Treatment of Tibial Plateau Fractures Involving Posterolateral Column Through the Extended Anterolateral Approach

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Research Article

Keywords: Posterolateral tibial plateau fracture, Extended anterolateral approach, Surgical treatment, Fracture reduction and fixation

Posted Date: February 15th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-198072/v1>

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Abstract

Objective

To summarize the surgical technique and the clinical effects of extended anterolateral approach for the treatment of Schatzker type II and Schatzker type V/VI which involving the posterolateral column tibial plateau.

Methods

From January 2015 through December 2018, a total of 28 patients with tibial plateau fracture involving posterolateral column were included in this study. Among them, 16 patients were Schatzker type II treated via extended anterolateral approach with lateral tibial locking compression plate fixation. 12 patients were Schatzker type V or VI treated via extended anterolateral combine with medial approach by lateral tibial locking compression plate plus medial locking compression plate fixation. All cases were followed up for 15~31 months, with an average follow-up of 22.5 ± 3.7 months. During the follow-up, the tibial plateau angle (TPA), lateral posterior angle (PA) and Rasmussen radiological criteria were used to evaluate the effect of fracture reduction and fixation; the Hospital for Special Surgery (HSS) and the range of motion were used to evaluate knee function; the Lachman and knee Valgus (Varus) stress test were used to evaluate anteroposterior and lateral stability of the knee.

Results

All fractures healed. At the 12-month follow-up: in Schatzker type II group a mean TPA of $86.38 \pm 3.92^\circ$, a mean PA of $7.43 \pm 2.68^\circ$, and Rasmussen radiological score with an average of 16.00 ± 2.06 points, scores were excellent in 6 cases and good in 10 cases, as a result the excellent and good rate was 100%; while in Schatzker type V/VI group a mean TPA of $84.91 \pm 3.51^\circ$, a mean PA of $9.68 \pm 4.01^\circ$, and Rasmussen radiological score with an average of 15.33 ± 2.99 points, scores were excellent in 4 cases and good in 6 cases, as a result the excellent and good rate was 83.33%. During the one-year follow-up, when re-measured postoperative PA, TPA, Rasmussen score of the two groups did not change significantly ($P > 0.05$). At the last follow-up, in Schatzker type II group, the knee flexion angle was $110^\circ \sim 135^\circ$, with an average of $125^\circ \pm 8.56^\circ$, a mean of HHS score 88.37 ± 10.01 points, scores were excellent in 9 cases and good in 5 cases, as a result the excellent and good rate was 100%; in Schatzker type V/VI group, the knee flexion angle was $100^\circ \sim 130^\circ$, with an average of $120^\circ \pm 11.25^\circ$, a mean of HHS score 82.17 ± 10.76 points, scores were excellent in 5 cases and good in 3 cases, as a result the excellent and good rate was 66.67%. In addition, up to the last follow-up, Lachman and knee Valgus (Varus) stress test results of the two groups were negative. No complications were found.

Conclusions

Although there are many ways to treat posterolateral tibial plateau fractures, When choosing one or more combined approach, we must consider the condition of soft tissue injury, the shape of the whole platform fracture including the posterolateral bone block and the available fixation methods. The best approaches

should provide maximum exposure of the platform, enough space for reduction and fixation, and minimum damage to the surrounding structures. For anterolateral platform fractures combine with isolated posterolateral fracture fragments, the extended anterolateral approach is more suitable as a single approach. For multiple column tibial plateau fractures a dual approach (extended anterolateral combined with medial approach) can be used to enter the whole plateau area.

