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Early outcomes of modified hockey-stick medial plate in the treatment of Schatzker IV-VI tibial plateau fractures: a retrospective controlled study

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Abstract

Background Schatzker IV–VI tibial plateau fractures usually happen in the weight-bearing part of the knee joint. They are hard to fix with traditional methods because they damage soft tissues and make it hard to get back to normal activities. This study introduces a modified hockey-stick medial plate (mHSMP) designed to improve functional outcomes while reducing surgical complexity.

Methods This retrospective study included 40 patients with Schatzker IV-VI tibial plateau fractures (20 in the experimental group treated with the mHSMP and 20 in the control group treated with a traditional medial plate) who were followed up for 12 months. Surgical time, intraoperative blood loss, fracture healing time, postoperative complications, and knee function, as assessed by the Hospital for Special Surgery (HSS) score, were compared between the two groups.

Results Compared with the control group, the experimental group had significantly greater HSS scores at 3 days postsurgery (50.2 ± 1.7 vs. 43.6 ± 1.8, $P < 0.001$), 3 months (68.2 ± 1.8 vs. 61.7 ± 1.9, $P < 0.001$), and 6 months (83.2 ± 1.9 vs. 76.7 ± 2.1, $P < 0.001$). No significant differences were observed between the two groups in terms of surgical time, intraoperative blood loss, fracture healing time, or postoperative complications.

Conclusion Compared with traditional fixation methods, the mHSMP results in superior early functional recovery with comparable safety, providing an effective alternative for treating Schatzker IV-VI tibial plateau fractures.

Keywords Schatzker classification, Tibial plateau fractures, Modified hockey-stick medial plate, Functional recovery, Retrospective controlled study

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Introduction

Background

Schatzker IV-VI tibial plateau fractures represent some of the most complex types of knee fractures; these fractures often involve the primary weight-bearing area of the joint and are associated with severe soft tissue injuries. These fractures are typically caused by high-energy trauma in young adults or low-energy injuries due to osteoporosis in elderly individuals. Failure to provide timely and effective treatment may lead to knee joint stiffness, pain, and loss of function, severely impacting patients' quality of life [1–5].

Surgical treatment is the preferred approach for managing Schatzker IV-VI fractures, with core objectives including precise fracture reduction, reconstruction of joint stability, and early recovery of knee joint function [6–8]. However, traditional medial plate fixation methods, such as T-shaped plates, TomoFix plates, reconstruction plates, and double-plating techniques, while providing sufficient mechanical strength, face significant challenges in treating complex fractures [9–16]. These approaches often involve extensive soft tissue stripping and interference with the posteromedial complex (PMC) of the knee, which can negatively affect postoperative functional recovery. In particular, mechanical friction between the plate and the pes anserinus tendons may cause inflammatory reactions, impairing knee joint mobility and postoperative rehabilitation [17–20].

Additionally, existing techniques impose high demands on surgical procedures. For example, medial double-plating fixation requires complex patient positioning, and frequent intraoperative adjustments may increase both surgical difficulty and the risk of soft tissue injury [8, 12]. Traditional plates also suffer from poor individual anatomical adaptability, leading to decreased surgical efficiency and suboptimal fixation outcomes. Addressing these technical challenges is crucial for optimizing the treatment of Schatzker IV-VI tibial plateau fractures.

Objectives

In light of the challenges mentioned above, this study introduces an mHSMP, aptly named for its resemblance to a hockey stick. The design enhances the plate's anatomical fit through personalized shaping, minimizing interference with soft tissues, especially the pes anserinus tendons. Moreover, its distinctive curved structure reduces reliance on intraoperative positional adjustments, thereby streamlining the surgical procedure.

The aim of this study was to evaluate the clinical utility of the mHSMP in treating Schatzker IV-VI tibial plateau fractures through a retrospective case–control study. Compared with traditional medial plates, we comprehensively assessed differences in surgical time, intraoperative blood loss, fracture healing time, knee function recovery (assessed by the HSS score), and postoperative complications. Through this research, we hope to provide an innovative and effective solution for the treatment of complex tibial plateau fractures.

Methods

Study design and participants

This single-center retrospective case–control study included eligible patients with Schatzker IV–VI tibial plateau fractures who were treated at our institution between June 2021 and June 2023. All patients were radiographically confirmed (via X-ray or computed tomography (CT)) to have Schatzker IV-VI fractures and underwent surgical treatment, with a minimum follow-up of 12 months.

The inclusion criteria were as follows: [1] aged 18 to 70 years; [2] radiographic confirmation of Schatzker IV-VI tibial plateau fractures; [3] surgical treatment within 2 weeks of injury; and [4] complete clinical data with the ability to attend regular postoperative follow-ups.

The exclusion criteria were as follows: [1] open fractures, pathological fractures, or fractures with severe injuries to other anatomical sites; [2] significant degenerative knee disease or severe osteoporosis; and [3] inability to guarantee regular follow-up.

Grouping method

As a retrospective case–control study, patient grouping was based on prior clinical treatment records. Eligible patients were divided into two groups: the experimental group (20 patients treated with mHSMP) and the control group (20 patients treated with traditional medial plates). To minimize potential bias, an independent researcher not involved in the treatment or follow-up assessments categorized patients based on the treatment they received. Baseline characteristics, including sex, age, mechanism of injury, and fracture classification, were not significantly different between the two groups ($P > 0.05$) (Table 1).

Surgical procedures

Experimental Group (mHSMP Group).

