ORIGINAL RESEARCH

Efficacy of Arthroscopy-Assisted Minimally Invasive Surgery in the Treatment of Patients with Tibial Plateau Fractures

Shunli Jiang, MBBS; Hong Wei, MBBS; Junkai Shi, MBBS; Xingrong Xu, MBBS; Xuewei Hao, MBBS

ABSTRACT

Objective • This study analyzes the therapeutic effect of arthroscopy-assisted minimally invasive surgery in patients with tibial plateau fractures (TPFs) and its influence on knee function and range of motion (ROM) recovery.

Methods • This study enrolled 84 patients with TPFs admitted to the researchers' hospital between March 2021 and May 2022 as the study subjects, including 42 patients treated with open reduction and internal fixation (observation group) and 42 patients treated with arthroscopy-assisted minimally invasive surgery (experimental group). Then, perioperative indexes, knee symptom scores, knee function scores, knee ROM, and postoperative complications were compared between these two groups.

Results • Surgery time was significantly shorter, intraoperative bleeding was less, and the time of the first off-bed activity was signally earlier in the experimental group than in the observation group ($P < .05$). All postoperative Lysholm and Rasmussen scores in both groups increased compared with preoperative scores, and the degree of increase was higher in the experimental group than in the observation group ($P < .05$). The range of flexion, extension, and internal/external rotation angles of patients was more extensive in both groups after surgery than before surgery, and the improvement of the experimental group was greater than that of the observation group ($P < .05$). The experimental group had a considerably lower incidence of postoperative complications than the observation group ($P < .05$).

Conclusion • Arthroscopy-assisted minimally invasive surgery is highly effective in treating TPFs. Specifically, this surgery further improves knee symptoms, promotes the recovery of knee function, elevates knee ROM, and reduces the risk of postoperative complications compared to traditional open reduction and internal fixation. (*Altern Ther Health Med.* 2024;30(12):256-261).

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INTRODUCTION

High-energy injuries cause tibial plateau fractures (TPFs), typical intra-articular fractures often involving the joint's articular surface and other accessory structures.[1] Such fractures have a broad spectrum of clinical types and relatively complex clinical presentations, accompanied by ligament, meniscus, and other tissue injuries. The tibial plateau, a crucial weight-bearing region of the knee, is susceptible to fractures resulting in severe functional impairment.[2] The prevalence of TPFs has garnered attention in the medical community owing to the potential for profound consequences on patients' musculoskeletal health. Therefore, this disease requires prompt, accurate, and effective management in the clinic, or it may result in abnormal recovery of the patient's knee function. Unconventional recovery of knee function can lead to disability and arterial, venous, and nerve damage, which can seriously affect the prognosis and quality of life of patients.[3]

Previously, TPF patients were majorly managed with open reduction and internal fixation (ORIF) in the clinic. Nevertheless, it has been reported that ORIF can result in significant damage to the body of patients, slow the recovery of patients, and even significantly enhance the risk of postoperative complications.[4] In recent years, knee arthroscopy-assisted minimally invasive treatment has been gradually recognized in the clinic with the continuous development of arthroscopic techniques and instruments in China. Arthroscopy-assisted minimally invasive surgery possesses the advantages of low injury, less bleeding, short surgery time, fast postoperative recovery, and allows precise and accurate observation of fractures in patients, which is beneficial for clinical assessment of the effect of fracture reduction in patients.[5] This study was performed to the therapeutic effect of arthroscopy-assisted minimally invasive surgery and ORIF, as well as their impacts on the recovery of knee function and range of motion (ROM), to provide corresponding clinical reference. The researchers anticipated that arthroscopy-assisted minimally invasive surgery would demonstrate superior efficacy in treating TPFs compared to traditional ORIF. The researchers' expectations included improved postoperative knee symptoms, enhanced recovery of knee function, more significant improvement in knee range of motion, and a reduced incidence of postoperative complications compared to ORIF.

