devices and were able to bear full weight while walking on flat ground.

For patients in both groups who are older, have severe comminution of the fracture, or may develop severe osteoporosis in the future, the duration of crutch use was appropriately extended based on individual circumstances.

Postoperative follow-up plan

The clinical and radiological evaluation methods for postoperative follow-up include the following aspects:

Clinical follow-up

- Assess the patient's knee pain, range of motion, and function, with particular focus on the recovery of quadriceps strength (measured using an isokinetic dynamometer to evaluate peak torque).
- Evaluate the patient's knee pain using the Visual Analog Scale (VAS), record the range of motion (ROM) of the knee, and assess the Böstman score.The Böstman score is a widely used clinical tool for functional prognosis evaluation after patellar fractures, covering parameters such as pain severity, walking ability, range of motion, squatting ability, quadriceps atrophy, and complications (e.g., infection or loss of reduction). The total score ranges from 0 to 30, with a higher score indicating better functional outcomes.
- For Group A patients, regular follow-up is conducted on postoperative day 1, and at 1 month and 2 months, with the rehabilitation plan gradually adjusted based on functional recovery.

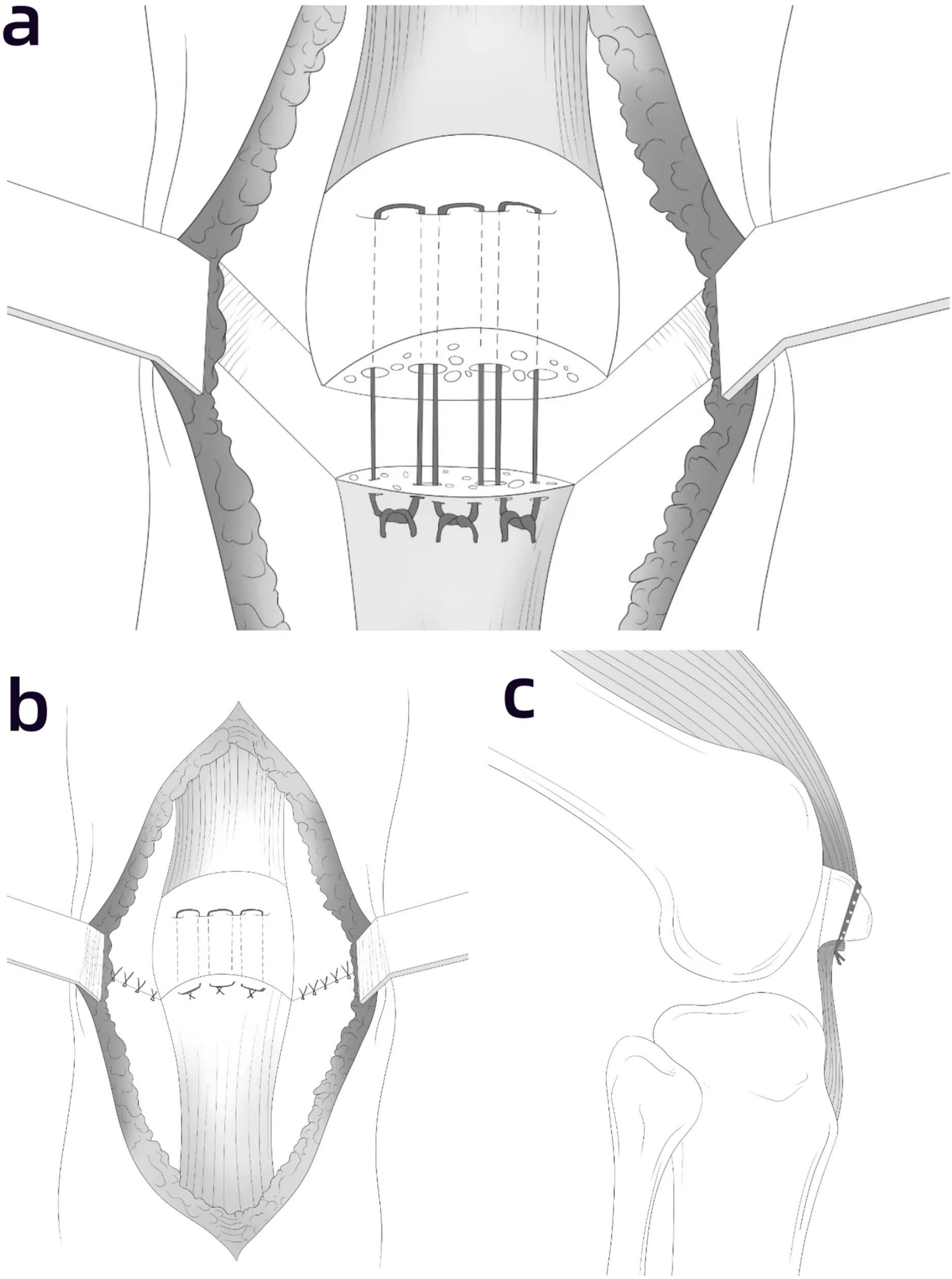

Fig. 2 **a** Drill parallel holes in the central and lateral areas of the patella using Kirschner wires, approximately 1.5 cm from the fracture edge. Then, pass the suture through the patellar tendon and into the bone tunnels in the patella. **b**, **c** Tightly secure the sutures to ensure firm contact between the patellar tendon and the bone surface

Radiological follow-up

- For Group A patients, knee joint anteroposterior and lateral X-rays are taken on postoperative day 1, at 1 month, 2 months, and then weekly after 2 months, until complete fracture healing is observed.
- For Group B patients, knee joint X-rays are taken monthly, with a focus on observing changes in patellar height and position. The Insall-Salvati ratio (IS ratio) of the patella height is recorded. An IS ratio > 1.2 indicates patellar elevation, while an IS ratio < 0.8 indicates patellar subluxation.

In addition, the surgical time, intraoperative blood loss, length of hospital stay, and complication rates between the two groups were compared. A comprehensive analysis was conducted on the clinical and radiological recovery parameters during the postoperative follow-up period for both groups.