Patients in the experimental group underwent surgery under general anesthesia in the supine position. During the procedure, a 3.5 mm stainless steel reconstruction plate (DePuy Synthes, model: 245.122) was shaped into a hockey-stick configuration based on of the anatomical features of the medial tibial plateau. The proximal end of the plate was placed in the soft tissue space beneath the pes anserinus, and the distal end was positioned slightly anteriorly to avoid tibial insertion of the pes anserinus tendons. The plate was fixed with 3.5 mm cortical screws. Intraoperative reduction and plate positioning were

Table 1 Comparison of baseline characteristics between groups

Characteristics	Experimental group ($n=20$)	Control group ($n=20$)	P value
Age (years)*	42.7 ± 16.9	48.6 ± 11.8	0.271†
Gender‡			0.436§
Male	12 (60.0)	8 (40.0)	
Female	8 (40.0)	12 (60.0)	
Injury mechanism‡			0.836§
Traffic accident	2 (10.0)	5 (25.0)	
Sports injuries	2 (10.0)	1 (5.0)	
Falls	6 (30.0)	4 (20.0)	
Nonmotor vehicle injuries	10 (50.0)	10 (50.0)	
Schatzker classification‡			0.954§
IV	8 (40.0)	7 (35.0)	
V	6 (30.0)	7 (35.0)	
VI	6 (30.0)	6 (30.0)	

Note: *Continuous variables are presented as the means ± standard deviations; ‡Categorical variables are presented as numbers (percentages); †Independent samples t test; §Chi-square test; $P<0.05$ was considered statistically significant

confirmed via C-arm fluoroscopy to ensure close contact between the plate and the bone cortex (Figs. 1 and 2).

The plate-shaping process followed a three-step bending technique: [1] an overall arc adjustment to fit the medial tibial anatomy; [2] two additional bends to match the curvature of the medial plateau surface in the coronal plane; and [3] a distal twist to align with the medial tibial shaft anatomy (Fig. 3).

Control Group (Traditional Plate Group).

Patients in the control group underwent surgery on the basis of the fracture type, with the surgical position (supine, lateral, or prone) and approach (single or combined) selected accordingly. In some cases, the pes anserinus tendons were transected to adequately expose the fracture site and accommodate the plate; transected tendons were reconstructed postoperatively. Following fracture reduction, traditional T-shaped locking plates (Changzhou Waston Medical Appliance Co., Ltd., model: 30726) were used to fix the tibial plateau, with posteromedial reconstruction plates applied if necessary. C-arm fluoroscopy was used to confirm fracture reduction and plate positioning (Fig. 4).

Outcome measures

Clinical outcomes were assessed by recording surgical time and intraoperative blood loss. Postoperative follow-ups were conducted at 3 days, 3 months, 6 months, and 12 months to evaluate knee function and fracture healing. Radiographic criteria for fracture healing included the formation of continuous trabeculae. Knee function was comprehensively evaluated via the HSS scoring system, which assesses pain, function, range of motion, muscle strength, flexion deformity, and joint stability [21]. Complications such as incision infection, implant loosening, deep vein thrombosis, and nonunion were recorded.

Statistical analysis

All the statistical analyses were performed via SPSS software (version 25.0). Continuous data are expressed as the means ± standard deviations (SDs) and were compared via independent sample t tests. Categorical data are presented as frequencies (percentages) and were analyzed via Fisher's exact test. Comparisons of HSS scores between groups were conducted via independent sample t tests. A significance level of $\alpha=0.05$ was applied, and $P<0.05$ was considered statistically significant.

Results

Baseline characteristics

A total of 40 patients with Schatzker IV-VI tibial plateau fractures were included in this study, with 20 patients in the experimental group (mHSMP group) and 20 patients in the control group (traditional plate group). The mean age was 42.7 ± 16.9 years in the experimental group and 48.6 ± 11.8 years in the control group. There were no significant differences between the two groups in terms of age ($P=0.271$), sex distribution ($P=0.436$), mechanism of injury ($P=0.836$), or fracture classification ($P=0.954$), ensuring baseline comparability between the groups (Table 1).

3.2 Surgical outcomes and complications

The mean surgical time was 168.3 ± 46.2 min in the experimental group and 175.4 ± 43.8 min in the control group, with no statistically significant difference between the two groups ($P=0.673$). The amount of intraoperative blood loss was 168.0 ± 65.7 mL in the experimental group and 192.0 ± 77.4 mL in the control group, which was not significantly different ($P=0.395$). The time to fracture healing was 14.4 ± 1.1 weeks in the experimental group and 14.5 ± 1.5 weeks in the control group, with no significant difference between the groups ($P=0.845$) (Table 2).

In terms of complications, two patients (10.0%) in the experimental group experienced superficial surgical site infections, while one patient (5.0%) in the control group developed a superficial surgical site infection, and two patients (10.0%) experienced lower extremity deep vein thrombosis. The overall complication rates were not significantly different between the two groups (10.0% vs. 15.0%, $P=1.000$) (Table 2). All complications were effectively managed with appropriate interventions.