SUBJECTS AND METHODS

Study Subjects

In this study, 84 TPF patients admitted to the researchers' hospital between March 2021 and May 2022 were selected as the study subjects. Basic information, including gender, age, time from fracture to admission, fracture side, and Schatzker's types, was recorded for patients in both groups. The 42 patients treated with ORIF were set as the observation group, and the 42 patients treated with arthroscopy-assisted minimally invasive surgery were selected as the experimental group. The Ethics Committee of the researchers' hospital approved the study.

Inclusion and Exclusion Criteria

The inclusion criteria for this study consisted of the following: (1) Patients who received a diagnosis of TPFs based on clinical tests; (2) Patients who underwent surgery at the researchers' hospital; (3) Patients with fractures classified as Schatzker[6] type ≤ III; (4) Fractures that occurred within a maximum of patients of 12 hours; and (5) Patients and their families who were informed about the study and provided the necessary informed consent.

The exclusion criteria were as follows: (1) Patients with severe functional impairment; (2) Patients with severe osteoporosis and other joint diseases; (3) Patients who were unable to undergo surgical treatment; (4) Patients with co-morbid psychiatric disorders; and (5) Patients and family members who demonstrated poor compliance or were unable to cooperate effectively with the study.

The choice of Schatzker type III fractures as the upper limit for inclusion was based on the consideration that higher-grade fractures might exhibit increased complexity and variability in clinical presentation. By focusing on Schatzker type III and below, the researchers aimed to create a more homogenous study population, allowing for a more specific assessment of the comparative outcomes between arthroscopy-assisted minimally invasive surgery and traditional ORIF. Additionally, this approach aligns with the literature, which often categorizes TPFs into specific types for research and clinical purposes due to distinct management strategies and prognoses associated with each type.

Methods

Patients in the observation group were treated with ORIF*: under routine general anesthesia, an anteromedial or anterolateral incision was selected as the surgical approach according to the fracture to expose the tibial plateau and upper tibia. The joint capsule was incised transversely below the meniscus, and then the meniscus was retracted upward under direct vision. Afterward, the fracture was repositioned. The articular surface of the plateau was maintained as flat as possible. Meniscus injuries and collateral ligament injuries were repaired sequentially. In case of a collapsed fracture, a window was opened in the tibialis anterior cortex, and the periosteum was elevated with a periosteal elevator through the window until it was repositioned, followed by bone grafting in the defect.[7] Finally, the fracture was fixed with steel plates and screws to complete the surgery.

Patients in the experimental group were treated with arthroscopy-assisted minimally invasive surgery: routine general anesthesia was used, and anteromedial and anterolateral portals were selected as the arthroscopic approach based on the fracture. The joint cavity was flushed to remove clots, blood, and free bones. Patients' displaced direction, bone defect, and plateau collapse were observed and treated accordingly. Specifically, the fracture fragment of patients with type I fractures were repositioned by arthroscopic pressure and fixed with percutaneous K-wire plus screws. For patients with type II and III fractures, arthroscopic puncture anatomy was performed to reposition the collapsed plateau until the articular surface of the plateau was flat. Additionally, the bone defect was filled with autogenous iliac bone. Fracture reduction was observed with C-arm X-ray fluoroscopy, and internal fixation was conducted with anatomical plates after satisfactory reduction.[8] The same surgical team performed all surgeries.

Postoperative Rehabilitation Protocols

Postoperative rehabilitation protocols played a pivotal role in shaping the outcomes for both groups in the study. In the traditional ORIF group, the rehabilitation process typically involved a gradual and cautious approach to weight-bearing activities. Patients were guided through progressive exercises to restore joint mobility and strengthen the surrounding muscles, focusing on protecting the surgically treated area from excessive stress.

Conversely, the arthroscopy-assisted minimally invasive surgery group followed a rehabilitation protocol tailored to the less invasive nature of the procedure. With an emphasis on early mobilization, this group often underwent a more accelerated transition to weight-bearing activities. The reduced trauma associated with arthroscopy allowed for an expedited rehabilitation timeline, concentrating on promptly optimizing knee function and range of motion.

The primary difference in rehabilitation between the two groups lies in the approach to weight-bearing and the timing of progressive exercises. Arthroscopy-assisted minimally invasive surgery facilitated an earlier initiation of weight-bearing activities and functional movements, whereas the ORIF group adhered to a more cautious and conservative progression.