1. Introduction

Tibial plateau fracture is an intra-articular fracture, always accompanied by varying degrees of depression, displacement, surgical complications, affect the stability and movement ability of the knee. In the later stage, it aggravated the degeneration of knee joint and traumatic arthritis. The posterolateral fracture of tibial plateau fracture is defined as any single fracture segment based on the posterolateral quadrant, or the fracture line extends to the posterolateral cortical bone[1]. With the development of CT(computed tomography) and image reconstruction technology, the Schatzker and AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen) classification based on X-ray examination can not meet the practical needs, Luo[2,3] et al, proposed three column classification of tibial plateau through multi-dimensional reconstruction images to improve the evaluation of tibial plateau fractures. After that our understanding of tibial plateau fractures has gradually deepened. Recently, an epidemiological statistical analysis of tibial plateau fractures found that the classification of single lateral column fractures are relatively rare, which incidence is only 12.54%, while the incidence of posterolateral column fractures is 62.69% [1,4]. Among all kinds reason of high-energy injuries, the proportion of injuries caused by electric vehicle traffic accidents is as high as 32.42%, nowadays the electric bicycles are widely used to commute around the world already[5]. Traditionally, anterolateral approach is used to solve these fractures by direct reduction and fixation. However, the traditional anterolateral approach are difficult to access the posterolateral angle (the posterolateral column of the tibial plateau) behind the fibular head. In order to increase the exposure and operation space of posterolateral tibial plateau, the clinical efficacy of extended anterolateral approach in the treatment of posterolateral tibial plateau fractures in our hospital from 2015 to 2018 was retrospectively analyzed.

2. Materials And Methods

2.1 Inclusion and Exclusion Criteria

Inclusion criteria: (i) The lateral tibial plateau fracture, by preoperative CT examination of the knee, fracture line involved the posterior column, (ii) extended anterolateral approach was used in the operation, (iii) no vascular and nerve injury, (iv) no osteofascial compartment syndrome.

Exclusion criteria: (i) Multiple fractures of the ipsilateral lower limb, (ii) primary disease of the ipsilateral hip and ankle joint, unable to walk normally before injury, (iii) severe degeneration of the knee joint with osteoarthritis, dysfunction, (iv) previous history of rheumatoid arthritis or rheumatoid arthritis, (v) follow-up time less than 12 months, (vi) old fracture.

2.2 General Information

A total of 28 patients who met the above criteria from January 2015 to December 2018 were selected and divided into two groups according to Schatzker classification: Schatzker type II group and Schatzker type V/VI group. In Schatzker type II group, included of 5 males and 11 females, at a mean age of 48.06 ± 12.58 years (range 28~68 years); Causes of injury: 8 cases of traffic accidents, 6 cases of falls, and 2 cases of other injuries. In Schatzker type V/VI group, included of 8 males and 4 females, at a mean age of 49.75 ± 10.17 years (range 29~67 years); Causes of injury: 7 cases of traffic accidents, 2 cases of falls, and 3 cases of other injuries. The demographic information are shown in Table 1.

2.3 Preoperative planning

Before the operation all patients underwent knee X-ray, CT three-dimensional reconstruction, MRI(Magnetic Resonance Imaging) examination and lower extremity vascular color Doppler ultrasound before operation to determine the fracture type, articular surface depression degree, fracture displacement degree, whether combined with knee ligament and meniscus injury, whether combined with lower extremity deep venous thrombosis, exclude preoperative contraindications, and formulate individualized operation plan according to the results of radiologic examination.

On the first day of hospitalization, all patients were treated with limb elevation, detumescence and pain relief. 16 patients with severe swelling of the soft tissue around the knee joint or obvious displacement of the fracture end were treated with calcaneal bone traction. The traction weight was one twelfth of their body weight.

2.4 The Surgical Method

- i. Position: The patient was set supine position, after general or epidural anesthesia, the calcaneal traction device was removed, and sterile sheet was placed under the injured shank to make the knee joint slightly bent at about 30 degrees position.
- ii. Incision: the incision starts from the anterior edge of biceps femoris (about 5cm above the crease of knee joint) and extends down to the level of fibular head, then arc cuts forward, through the Gerdy's tubercle or the front edge of the fibular head, next about 3 cm outside the tibial tubercle was used as the marker point, the incision was parallel to the anterior edge of fibula, passing through the marked point and extending to the distal tibia, the whole incision showed a "s" shape and with a length of 10-15cm.
- iii. Exposure: After incision of skin and subcutaneous tissue, incision was made along the space between iliotibial tract and biceps femoris tendon, and then iliotibial tract and lateral collateral ligament were separated from anterolateral proximal tibia, after that the coronal ligament and lateral joint capsule were cut to release the blood in the joint cavity, and varused knee joint to expose the lateral tibial plateau. After that, the edge of lateral meniscus was sutured and suspended with surgical suture and the lateral collateral ligament was pulled back, finally the depressed posterolateral articular surface of tibial plateau could be seen under direct vision.