Functional outcomes

Knee joint functional assessments revealed that the experimental group had significantly higher HSS scores than did the control group at 3 days postsurgery (50.2 ± 1.7 vs. 43.6 ± 1.8, $P<0.001$), 3 months postsurgery

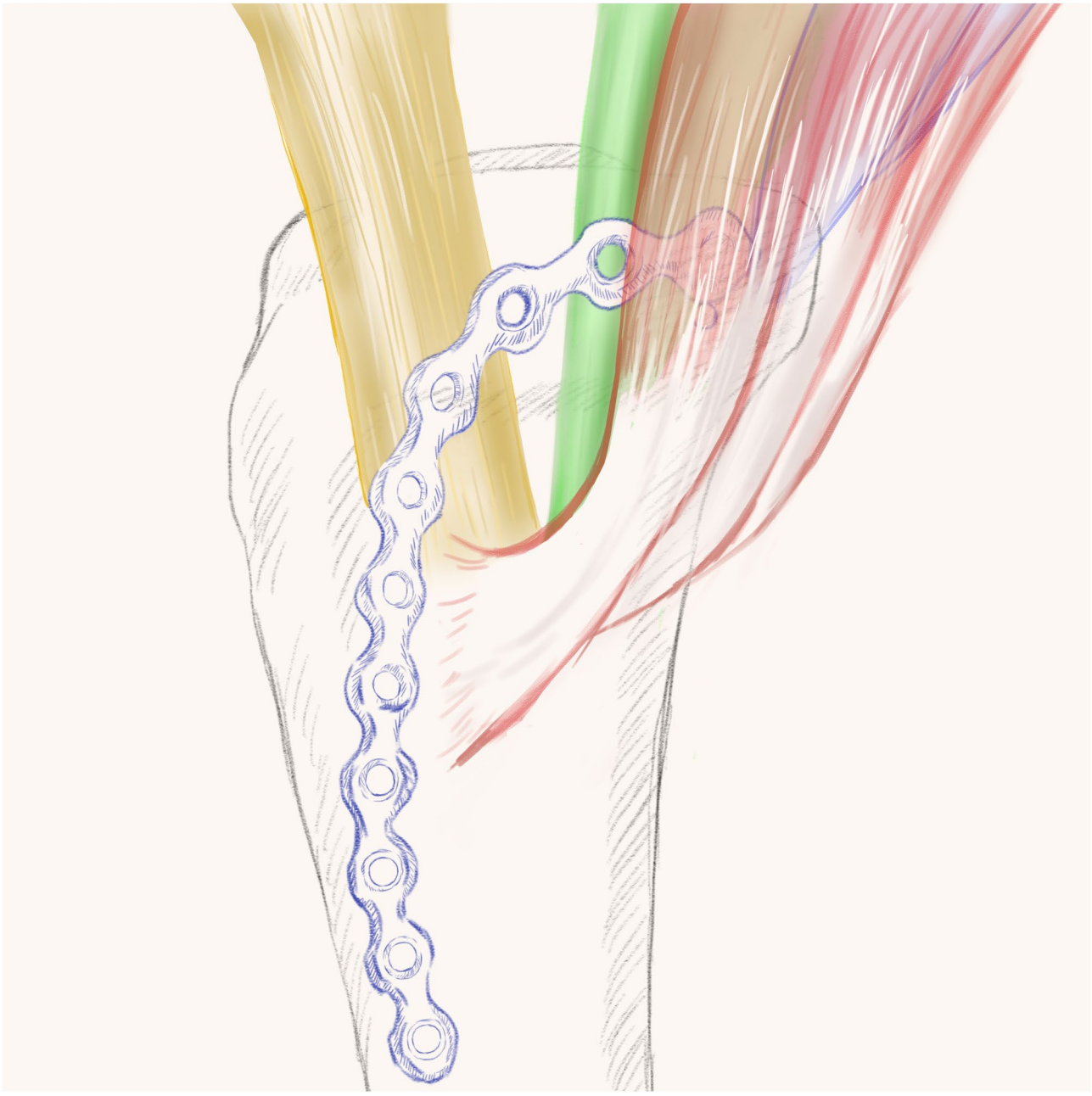

Fig. 1 The schematic diagram illustrates the placement of the mHSMP. The following structures were labeled: the medial patellar support band in light yellow, the medial collateral ligament in green, the semitendinosus in sky blue, the pes anserinus in red, and the plate in dark blue

(68.2 ± 1.8 vs. 61.7 ± 1.9, $P < 0.001$), and 6 months post-surgery (83.2 ± 1.9 vs. 76.7 ± 2.1, $P < 0.001$). These results demonstrated the superior early functional recovery achieved with the mHSMP. However, at the 12-month follow-up, there was no statistically significant difference in the HSS score between the two groups (89.2 ± 1.8 vs. 86.4 ± 4.5, $P = 0.082$) (Table 3; Fig. 5).

Discussion

Limitations of existing fixation techniques and directions for optimization

In the treatment of Schatzker IV-VI tibial plateau fractures, traditional fixation methods (e.g., T-shaped medial plates, TomoFix plates, reconstruction plates, and double-plating techniques) provide sufficient mechanical strength but are limited by their significant interference with soft tissues. For example, the implantation of traditional plates often requires extensive stripping of the

Fig. 2 Illustration of the treatment process for a Schatzker VI tibial plateau fracture via the mHSMP. This case involves a patient who sustained a left tibial plateau fracture as a result of a traffic accident. Preoperative anteroposterior and lateral X-rays (Fig. 2**A, B**) revealed a severely comminuted fracture of the tibial plateau. The fracture morphology was further clarified through three-dimensional CT reconstruction (Fig. 2**C, D**). During surgery, the mHSMP was shaped and positioned with precision, as shown in the schematic representation of the surgical incision and plate placement (Fig. 2**E, F**). Postoperative X-rays at 3 days (Fig. 2G, H) confirmed satisfactory fracture reduction and stable internal fixation. At the 1-year follow-up, X-rays demonstrated excellent fracture healing (Fig. 2**I, J**), whereas the patient's knee flexion and extension ability had recovered to a satisfactory level, as shown in the clinical evaluation (Fig. 2**K, L**). This case highlights the clinical effectiveness of the mHSMP in achieving early functional recovery and stable fixation in complex tibial plateau fractures