This disparity in rehabilitation strategies likely influenced the outcomes in several ways. The early engagement in weight-bearing and exercises for the arthroscopy-assisted group may have contributed to a faster recovery of muscle strength and joint function. This accelerated rehabilitation could have played a role in the observed shorter surgery time, reduced intraoperative bleeding, and earlier initiation of off-bed activities in the arthroscopy-assisted group.

Observation Indexes

The following perioperative indexes were observed: surgery time, intraoperative bleeding, and the time of the first off-bed activity, which hospital doctors and nurses recorded. Knee symptoms were scored as follows: This index represented the therapeutic effect in patients. The Lysholm scale proposed by Gillqui[9] was used to assess patients' knee symptoms before and after surgery, which consisted of walking disorder, swelling, flexion and extension disorder, and pain, with 100 scores for each part. The higher the score of patients, the better the improvement of the corresponding symptom.

The knee function was scored as follows: The Rasmussen score[10] (30 scores) was utilized before and after surgery to evaluate the recovery of knee function. Higher scores for patients indicated more favorable recovery of knee function.

Knee ROM was observed: The changes in knee flexion, extension, and internal/external rotation were recorded before and after surgery. The standard reference values for knee ROM were 120°-150° for flexion, 5°-10° for extension, 10° for internal rotation, and 20° for external rotation. The closer the postoperative knee ROM of patients was to the average value, the better the recovery of that motion.

The patients were followed up for 12 months to record postoperative complications. Postoperative complications comprised venous thrombosis, joint stiffness, wound infection, and joint adhesions.

Statistical Analysis

The data of this study were collated and analyzed with SPSS 23.0. The measurement data were summarized as mean ± standard deviation and compared with the *t* test, while the count data were expressed as the number of cases (rate) and compared with the χ^2 test. $P < .05$ indicated that the comparison was statistically significant. GraphPad Prism 8 was chosen as the graphing software.

RESULTS

Comparisons of General Information

In the observation group, there were 23 males and 19 females, and patients were 22-65 years old with a mean age of (43.41 ± 1.78) years. In addition, the time from fracture to admission was 1-9 h in the observation group with a mean value of (3.42 ± 0.54) h. Meanwhile, the observation group had 17 cases with left fractures and 25 cases with right fractures, as well as 9 cases of type I, 17 cases of type II, and 16 cases of type III. Patients in the experimental group were aged 20-64 with a mean age of (43.45 ± 1.72) years, including 25 males and 17 females. The time from fracture to admission was 2-8 h in the experimental group, with a mean time of (3.44 ± 0.47) h. For fracture sides, 20 cases of left fractures and 22 cases of right fractures existed in the experimental group. In addition, type I fractures were 12 cases, type II fractures were 16 cases, and type III fractures were 14 cases in the experimental group. The general information of patients was comparable between the two groups, without significant differences ($P > .05$) (Table 1).

Comparison of Perioperative Indexes

As shown in Figure 1, surgery time, intraoperative bleeding, and the time of the first off-bed activity of patients were 112.37 ± 15.75, 64.25 ± 8.43, and 5.65 ± 1.38 in the observation group, respectively. In addition, the above indexes of patients in the experimental group were 82.43 ± 12.40, 43.54 ± 7.35, and 3.32 ± 1.18, respectively, substantially lower than those in the observation group ($P < .05$).

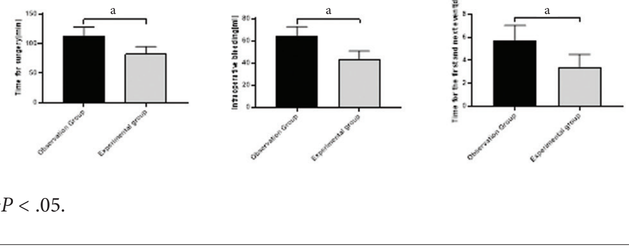
Comparisons of Knee Joint Symptom Scores

As manifested in Figure 2, the scores of walking disorder, swelling, flexion, extension disorder, and pain in the observation group were 52.09 ± 5.43, 68.54 ± 3.42, 49.58 ±