Observational indicators and statistical methods

In this study, data analysis was performed using SPSS 27.0 statistical software to ensure the scientific validity and reliability of the statistical analysis. Categorical data were presented as frequencies or percentages, and chi-square tests were used for intergroup comparisons. For continuous variables, all data were presented as mean ± standard deviation. The Shapiro–Wilk test was used to assess the normality of the data. For continuous variables that followed a normal distribution, independent t-tests were used for analysis, while Mann–Whitney U tests were applied to continuous variables that did not follow a normal distribution. A p-value less than 0.05 was considered statistically significant in all statistical analyses.

Results

A total of 28 patients were included in this study, all of whom completed follow-up, with follow-up durations ranging from 12 to 18 months. The surgical incisions in both groups healed primarily. All fractures in Group A healed, allowing for full knee extension. In Group B, one patient reported knee pain during daily activities, and two patients experienced knee extension weakness. X-ray examinations in Group B showed reduced patellar height and decreased patellofemoral contact area after partial patellectomy.

Comparison of general data

Both groups of patients (Group A and Group B) had comminuted inferior pole patellar fractures. There were no significant differences in terms of age, gender, side of fracture, length of hospital stay, time from injury to surgery, and follow-up duration, indicating that the two groups are comparable. See Table 1 for details.

Clinical effectiveness analysis

Comparison of surgical-related indicators

There were no significant differences between the two groups of patients in terms of operative time, intraoperative blood loss, and incision length. Specifically, the average operative time for Group A was 37.86 ± 5.32 min, and the average intraoperative blood loss was 33.29 ± 8.15 ml. In Group B, the average operative time was 41.21 ± 5.58 min, and the average intraoperative blood loss was 36.71 ± 10.55 ml ($P = 0.115$, $P = 0.595$). Regarding incision length, Group A measured 8 0.86 ± 1.46 cm, while Group B measured 9.07 ± 1.54 cm, with no statistically significant difference (P = 0.709). The two groups showed similarity in these surgical-related indicators, indicating no significant differences in the difficulty of the surgical procedures between the groups.