- iv. Reduction: According to the compression range and depth of tibial plateau, the circular saw opened the bone cortex under the anterolateral tibial plateau and then the bone marrow canal was established. Restoration the collapsed articular surface with the “reduction rod”, after that autologous bone or allogeneic bone was implanted to support under tibial plateau and bone marrow canal. Through the reduction forceps and Kirschner wire make the fracture was temporarily fixed. Then the C-arm X-ray checked the reduction.
- v. Fixation: After the fracture reduction, the lateral tibial plateau locking plate was inserted. Technique: the locking plate was placed as far back as possible, and the height was about above the fibular head. Four transverse 3.5mm locking screws on the plate head were used to further strengthen and support the articular surface of tibial plateau. For some partial comminuted posterolateral splitting fractures, one or two additional screws were added from the lateral position of the tibial plateau to the direction of the posterior wall bone block to assist compression fixation.

For cases which involving three lateral column fractures (Schatzker type V/ VI) take extended anterolateral combine with medial approach. The arc-shaped incision was located at the medial side of the knee joint, about 15 cm long, cut apart the skin and subcutaneous tissue to expose pesanserinus tendon anterior segment of gastrocnemius, while there is a gap between them, next along the direction of skin incision to cut pesanserinus tendon and marked it with operative suture. Then separated the gastrocnemius from this gap, finally medial tibial plateau fracture line became visible. On the same conditions, reduction, Kirschner wire temporary fixation, C-arm X-ray checked the reduction, use the medial tibial plateau locking plate fixation fracture.

2.5 Surgical technique and experience

- i. Locking plate should be placed as far back as possible, even above the fibular head, covering the posterolateral articular surface otherwise, the edge of the plate may protrude from the skin overlap, leading to skin necrosis or postoperative pain.
- ii. When the reduction forceps holder could not restore the width of tibial plateau, it should be considered that the meniscus may be embedded in the fracture line near the intercondylar spine. During the operation, we found that the lateral meniscus of Schatzker type V/ VI fracture was often embedded in the fracture end, which hindered the reduction, the exposure of the extended anterolateral approach allows the detection of lateral meniscus injury (also helpful for reduction and fixation of avulsion fracture of anterior cruciate ligament).
- iii. When using the “reduction rod” to restoration, gently knocking the depressed articular bone block, a little excessive reduction can be used to compensate for the loss of articular surface height during the subsequent operation.
- iv. The reduction sequence usually starts from the medial side, because the medial bone block is generally large, and the overall split, the degree of comminution is low, it is easy to find the reduction mark.

Fig. 1 The extended anterolateral approach exposure articular surface and use the “reduction rod” to restore depressed area, then the established tibial bone tunnel was filled with autogenous or allogeneic bone

2.6 Postoperative Treatment

Postoperative routine drainage lasted for 48 hours and antibiotics were used for 24 hours to prevent infection. Active knee flexion and extension were performed on the second day after operation. CPM(Continuous passive motion machine) was used twice a day for 2 hours until the knee joint reached 0 ° to 95 ° flexion for some patients had poor knee function. The range of knee motion of all patients gradually increased at least 5 ° each day, until the range reached more than 120 °. After operation 12 weeks, the patients began to load gradually.

2.7 Follow-up and Evaluation Indicators

The operation time, blood loss, fracture healing time, hospital stay, and postoperative complications of each patient were recorded. All patients were followed up every three months, through the physical examination and standard X-ray radiographs were obtained at each follow-up visit to evaluate the recovery of knee joint function and range of motion. In addition, Anteroposterior and lateral stability of the knee joint was measured by Lachman and knee Valgus (Varus) stress test. Rasmussen radiological score system[6] was used to evaluate fracture reductions and fixation. The total score of Rasmussen radiological score was 18 points, including the degree of articular surface collapse (6 points), width of tibial plateau (6 points) and angular deformity (6 points). 18 points were excellent, 12-17 points were good, 6-11 points were fair, and 0-5 points were poor. The knee joint function was evaluated by HSS (Hospital for Special Surgery) score system[7], it included mainly includes pain (30 points), function (22 points), range of motion (18 points), muscle strength (10 points), knee deformity (10 points) and knee stability (10 points), 85-100 points were excellent, 70-84 points were good, 60-69 points were fair, and less than 60 points were poor.