Table 1. The General Information of Patients [± s, n (%)]

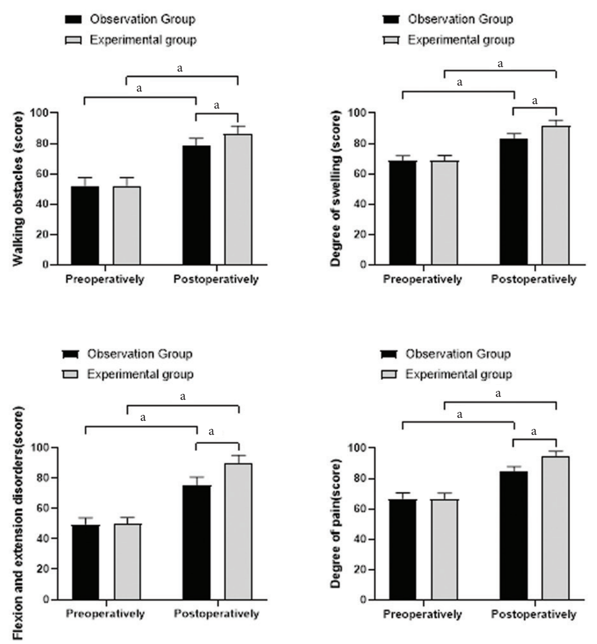
	Observation group (n = 42)	Experimental group (n = 42)	t/χ^2	*P* value
Gender			0.194	.659
Male	23	25		
Female	19	17		
Mean age (years)	43.41 ± 1.78	43.45 ± 1.72	-0.105	.917
Time from fracture to admission (h)	3.42 ± 0.54	3.44 ± 0.47	-0.181	.857
Fracture side			0.435	.510
Left fracture	17	20		
Right fracture	25	22		
Schatzker types				
Type I	9	12	0.571	.450
Type II	17	16	0.050	.823
Type III	16	14	0.207	.649

Figure 1. The Results of Comparisons of Perioperative Indexes Between the Two Groups



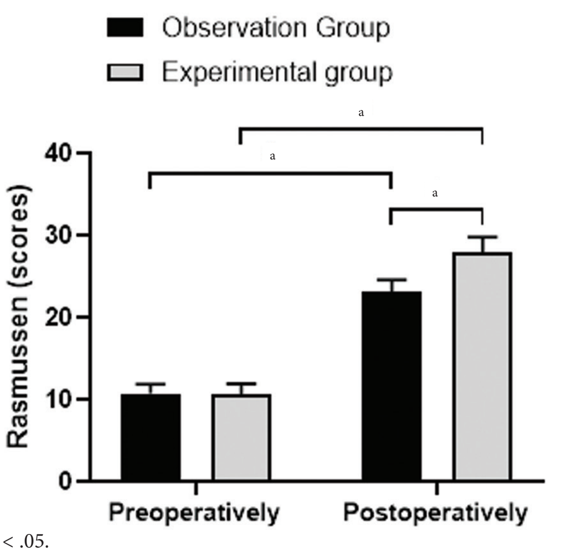
[a]$P < .05$.

Figure 2. The Results of Comparisons of Knee Joint Symptom Scores Between the Two Groups



[a]$P < .05$.

Figure 3. The Results of Comparisons of Knee Function Scores Between the Two Groups ($\bar{x} \pm s$)



[a]$P < .05$.

4.32, and 66.72 ± 3.81 before surgery and 78.33 ± 5.15, 83.15 ± 3.27, 75.24 ± 5.47, and 84.45 ± 3.43 after surgery, respectively. In addition, the scores for walking disorder, swelling, flexion and extension disorder, and pain in the experimental group were 52.14 ± 5.38, 68.64 ± 3.39, 49.64 ± 4.43, and 66.65 ± 3.83 before surgery and 86.25 ± 5.31, 91.88 ± 3.48, 89.52 ± 5.44, and 94.52 ± 3.48 after surgery, respectively. All postoperative Lysholm scores of patients in both groups improved compared with preoperative scores, with a higher degree of increase in the experimental group than in the observation group ($P < .05$).