Comparison of functional assessment

At the final follow-up, Group A demonstrated significantly better knee function recovery compared to Group B. The range of motion (ROM) in Group A was significantly greater than that in Group B, with an average knee flexion range of 131.07 ± 4.88° for Group A and 116.43 ± 11.84° for Group B ($P < 0.001$). Additionally, the Bostman score for knee function in Group A was significantly higher (28.29 ± 0.83) than that in Group B (25.79 ± 1.93) ($P < 0.001$), indicating better knee function recovery for Group A patients. In terms of pain scores, the VAS score for Group A (0.36 ± 0.63) was lower than that for Group B (1.64 ± 1.82), indicating that patients in Group A experienced less postoperative pain.

Biomechanical analysis

The results of the peak torque measurement at the knee joint showed that the average peak torque for Group A was 107.86 ± 10.51 Nm, significantly higher than that of Group B, which was 93.71 ± 16.14 Nm ($P = 0.011$). This indicates that the recovery of knee strength in Group A patients was better than that in Group B, reflecting superior clinical outcomes.

In the analysis of patellar height, patients in Group B exhibited a significant decrease in patellar height. X-ray examinations revealed that after the partial resection of the inferior pole of the patella in Group B, the patellar height decreased, and the patellofemoral contact area was reduced, with an IS ratio of 0.71 ± 0.66, which is below the normal patellar height ratio (> 0.8). In contrast, the IS ratio for Group A was 1.01 ± 0.13, within the normal range, and the difference compared to Group B was statistically significant ($P < 0.001$). This further supports the advantages of the surgical method used in Group A in preserving the anatomical structure and function of the patella.

Fracture healing and complications analysis

The average fracture healing time for patients in Group A was 10.79 ± 1.53 weeks, with all patients achieving fracture healing and being able to fully extend their knees. Although one patient in Group A experienced mild discomfort due to hardware irritation postoperatively, no serious complications such as hardware loosening or re-displacement of the fracture were observed. In contrast, Group B had three patients with complications: one patient reported knee pain postoperatively, and two patients experienced knee extension weakness during rehabilitation training after the removal of the cast. The complication rate in group B was higher than in group A, but statistical analysis showed no significant difference between the two groups (p = 0.596). This result suggests that the combination of Kirschner wire tension band and anchor cross-suture fixation may have a potential advantage in reducing complications.

See Table 2 for details.

Discussion

Patellar inferior pole fractures occur in the distal quarter of the patella and are a specific type of patellar fracture, classified as a non-articular fracture [16]. The main finding of this study is that the combination of Kirschner wire tension band and anchor cross-suture fixation technique demonstrates significant advantages in the treatment of comminuted patellar inferior pole fractures. It not only provides reliable fixation stability and effectively restores knee joint function but also reduces the incidence of postoperative complications. Compared to the use of a single Kirschner wire tension band fixation or partial patellectomy, this technique shows better outcomes in both functional recovery and complication prevention.

The inferior pole of the patella is an important component of the knee extension mechanism. Clinical intervention is usually required when patellar surface collapse exceeds 3 mm or separation is greater than 4 mm [1, 4]. The main goals of surgery are to restore the integrity and stability of the knee extension mechanism, achieve anatomical reduction as much as possible, facilitate early and effective rehabilitation, maximize knee joint function, and reduce the occurrence of fracture complications [5]. Currently, despite the variety of surgical methods available for treating inferior pole patellar fractures, there are still many challenges in restoring anatomical structure, achieving effective fixation, and facilitating early postoperative rehabilitation [17, 18]. Optimizing surgical techniques to improve fracture healing quality and functional recovery remains a key focus in clinical research and practice.

In cases of comminuted fractures of the patellar inferior pole that are difficult to fix, some clinical experts prefer to perform partial excision of the non-articular fragments of the patellar inferior pole and reattach the patellar tendon to the remaining part of the patella using transosseous sutures [19, 20]. Research has shown that after excision of non-articular fractures of the patellar inferior pole and reconstruction of the patellar tendon, with about 6 weeks of external immobilization, the rate of excellent joint scores can reach 73.5% [21]. Marder et al. [22] demonstrated that after excision of the patellar inferior pole and reconstruction of the patellar tendon, there is no significant difference in the patellofemoral contact area and patellofemoral joint pressure compared to normal conditions. Scapinelli et al. [23] hold a similar view.