PACS (Picture Archiving and Communication Systems) was used to measure two parameters on X-ray of knee joint: TPA(tibial plateau angle): medial angle formed by tibial anatomical axis and tibial plateau tangent on anteroposterior X-ray of knee joint; lateral PA(posterior angle): angle formed by the intersection of lateral line of tibial plateau at the vertical line of anterior tibial cortex on lateral X-ray of knee joint. Loss of reduction was defined as tibial plateau depression > 2mm, $TPA \geq 95^\circ$ and $PA \geq 15^\circ$. Further displacement of fracture was defined as the articular surface of tibial plateau was depression > 2mm, TPA or PA difference > 5 ° compared with immediate postoperative X-ray radiographs[8].

2.8 Statistical Analysis

The statistical analyses of the data were performed using SPSS(Statistical Product and Service Solutions) 24.0 software. Data were expressed as mean $\pm$ SD. With regard to repeated measurement data,

such as the TPA,PA,and Rasmussen score were compared using one-way ANOVA(analysis of variance), and the difference was statistically significant at $P<0.05$.

3. Result

3.1 Statistics of perioperative

The mean operation time was 81.68 ± 18.59 min, and the mean blood loss volume was 79.37 ± 23.79 ml in group of Schatzker type II; The mean operation time was 141.25 ± 30.46 min, and the mean blood loss volume was 114.16 ± 50.89 ml in group of Schatzker type V/VI. The surgical details are presented in Table 2. In group of Schatzker type II, patients were treated with lateral tibial locking compression plate fixation (Fig. 2); In Schatzker type V/VI group, patients were treated with lateral tibial locking compression plate plus medial locking compression plate fixation(Fig. 3).

Female patient, 28 years old, right tibial plateau fracture (Schatzker type II) and fibular head fracture due to traffic accident injury. Preoperative X-ray and CT cross-sectional, coronal and sagittal reconstruction showed that the fracture line involved the posterior and lateral column(A~F). Extended anterolateral approach, L-shaped plate plus auxiliary screw fixation in the treatment. Immediately Post-op X-ray (G,H), anatomical reduction was achieved. 15 months after operation X-ray(I,J), articular surface without depress and the width of tibial plateau without increase.

Male patient, 47 years old, left tibial plateau fracture (Schatzker type VI) due to traffic accident injury. Preoperative X-ray and CT reconstruction showed that the fracture line involved the medial, lateral and posterior three columns (A~I). Extended anterolateral combined medial approach, L-shaped locking compression plate plus medial locking compression plate fixation in the treatment. Immediately Post-op X-ray (J,K), anatomical reduction was achieved. 12 months after operation X-ray(L,M), the fracture healed well and the fracture line was blurred,and articular reduction was still maintained.

3.2 Fracture Healing

All 28 patients in this review were followed up for 15~31 months, with an average of 22.51 ± 3.76 months. Bone healing was achieved in all patients. Fracture healing time for the Schatzker type II which take extended anterolateral approach was 12~17 weeks, with an average of 15.81 ± 2.73 weeks; Fracture healing time for the Schatzker type V/VI which take extended anterolateral and medial approach was 13~19 weeks, with an average of 16.83 ± 3.53 weeks.

3.3 Radiological follow-up evaluation

Until to the last follow-up there is no reduction loss and the width of the platform and the lower limb force line were normal in Schatzker type II group.But in Schatzker type V/ VI group 2 patient tibial plateau depression over 2mm, belong to further displacement criteria. According to the Rasmussen radiological system, the scores at the 12 month after operation follow-up were:the Schatzker type II group score was 12~18 points, with an average of 16.00 ± 2.06 points; scores were excellent in 6 cases and good in 10

cases, as a result the excellent and good rate was 100%. While Schatzker type V / VI group score was 10~18 points, with an average of 15.33 ± 2.99 points; scores were excellent in 4 cases and good in 6 cases, as a result the excellent and good rate was 83.33%. During the one-year follow-up, when re-measured postoperative PA, TPA, Rasmussen score of the two groups did not change significantly ($P > 0.05$) (Table 3).