Table 2. The Results of Comparison of Knee Joint ROM [± s, °]

Items	Time	The observation group (n = 42)	The experimental group (n = 42)	*t*	*P value*
Flexion	Pre-surgery	37.83 ± 4.56	37.69 ± 5.12	0.132	.895
	Post-surgery	95.47 ± 5.23*	112.54 ± 8.67*	-10.926	<.001
Extension	Pre-surgery	1.43 ± 0.61	1.35 ± 0.56	0.626	.533
	Post-surgery	2.92 ± 1.54*	6.63 ± 1.61*	-10.792	<.001
Internal rotation	Pre-surgery	1.35 ± 0.68	1.36 ± 0.72	-0.065	.948
	Post-surgery	5.23 ± 1.55*	8.62 ± 1.21*	-11.173	<.001
External rotation	Pre-surgery	7.97 ± 1.23	8.02 ± 1.16	-0.192	.848
	Post-surgery	11.61 ± 1.24*	14.25 ± 1.43*	-9.039	<.001

Table 3. The Results of Comparisons of Postoperative Complications [n (%)]

Groups	Cases	Venous thrombosis	Joint stiffness	Wound infection	Joint adhesions	Total incidence (%)
Observation group	42	1	4	5	1	26.2% (11/42)
Experimental group	42	0	1	2	0	7.1% (3/42)
χ^2	-	-	-		-	5.486
P value	-	-	-		-	.019

Comparison of Knee Function Scores

As demonstrated in Figure 3, the preoperative Rasmussen score was 10.74 ± 1.14, and the postoperative Rasmussen score was 23.22 ± 1.35 in the observation group. Furthermore, the experimental group had a preoperative Rasmussen score of 10.63 ± 1.32 and a postoperative Rasmussen score of 27.96 ± 1.84. The postoperative Rasmussen scores of patients in both groups were elevated compared with the preoperative scores, and the degree of elevation was higher in the experimental group than in the observation group ($P < .05$).

Comparisons of Knee Joint ROM

The postoperative flexion, extension, and internal/external rotation angles of patients in both groups were improved post-surgery, among which all angles were more prominent in the experimental group than in the observation group ($P < .05$) (Table 2).

Comparisons of Postoperative Complications

The incidence of postoperative complications in patients was 26.2% (11/42) in the observation group, including 1 case of venous thrombosis, 4 cases of joint stiffness, 5 cases of wound infection, and 1 case of joint adhesions. The incidence of postoperative complications of patients in the experimental group was 7.1% (3/42), including 0 cases of venous thrombosis, 1 case of joint stiffness, 2 cases of wound infection, and 0 cases of joint adhesions. The incidence of postoperative complications in the experimental group was significantly lower than that in the observation group ($P < .05$) (Table 3).

DISCUSSION

The therapeutic effect of TPFs, a serious fracture type, is directly related to the morphology, function, and stability of knee joints in patients.[11] With the widespread application of minimally invasive orthopedic treatments, the treatment of TPFs has changed from solid metal internal fixations to biological fixation. As a result, academic circles have paid increasing attention to the therapeutic effect of arthroscopy-assisted minimally invasive surgery in treating TPFs.[12] Knee arthroscopy-assisted minimally invasive surgery has been reported to contribute to ideal outcomes in treating type I-III TPFs.[13] Hofmann et al.[14] found that knee arthroscopy-assisted minimally invasive surgery was associated with fewer soft tissue injuries in patients with type I-III fractures and promoted fracture healing and knee joint recovery compared to conventional ORIF. A study by Elabjer et al.[15] also indicated that the low comminution degree in patients with fractures below type III is beneficial to arthroscopic surgery, which allows for the reduction and fixation of the fracture without incision of the joint capsule and is effective in evaluating and treating combined soft tissue injuries in the knee joint compared to conventional surgery. The recovery of knee function and ROM in TPF patients has always been a crucial indicator of the clinical outcome of knee surgery.[16] Nonetheless, there are relatively few studies on the effects of arthroscopy-assisted minimally invasive surgery on knee function and ROM recovery in TPF patients. This study analyzed the therapeutic effects of arthroscopy-assisted minimally invasive surgery in treating TPFs and its impacts on the recovery of knee function and ROM.