However, some scholars argue that excision of the patellar inferior pole can lead to patellar displacement, disrupt the original anatomical relationships, alter the mechanical structure of the patellar joint surface, and increase the load on the quadriceps during knee movement. This could potentially result in long-term adverse effects such as knee pain, knee extension dysfunction, and traumatic patellofemoral arthritis [21, 24–28].In addition, healing after excision of the patellar inferior pole often relies on tendon-to-bone healing, which is typically unreliable. A study by Veselko et al. [21] found that patients who underwent surgery preserving the

Table 2 Postoperative Clinical Outcomes and Functional Indicators of Patients

	Group A	Group B	P
Operative time, minutes	37.86±5.32	41.21±5.58	0.115
Intraoperative blood loss, mL	33.29±8.15	36.71±10.55	0.595
Incision length, cm	8.86±1.46	9.07±1.54	0.709
Fracture healing time, weeks	10.79±1.53		
Range of motion，°	131.07±4.88	116.43±11.84	＜0.001
Bostman score	28.29±0.83	25.79±1.93	＜0.001
Average peak torque of the knee joint, Nm	107.86±10.51	93.71±16.14	0.011
Salvati Index	1.01± 0.13	0.71±0.66	＜0.001
VAS score	0.36±0.63	1.64±1.82	0.541
Complications, n	1	3	0.596

patellar inferior pole had significantly better recovery in terms of knee function and pain compared to those who had the patellar inferior pole excised. Similar results were reported by Matejčić et al. [26]. Deng et al. [29] found that long-term follow-up after partial resection of the patellar lower pole showed satisfactory outcomes for knee joint function in patients. However, due to the wide age range of patients with lower pole patellar fractures, some have higher expectations for short-term recovery of knee function. Prolonged plaster immobilization postoperatively may lead to muscle atrophy, which can hinder recovery [23]. Furthermore, postoperative rehabilitation exercises for patients who have undergone lower pole patellar resection should be performed under the guidance of a professional.

The Kirschner wire tension band is the most commonly used and classic method for open reduction and internal fixation of patellar fractures. It can effectively and simply fix patellar fractures by converting the tensile force of the wire into axial pressure at the fracture site, thereby increasing the stability of the fracture ends. The postoperative excellent rate is relatively high [23]. However, this method requires relatively intact bone support. When dealing with comminuted fractures of the lower pole of the patella, the Kirschner wires are prone to loosening, resulting in incomplete reduction and ineffective fixation [30, 31]. Studies have indicated that for comminuted fractures of the lower pole of the patella, the probability of requiring a secondary surgical fixation after using only the Kirschner wire tension band for treatment is approximately 21% to 58% [32, 33]. In our clinical practice, we have also found that the stability of using only the Kirschner wire tension band for fixing comminuted patellar fractures is poor, especially when the bone quality of the lower pole of the patella is relatively porous. The internal fixation Kirschner wires and wires tend to cut through the porous bone, leading to loosening and failure of the internal fixation.

Currently, various surgical techniques are used in clinical practice to treat patellar inferior pole fractures. The use of a basket-shaped plate for internal fixation provides good functional recovery and long-term effectiveness. However, the insertion of the steel prongs may damage the patellar ligament, affecting functional recovery, and may also impair fracture healing due to compromised local blood supply [10, 34]. The suture anchor technique provides good functional recovery, but its fixation strength is relatively weak. When used alone, it may lead to fracture instability and is prone to postoperative complications [17, 35]. The nickel-titanium patellar device can effectively stabilize the fracture fragments, but the surgical procedure is more complex. If not performed correctly, it may lead to poor fracture reduction and may also cause patellofemoral joint injury and soft tissue irritation [36]. Although the SVW modified technique offers good functional recovery and radiological outcomes, wire breakage during follow-up can lead to fracture instability, which may result in complications and hinder healing [37]. In contrast, the Kirschner wire tension band combined with anchor cross-suture fixation technique provides stronger fixation strength, ensuring fracture stability with minimal surgical intervention. This reduces interference with the patella and helps the patient recover function earlier. Compared to other methods, it is associated with a lower incidence of complications.