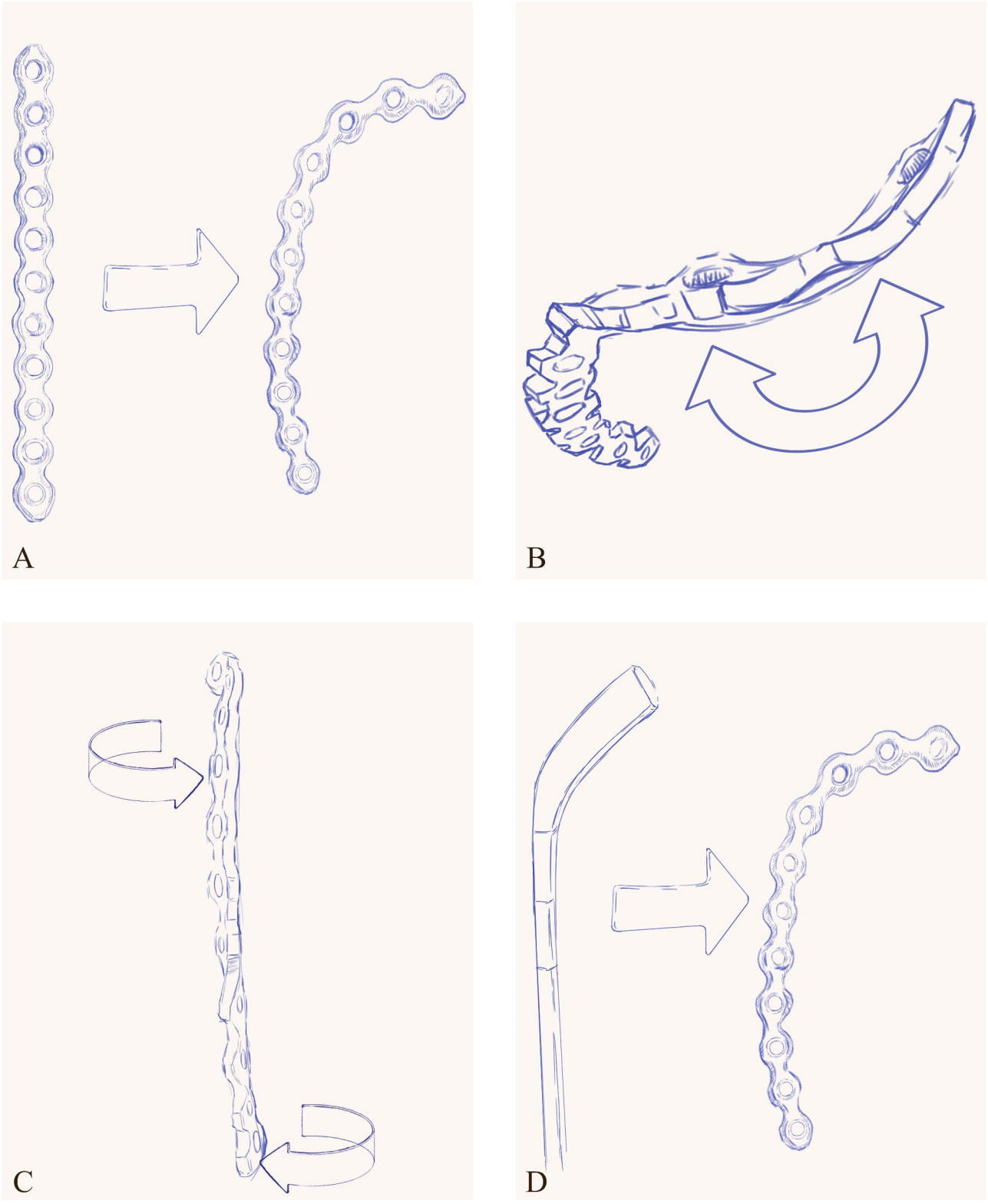

Fig. 3 The mHSMP was prepared via a three-step bending technique. **A**: Overall arc adjustment to generally conform to the medial tibial anatomical structure; **B**: Two bends on the basis of the surface curvature of the medial plateau in the coronal plane to further enhance fit; **C**: Distal twisting of the plate to match the anatomical characteristics of the medial tibial shaft; **D**: The final shape of the plate resembles a hockey stick