The data of this study elucidated that the perioperative indexes, postoperative knee symptom scores, and postoperative complications of patients in the experimental group were superior to those in the observation group, consistent with the results of previous studies.[17,18] ORIF can result in a large surgical incision, which prevents patients from timely functional exercises after surgery.[19] In addition, it is difficult to reposition the joint surface under direct vision during ORIF. In this context, other combined injuries within the joint of patients with complex TPFs cannot be detected and treated promptly, which seriously influences the recovery of knee function and ROM following surgery.[20] In a study by Wang et al.[21], patients in the observation group underwent knee arthroscopy-assisted minimally invasive surgery, and patients in the control group were subjected to traditional ORIF. The results revealed that the knee function and ROM of patients recovered better in the observation group than in the control group, similar to the results of this study. These results confirmed that arthroscopy-assisted minimally invasive surgery is more effective in the recovery of knee function and ROM in patients with type I-III fractures.

While this study provides valuable insights into the efficacy of arthroscopy-assisted minimally invasive surgery compared to traditional ORIF in TPFs, it is essential to consider the generalizability of these findings to diverse patient populations and fracture types. The generalizability of this study's results may vary across different patient populations.

Age, overall health status, and comorbidities can influence the response to surgical interventions. Additionally, patients with severe functional impairment, osteoporosis, or specific joint diseases were excluded from this study, and the applicability of the results to these populations remains uncertain. Tibial plateau fractures encompass a spectrum of clinical presentations, and the effectiveness of AAMIS may differ based on fracture complexity. The present study focused on Schatzker type I-III fractures, and extending these findings to higher-grade fractures should be approached cautiously. More complex fractures (e.g., type IV-VI) might require tailored interventions, and the benefits observed in the present study may not directly translate to these cases. A careful assessment of individual patient characteristics and fracture patterns should guide the choice between AAMIS and ORIF. When determining the most appropriate surgical approach, surgeons should consider factors such as the degree of comminution, intra-articular involvement, and associated soft tissue injuries.

Certain limitations exist in the current study. First, this study did not use the same surgical team, and the individualized differences between different groups may result in selection bias in clinical outcomes. Second, only patients with type I-III TPFs were included in this study, and, therefore, the study failed to evaluate the outcome of patients with type V-IV TPFs after arthroscopy-assisted minimally invasive surgery. Consequently, the deficiencies of this study still need to be improved and solved in subsequent studies.

Future studies should explore the specific patient and fracture characteristics that influence the outcomes of AAMIS. Investigating whether specific subgroups derive more significant benefits from AAMIS and identifying factors associated with optimal outcomes will contribute to a more nuanced understanding of the procedure's applicability.

CONCLUSION

Arthroscopy-assisted minimally invasive surgery is effective in the treatment of TPF patients. Compared to traditional ORIF, arthroscopy-assisted minimally invasive surgery alleviated knee symptoms, facilitated the recovery of knee function and ROM, and diminished the risk of postoperative complications. These findings have important clinical implications for the management of TPFs. AAMIS emerges as a highly effective alternative to traditional ORIF, offering advantages such as shorter surgery times, faster recovery, and a lower risk of complications. Clinicians should consider the benefits of AAMIS, particularly in cases of less complex TPFs (Schatzker type I-III), where its minimally invasive nature and superior outcomes make it a favorable choice.

CONFLICT OF INTEREST

All authors declare that they have no conflict of interest.

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AUTHORS' CONTRIBUTIONS

Shunli Jiang wrote the main manuscript text and prepared figures and tables. All authors reviewed the manuscript. All authors have read and approved the manuscript. Shunli Jiang and Hong Wei contributed equally.

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Not applicable

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study has been approved by The Affiliated Lianyungang Oriental Hospital of Xuzhou Medical University ethics committee, and Patients and their families were informed of the research content and voluntarily signed the informed consent consent. All the methods were carried out within the guidelines of the Declaration of Helsinki.

CONSENT FOR PUBLICATION

Not applicable

DATA AVAILABILITY STATEMENT

No data was used in this study.

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