In recent years, we have employed the method of Kirschner wire tension band combined with anchor cross-suture internal fixation for treating comminuted fractures of the inferior pole of the patella [38]. This combined fixation method has shown excellent performance in improving fracture stability and reducing internal fixation loosening. It overcomes the limitations of the single method and provides a more reliable solution for the treatment of comminuted fractures of the lower pole of the patella. This study utilized the Kirschner wire tension band combined with anchor cross-suture internal fixation technique and achieved good results in clinical practice. This treatment method has the following advantages: (1) The Kirschner wire tension band, as the most classic treatment for patellar fractures, can convert the tension on the cortical bone surface into pressure, promoting bone healing while preserving the fracture fragments of the lower pole of the patella;(2) Screwing the anchors vertically into the transverse section of the proximal patellar fracture fragments can effectively ensure the stability of the anchors; (3) Using the anchor suture technique to wrap the comminuted fracture fragments of the lower pole of the patella provides strong and effective internal fixation. This method can restore the extensor mechanism of the knee and promote bone-to-bone healing at the fracture site, laying the foundation for early rehabilitation exercises of the knee joint and helping to prevent joint stiffness.

In this study, patients in Group A were able to perform early knee flexion and extension exercises without experiencing internal fixation loosening or fracture redisplacement. However, in Group B, one patient experienced knee pain, and two patients showed postoperative weakness in knee extension. Although these patients were able to meet their daily activity needs after rehabilitation exercises, their knee joint function and Bostman scores were significantly lower compared to Group A. These results further validate the significant advantage of the Kirschner wire tension band combined with anchor cross-suture fixation technique in providing fracture stability. Based on the results of this study, we believe that partial patellectomy should only be considered for comminuted patellar inferior pole fractures when reduction is difficult or stable fixation cannot be achieved. Clinically, more experts tend to preserve the patellar inferior pole and restore the original extensor mechanism and anatomical structure as much as possible to improve postoperative functional recovery and quality of life for patients [39–41].

Although this study validated the effectiveness of the technique, there are still limitations. First, it only included patients with comminuted patellar inferior pole fractures, and the small sample size may limit the generalizability of the results. In addition, this study is a retrospective design rather than a prospective study, which may introduce selection bias. Moreover, due to the relatively short follow-up period, the long-term effects of the technique cannot be fully evaluated. Therefore, future studies should include larger sample sizes, employ prospective randomized controlled trials, and conduct long-term follow-up to further validate the clinical value and long-term efficacy of this technique.

Conclusion

This study provides important clinical evidence for the use of Kirschner wire tension band combined with anchor cross-suture internal fixation in the treatment of comminuted inferior pole patellar fractures. The results show that this technique outperforms traditional partial patellectomy in improving knee joint function and promoting postoperative rehabilitation, particularly in cases of complex comminuted fractures with small fracture fragments. The unique contribution of this study lies in proposing an innovative treatment strategy that provides scientific evidence for the management of complex inferior pole patellar fractures. This technique balances the need for stable fracture fixation with postoperative functional recovery, leading to better treatment outcomes for patients and positively influencing the current treatment algorithm. In the future, further multicenter studies and long-term follow-up will help validate the applicability and efficacy of this technique, providing stronger data support for optimizing the treatment of inferior pole patellar fractures. This study offers a feasible and efficient treatment option for surgeons and holds significant clinical importance.

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Clinical trial number
Not applicable.

Authors' contributions
Z-CC designed the study and interpreted the data. H-RL collected the data. MS analyzed the data. S-YD，H-FL and R-DX wrote the paper. All authors have read and agreed to the published version of the manuscript.

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Data availability
Data availability The datasets generated and/or analyzed during the current study are not publicly available due to limitations of ethical approval involving the patient data and anonymity. However, all data generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the Affiliated Central Hospital of Shenyang Medical College (Ethics No. 2020020). All procedures were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all patients.

Consent for publication
Informed consent for publication has been obtained from all participants.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Orthopedic Surgery, The Second Hospital Affiliated to Shenyang Medical College, Shenyang City, Liaoning Province, China. [2]Liaoning Province Key Laboratory for Phenomics of Human Ethnic Specificity and Critical Illness, and Shenyang Key Laboratory for Phenomics, Liaoning, China. [3]Department of Orthopedic Surgery, Central Hospital Affiliated to Shenyang Medical College, Shenyang City, Liaoning Province, China.

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