3.4 Function follow-up evaluation

Until to the 12 month after operation follow-up there is no patients experienced no significant influence on daily life and exhibited knee instability. Moreover, both of Lachman and knee Valgus (Varus) stress test results were negative. The knee joint of all patients can reach the full extension position. As to Schatzker type II group, the the knee flexion angle was $110^\circ \sim 135^\circ$, with an average of $125^\circ \pm 8.56^\circ$, and the HSS knee score at the last follow-up was 69~98 points, with an average of 88.37 ± 10.01 points, scores were excellent in 9 cases and good in 5 cases, therefore the excellent and good rate was 100%. For Schatzker type V/VI group, the the knee flexion angle was $100^\circ \sim 130^\circ$, with an average of $120.83^\circ \pm 11.25^\circ$, and the HSS knee score at the last follow-up was 63~95 points, with an average of 82.17 ± 10.76 points, scores were excellent in 5 cases and good in 3 cases, therefore the excellent and good rate was 66.67%.

3.5 Complications

All patients' incisions healed well, no infection and skin necrosis occurred in perioperative period. Up to the last follow-up, no patient had joint stiffness, knee instability, internal fixation loosening, fracture and rejection. But one patient in Schatzker type V/VI group had deep venous thrombosis, and three patients in Schatzker type II group had calf intramuscular venous thrombosis, which were improved after subcutaneous injection of low molecular weight heparin.

4. Discussion

Fractures of the posterolateral column of the tibial plateau are usually caused by axial and valgus forces when the knee joint is in a semi flexion position ($30^\circ \sim 60^\circ$) [9,10], however, our knees happen to be in this position when we ride. Although there is no official treatment guideline for posterolateral column fractures of tibial plateau requiring strict surgical intervention, but with regard to the posterolateral split and collapse fractures of the platform caused by the shear force, if we don't take effective steps to reduction and fixation, the posterolateral stability of the knee may be affected, after weight-bearing of knee joint often leads to further displacement or collapse of fracture, leading to instability of joint flexion and limited range of motion. When the joint surface collapses reach to 3 mm, the local stress will increase by 75%, and the local stress will further increase with the aggravation of the collapse degree, then the abrasion of articular cartilage will increase correspondingly, which will accelerate the degeneration of the joint and seriously affect the function of the knee joint. At present, the generally accepted surgical indications for tibial plateau fractures are: Plateau collapse more than 2 mm, metaphysis displacement more than 1 cm, coronal or sagittal angle more than 10 degrees, all of which should be treated with surgical reduction and internal fixation [11-13].

For a single fracture of the lateral column of the tibial plateau, the standard anterolateral approach is usually sufficient. However, for posterolateral plateau fractures, the fracture line extends to the posterior tibial plane, because of the existence of the fibular head, the standard anterolateral approach is not only relatively difficult to expose, which hinders the visualization of the fracture sites, but also the narrow space between the lateral tibial plateau and the fibular head lead to the plate can not be placed across the fibular head, as a consequence, the fracture of posterior column of tibial plateau was not achieved reduce and fixe. At present, the best surgical approach for posterolateral tibial plateau fractures is still uncertain, but it should have the greatest degree of visualization and easy reduction, and the damage to the surrounding structure is minimal, so as to ensure the quality of reduction, the stability of fixation and ERAS(enhanced recovery after surgery)[1,14]. At the moment, common surgical approaches for posterolateral tibial plateau fractures include direct posterior approach, posterolateral approach with or without fibular osteotomy, posteromedial approach and modified or extended anterolateral approach. Since the posterior surface of the proximal tibia is obviously inclined, and operation area is relatively deep, lead to difficulty restore the depression area and plate fixation in various posterior approaches. In this regard, a variety of improved posterior and combined approaches have also been proposed and promoted, and achieved good results[3,8]. Frosch[15] et al, proposed a improved posterolateral approach, without fibular osteotomy and directly expose the posterolateral column, including the marginal area and posterior wall of the posterolateral platform. Although, it has significant advantages in exposure of posterolateral fracture block and reduction and fixation, however, the exposure of the surface of tibial plateau is poor, and the tibial plateau is mostly collapsed or depression fractures[16], After recovering the depressed articular surface of the platform, with this approach, it is not sure whether it is smooth or not, besides the fracture block in the front of the lateral platform still needs other approaches assist[17]. Furthermore, prone or lateral position should be used in posterior surgery, risk of injury to the lower lateral knee, anterior tibial artery and common peroneal nerve during operation, all of these lead to higher requirements for body position and operation level of doctors, so that posterior approach is usually used for the rare isolated posterolateral coronary shear fractures. In general, all kinds of posteromedial and posterolateral plateau fractures can be solved through posterior approach. However, once the anterolateral tibial plateau is involved, no matter what type of fracture type, other anterolateral methods are needed to assist in solving.