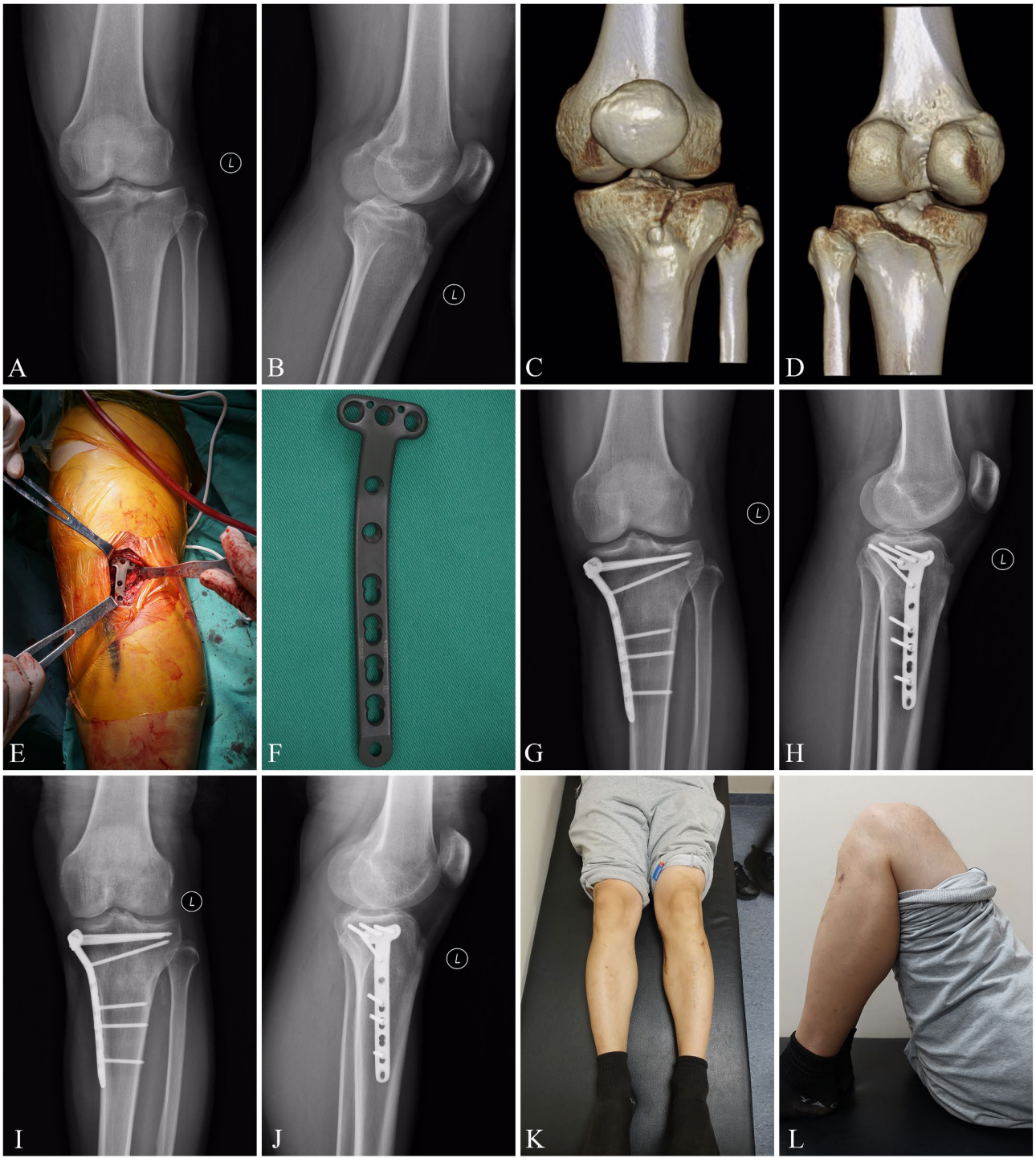

Fig. 4 Demonstration of the treatment process for a Schatzker IV tibial plateau fracture via a traditional medial T-shaped plate. This case involves a patient who sustained a left tibial plateau fracture due to an electric scooter accident. Preoperative anteroposterior and lateral X-rays (Fig. 4**A, B**) revealed a medial plateau fracture. The fracture morphology was further detailed through three-dimensional CT reconstruction (Fig. 4**C, D**). During surgery, the T-shaped plate was positioned and secured, as shown in the schematic representation of the surgical incision and plate placement, along with the shape of the plate (Fig. 4**E, F**). Postoperative X-rays at 3 days (Fig. 4G, H) confirmed satisfactory fracture reduction and stable internal fixation. At the 1-year follow-up, X-rays indicated excellent fracture healing (Fig. 4**I, J**), and the patient's knee flexion and extension function had recovered satisfactorily, as shown in the clinical evaluation (Fig. 4**K, L**). This case highlights the utility of the traditional T-shaped plate in achieving stable fixation and functional recovery in medial tibial plateau fractures

Table 2 Comparison of intraoperative data, fracture healing, and complications between groups

Variables	Experimental group ($n=20$)	Control group ($n=20$)	*P* value
Operation time (minutes)*	168.3 ± 46.2	175.4 ± 43.8	0.673†
Blood loss (mL)*	168.0 ± 65.7	192.0 ± 77.4	0.395†
Healing time (weeks)*	14.4 ± 1.1	14.5 ± 1.5	0.845†
Complications‡			
Surgical site infection	2 (10.0)	1 (5.0)	-
Deep vein thrombosis	0 (0.0)	2 (10.0)	-
Total complications	2 (10.0)	3 (15.0)	1.000¶

Note: ¶Fisher's exact test

Table 3 Comparison of postoperative HSS scores between groups

Time point	Experimental group ($n=20$)	Control group ($n=20$)	*P* value†
3 days*	50.2 ± 1.7	43.6 ± 1.8	< 0.001
3 months*	68.2 ± 1.8	61.7 ± 1.9	< 0.001
6 months*	83.2 ± 1.9	76.7 ± 2.1	< 0.001
12 months*	89.2 ± 1.8	86.4 ± 4.5	0.082

PMC of the knee, which can lead to soft tissue functional damage and postoperative inflammation [10, 12–15, 20]. Furthermore, these methods frequently involve complex intraoperative positional adjustments and multistep procedures, imposing high technical demands on surgeons and requiring seamless team coordination [12, 16]. These challenges significantly increase surgical complexity and may delay early functional recovery for patients.

The mHSMP was designed to overcome these issues. Through personalized shaping, the plate conforms more closely to the anatomical characteristics of the medial tibial plateau. The distal curvature of the plate is positioned anteriorly, effectively reducing mechanical friction with the pes anserinus tendons, thereby lowering the incidence of postoperative inflammation. This design also streamlines the surgical process by reducing the dependence on intraoperative positional adjustments, enhancing surgical efficiency, and minimizing complications caused by excessive soft tissue stripping [22, 23].

Clinical advantages and surgical optimization of the modified plate

This study compared the clinical outcomes of the mHSMP with those of traditional medial plates in the treatment of Schatzker IV-VI tibial plateau fractures. Compared with the traditional plate, the mHSMP significantly improved early knee joint function, as evidenced by higher HSS scores at 3 days, 3 months, and 6 months postoperatively. This highlights the clinical advantage of the mHSMP in promoting early postoperative recovery of knee function.

The hockey-stick-shaped design was tailored to the anatomical features of the medial tibial plateau. By positioning the distal end of the plate anteriorly to avoid tibial insertion of the pes anserinus tendons and achieving closer cortical bone contact through intraoperative shaping, the plate reduces friction and irritation between the implant and soft tissues, particularly the pes anserinus tendons. This structural optimization decreases the incidence of postoperative soft tissue inflammation, thereby minimizing interference during the rehabilitation process. It also improves patient comfort and facilitates early functional recovery [22, 23].

Notably, patients in the mHSMP group were able to achieve 90 degrees of knee flexion without pain within 1–2 weeks postoperatively, demonstrating significant early recovery potential. In contrast, patients in the traditional plate group often experienced limited knee flexion during the same follow-up period because of soft tissue irritation or postoperative pain. Although no statistically significant difference in HSS scores was observed between the two groups at 12 months postoperatively, the early recovery advantage of the mHSMP cannot be overlooked, as it provides better initial experience for functional rehabilitation.

From a surgical perspective, the design of the mHSMP significantly simplifies intraoperative procedures. Its anteriorly positioned distal end reduces the need for extensive posteromedial exposure, minimizes interference with the PMC, and avoids excessive stripping of soft tissues such as the pes anserinus tendons. This design not only simplifies surgical steps but also lowers the risk of complications related to soft tissue retraction. The mHSMP offers high intraoperative malleability, allowing precise contouring to match the anatomical features of the medial tibial plateau. This reduces the need for adjustments during implantation. The results of this study revealed no significant differences between the mHSMP group and the traditional plate group in terms of surgical time, intraoperative blood loss, or complication rates, indicating that the new plate maintains safety while offering excellent applicability. Its streamlined surgical workflow is particularly suitable for the treatment of complex fractures, providing a solid foundation for early functional recovery.

Cost-effectiveness analysis

Although this study did not directly evaluate economic outcomes, the mHSMP indirectly reduces surgical costs by simplifying procedures and shortening operative times. Additionally, the significant improvement in early functional recovery associated with the mHSMP may shorten postoperative rehabilitation periods, thereby reducing hospital stays and subsequent rehabilitation expenses. These findings suggest that the mHSMP offers high cost-effectiveness in clinical practice.