Traditionally, lateral tibial plateau fractures are mostly treated by anterolateral approach. nevertheless, it is difficult to expose and fix the posterior tibial plateau through traditional anterolateral approach. Through literature review, the advantages of the extended anterolateral approach are as follows: the patient can be in the supine position; the exposure of the lateral, posterior and platform surface of the tibia is relatively clear, and there is enough operation space; the neurovascular injury and fibular head osteotomy are avoided to a large extent, and the damage to the original anatomical structure is small; In anterolateral column and posterolateral column fractures, this approach can be used alone for fracture reduction and plate fixation; the learning curve is relatively simple compared with the posterior approach[18,19]. Previous studies through the extended anterolateral approach for the treatment of posterolateral tibial plateau column fractures have achieved good clinical results.

Chen et al[20] in the last follow-up of 10 patients, with an average HHS score of 95.3 ± 6.5 points (range 80~100 points), an average knee flexion of $119.8^\circ \pm 17.2^\circ$ (range $95^\circ \sim 140^\circ$) and an average knee extension of $2.1^\circ \pm 2.1^\circ$ (range $0^\circ \sim 6^\circ$). Sun et al[21] By extended the anterolateral approach, on the basis of lateral tibial plateau locking plate fixation, another screw was inserted from the position around the tibial tubercle to the posterior wall of tibial plateau to assist fixation, according to the biomechanical experiment, that screw can provide similar biomechanical stability to the posterior support plate. During one year follow-up, the average range of motion of the affected knee was $2.3^\circ \sim 125^\circ$ and the average HSS score was 94.2 points.

Different from other retrospective study, in this study, Schatzker type II and Schatzker type V/VI were studied separately, two groups had their own before and after comparison. This is mainly because Schatzker type V/VI (involving three lateral columns of the tibial plateau) compare with Schatzker type II (involving bilateral columns of the tibial plateau), the degree of force, fracture comminution, soft tissue swelling and injury were more serious than Schatzker type II. In addition, in the perioperative period, Schatzker type V/VI has bilateral incision, long operation time, large blood loss, and late recovery of patients is relatively slow. Combined with previous data, the average anteroposterior distance of the lateral tibial plateau was 10.22mm (11.18-31.17mm), and the average posterior horizontal distance was 22.93mm (4.1-49.95mm)[16]. By extended the anterolateral approach, one or two screws can be fixed to the posterior bone block, and biomechanical tests show that the mechanical strength obtained by this method is greatly improved[22]. In this study, most patients obtained reliable internal fixation through the double "raft effect" can not only increase the fixation fastness, but also ensure the support to the articular surface, besides there was no significant difference in tibial plateau PA, TPA, Rasmussen score after operation. However, for Schatzker type V/VI, when there are more comminuted small bone blocks in the posterior side, the floating screw fixation may not meet the needs, the ratio of posterolateral fragment unfixed in this group was relatively high, and the posterior plate sometimes was needed for the fixation of the central bone block.

Conclusion

Although there are many ways to treat posterolateral tibial plateau fractures, When choosing one or more combined, we must consider the condition of soft tissue injury, the shape of the whole platform fracture including the posterolateral bone block and the available fixation methods. The best approaches should provide maximum exposure of the platform, enough space for reduction and fixation, and minimum damage to the surrounding structures. For anterolateral platform fractures combine with isolated posterolateral fracture fragments, the extended anterolateral approach is more suitable as a single approach. For multiple column tibial plateau fractures a dual approach (extended anterolateral combined with medial approach) can be used to enter the whole plateau area. This study is a single center retrospective study, and the number of cases included is relatively small, there is still a need for more long-term follow-up verification in multi center and large number of cases.