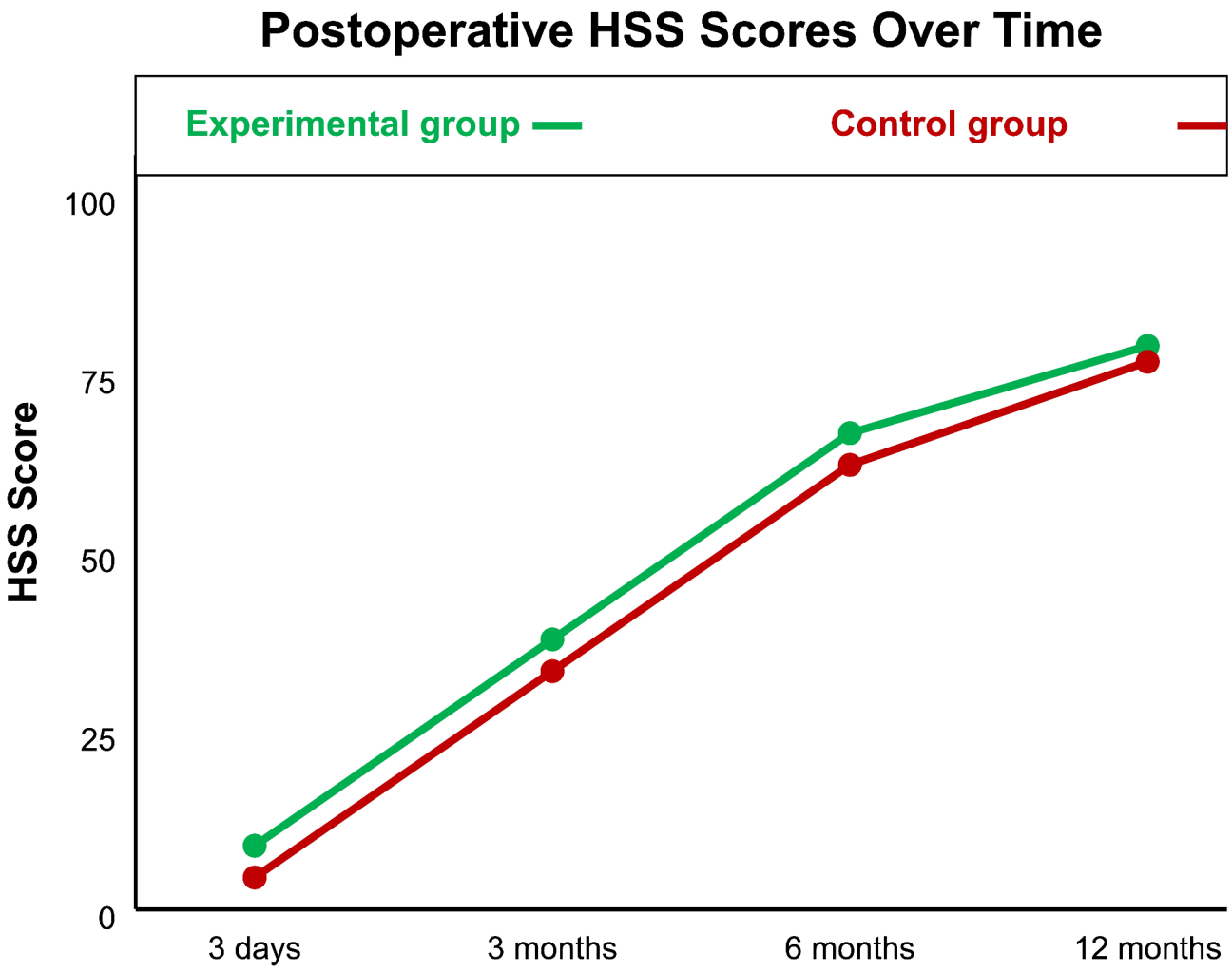

Fig. 5 Shows the trend of postoperative HSS scores. Compared with that of the traditional plate group, the early recovery of the mHSMP group was superior

Limitations and future directions

Despite the numerous advantages of the mHSMP, there are still challenges in its clinical application that warrant attention. Currently, the mHSMP relies on substantial three-dimensional bending, limiting its use to stainless steel reconstruction plates. This technique requires surgeons to possess precise intraoperative plate-bending skills, particularly accurate assessments of the medial tibial plateau anatomy and plate prebending ability (Fig. 3). To ensure proper positioning and fixation strength, proximal placement of the plate necessitates limited detachment of the semimembranosus muscle at its posteromedial insertion, which increases the technical complexity of the procedure. Surgeons must therefore have a precise understanding of the local anatomical structures and refine surgical techniques.

Although plate bending takes additional time during surgery, the procedure can be completed in the supine position, reducing the need for special surgical positions or repeated positional adjustments. This simplifies the surgical approach and exposure time, ultimately balancing the overall surgical duration. However, in cases of tibial plateau fractures with severe soft tissue injury, even with minimally invasive plate osteosynthesis (MIPO), subcutaneous plate placement may be limited. Surgeons should avoid repeated bending of the plate during shaping to prevent metal fatigue and compromise the fixation strength [11, 14, 24, 25].

This study has certain limitations. Although patients with severe osteoporosis were excluded, we did not perform a dedicated analysis of osteoporotic patients. Osteoporotic patients present unique challenges in the treatment of tibial plateau fractures, such as reduced implant stability, increased demands for postoperative rehabilitation, and delayed fracture healing [26]. Future research could address this gap by conducting subgroup analyses of plate performance in patients with varying bone densities. Additionally, this study did not directly

evaluate the biomechanical properties of the plate, which should be supplemented through biomechanical testing and analysis in future investigations.

On the basis of the findings of this study and our clinical experience, we have begun developing precontoured, anatomically locked mHSMPs. These new plates aim to combine the advantages of personalized customization with standardized anatomical locking designs to improve surgical efficiency and fixation outcomes, optimizing the clinical application process. Future research will focus on the following directions: conducting large-scale, multicenter, prospective randomized controlled trials with extended follow-up durations, incorporating patient-reported outcomes and quality-of-life assessments, and performing subgroup analyses for specific populations, such as osteoporotic patients, to develop individualized treatment protocols. Furthermore, finite element analysis, static strength testing with Sawbones models, and cadaveric studies will be conducted to systematically evaluate the biomechanical performance of the new plate, verifying its fixation strength and clinical potential. These efforts are expected to provide more precise solutions for the treatment of Schatzker IV-VI tibial plateau fractures.

Conclusions

The mHSMP has significant potential for promoting early functional recovery in the treatment of Schatzker IV-VI tibial plateau fractures. The design provides superior knee function recovery outcomes between 3 days and 6 months postoperatively and reduces the reliance on specific surgical positions, simplifying intraoperative procedures. Moreover, the mHSMP achieves safety and fracture healing outcomes comparable to those of traditional medial plates, showing promising clinical applicability. Although the long-term clinical effects require further validation, this innovative fixation method offers a new option for the treatment of complex tibial plateau fractures and provides a valuable reference for future research and clinical applications.

Abbreviations

CT	Computed tomography
HSS	Hospital for Special Surgery
mHSMP	modified Hockey-Stick Medial Plate
PMC	Posteromedial Complex
MIPO	Minimally invasive plate osteosynthesis

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Author contributions

X.W. (Xiao Wang) and Z.Z. (Zhangyu Zhu) were responsible for the study design, statistical analysis, and manuscript writing. B.L. (Bin Liang), J.Y. (Junwei Yan), and Z.Y. (Zhaowei Yin) performed the surgical treatments. H.X. (Haibo Xu), D.J. (Dongdong Jiang), and H.X. (Haonan Xiu) collected and collated the clinical data. J.Y. (Junwei Yan) and B.L. (Bin Liang) provided overall guidance for the study and revised and quality-controlled the manuscript. All authors reviewed and approved the final manuscript.

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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 Medical Ethics Committee of Nanjing First Hospital. Approval No: KY20241209-KS-01.

Consent to publish

The typical case patients presented in the manuscript agreed to the publication of their medical data (including medical records, photographs, and imaging data).

Competing interests

On behalf of all the authors, the corresponding author declares no conflicts of interest.

Consent to participate

As a retrospective study, informed consent was waived.

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References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37(8):691–7.
2. Elsoe R, Larsen P, Nielsen NPH, Swenne J, Rasmussen S, Ostgaard SE. Population-based epidemiology of tibial plateau fractures. Orthopedics. 2015;38(9):e780–786.
3. Yan B, Sun J, Yin W. The prevalence of soft tissue injuries in operative Schatzker type IV tibial plateau fractures. Arch Orthop Trauma Surg. 2020;141(8):1269–75.
4. Rademakers MV, Kerkhoffs GMMJ, Sierevelt IN, Raaymakers ELFB, Marti RK. Operative treatment of 109 tibial plateau fractures: five- to 27-year follow-up results. J Orthop Trauma. 2007;21(1):5–10.
5. Prat-Fabregat S, Camacho-Carrasco P. Treatment strategy for tibial plateau fractures: an update. EFORT Open Rev. 2016;1(5):225–32.
6. Schatzker J, McBroom R, Bruce D. The tibial plateau fracture: the Toronto experience 1968–1975. Clin Orthop. 1979;138:94–104.
7. Neidlein C, Watrinet J, Pätzold R, Berthold DP, Prall WC, Böcker W, et al. Patient-Reported outcomes following tibial plateau fractures: Mid- to Short-Term implications for knee function and activity level. J Clin Med. 2024;13(8):2327.
8. Schatzker J, Kfuri M. Revisiting the management of tibial plateau fractures. Injury. 2022;53(6):2207–18.
9. Samsami S, Pätzold R, Neuy T, Greinwald M, Müller PE, Chevalier Y, et al. Biomechanical comparison of 2 double plating methods in a coronal fracture model of bicondylar tibial plateau fractures. J Orthop Trauma. 2022;36(4):e129–35.
10. Söylemez MS, Cepni SK, Kemah B, Batar S. Posteromedial plate application using medial midline incision for complex tibia plateau fractures: a retrospective study. BMC Musculoskelet Disord. 2022;23(1):129.
11. Huang X, Zhi Z, Yu B, Chen F. Stress and stability of plate-screw fixation and screw fixation in the treatment of Schatzker type IV medial tibial plateau fracture: a comparative finite element study. J Orthop Surg. 2015;10(1):182.
12. Cho KY, Oh HS, Yoo JH, Kim DH, Cho YJ, Kim KI. Treatment of Schatzker type V and VI tibial plateau fractures using a midline longitudinal incision and dual plating. Knee Surg Relat Res. 2013;25(2):77–83.
13. Liu Zyu, Zhang J li, Liu C, Cao Q, Shen Qjie, Zhao J. chao. Surgical strategy for anterior tibial plateau fractures in hyperextension knee injuries. Orthop Surg. 2021;13(3):966–78.
14. Biggi F, Fabio SD, D'Antimo C, Trevisani S. Tibial plateau fractures: internal fixation with locking plates and the MIPO technique. Injury. 2010;41(11):1178–82.

15. Chang SM, Hu SJ, Zhang YQ, Yao MW, Ma Z, Wang X, et al. A surgical protocol for bicondylar four-quadrant tibial plateau fractures. Int Orthop. 2014;38(12):2559–64.
16. Zheng Y, Zhang JD, Shen JJ, Huang JF. out-in position in the surgical treatment of three-column tibial plateau fractures: A technical note. Injury. 2021;52(4):1074–8.
17. Lundquist RB, Matcuk GR, Schein AJ, Skalski MR, White EA, Forrester DM, et al. Posteromedial corner of the knee: the neglected corner. Radiographics. 2015;35(4):1123–37.
18. Charalambous CP, Kwaees TA. Anatomical considerations in hamstring tendon harvesting for anterior cruciate ligament reconstruction. Muscles Ligaments Tendons J. 2012;2(4):253–7.
19. Benninger B, Delamarter T. Distal semimembranosus muscle-tendon-unit review: morphology, accurate terminology, and clinical relevance. Folia Morphol. 2013;72(1):1–9.
20. LaPrade RF, Engebretsen AH, Ly TV, Johansen S, Wentorf FA, Engebretsen L. The anatomy of the medial part of the knee. J Bone Jt Surg. 2007;89(9):2000–10.
21. Ranawat CS, Insall J, Shine J. Duo-condylar knee arthroplasty: hospital for special surgery design. Clin Orthop. 1976;(120):76–82.
22. Lin W, Su Y, Lin C, Guo W, Wu J, Wang Y, et al. The application of a three-column internal fixation system with anatomical locking plates on comminuted fractures of the tibial plateau. Int Orthop. 2015;40(7):1509–14.
23. Berkson EM, Virkus WW. High-energy tibial plateau fractures. J Am Acad Orthop Surg. 2006;14(1):20–31.
24. Rozell JC, Vemulapalli KC, Gary JL, Donegan DJ. Tibial plateau fractures in elderly patients. Geriatr Orthop Surg Rehabil. 2016;7(3):126–34.
25. Moran E, Zderic I, Klos K, Simons P, Triana M, Richards RG, et al. Reconstruction of the lateral tibia plateau fracture with a third triangular support screw: A Biomechanical study. J Orthop Transl. 2017;11:30–8.
26. García Vélez DA, Headford M, Suresh KV, Liberatos PM, Bledsoe G, Revak T. Biomechanical analysis of dual versus lateral locked plating in elderly bicondylar tibial plateau fractures: does medial comminution matter? Injury. 2022;53(10):3109–14.

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