List Of Abbreviations

CT: computed tomography

AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen

MRI: Magnetic Resonance Imaging

PACS: Picture Archiving and Communication Systems

CPM: Continuous passive motion machine

HSS: Hospital for Special Surgery

TPA: tibial plateau angle

PA: posterior angle

SPSS: Statistical Product and Service Solutions

ANOVA: analysis of variance

ERAS: enhanced recovery after surgery

Declarations

Ethics approval (This study was retrospectively approved by the Ethics Committee of our institution and obtain patient consent)

Compliance with Ethical Standards: Informed consent

Consent to participate: Informed consent was obtained from all individual participants included in the study.

Consent for publication: The participant has consented to the submission of the case report to the journal.

Availability of data and material: The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors have no financial or proprietary interests in any material discussed in this article.

Funding: No funds, grants, or other support was received.

Authors' contributions : All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Ming Zhang, Yousen Zhu, Jinguang Wang and Jiangying Ru. Operation and patient management by Li Li and Gang Chen. The first draft of the manuscript was written by Wenwen Mao and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Acknowledgements: Not applicable.

References

1. Cho JW, Kim J, Cho WT, et al. Approaches and fixation of the posterolateral fracture fragment in tibial plateau fractures: a review with an emphasis on rim plating via modified anterolateral approach. *Int Orthop*. 2017;41(9):1887-97.
2. Zhai Q, Luo C, Zhu Y, et al. Morphological characteristics of split-depression fractures of the lateral tibial plateau (Schatzker type II): a computer-tomography-based study. *Int Orthop*. 2013;37(5):911-7.
3. Wang Y, Luo C, Zhu Y, et al. Updated Three-Column Concept in surgical treatment for tibial plateau fractures - A prospective cohort study of 287 patients. *Injury*. 2016;47(7):1488-96.
4. Johnson EE, Timon S, Osuji C. Surgical Technique: Tscherne-Johnson Extensile Approach for Tibial Plateau Fractures. *Clinical Orthopaedics and Related Research*. 2013;471(9):2760-7.
5. He QF, Sun H, Shu LY, et al. Tibial plateau fractures in elderly people: an institutional retrospective study. *J Orthop Surg Res*. 2018;13(1):276.
6. Rasmussen P S . Tibial condylar fractures. Impairment of knee joint stability as an indication for surgical treatment.[J]. *Journal of Bone & Joint Surgery American Volume*, 1973, 55.
7. Anderson A F , Irrgang J J , Kocher M S , et al. The International Knee Documentation Committee Subjective Knee Evaluation Form Normative Data[J]. *The American Journal of Sports Medicine*, 2006, 34(1):128-135.
8. Hui, Sun, Qi-Lin, et al. Combined approaches for fixation of Schatzker type II tibial plateau fractures involving the posterolateral column: a prospective observational cohort study[J]. *Archives of Orthopaedic&Trauma Surgery*, 2015, 135(2):209-221.
9. Zhu Y, Meili S, Dong MJ, et al. Pathoanatomy and incidence of the posterolateral fractures in bicondylar tibial plateau fractures: a clinical computed tomography-based measurement and the associated biomechanical model simulation. *Arch Orthop Trauma Surg*. 2014;134(10):1369-80.
10. Li Q, Zhang YQ, Chang SM. Posterolateral fragment characteristics in tibial plateau fractures. *Int Orthop*. 2014;38(3):681-2.
11. Yu B , Han K , Zhan C , et al. Fibular head osteotomy: A new approach for the treatment of lateral or posterolateral tibial plateau fractures[J]. *Knee*, 2010, 17(5):313-318.
12. Salvi, Prat-Fabregat, Pilar, et al. Treatment strategy for tibial plateau fractures: an update.[J]. *EFORT open reviews*, 2016, 1(5):225-232.

13. A M D , B R M A , A L D , et al. Arthroscopically assisted and three-dimensionally modeled minimally invasive rim plate osteosynthesis via modified anterolateral approach for posterolateral tibial plateau fractures - ScienceDirect[J]. The Knee, 2020, 27(3):1093-1100.
14. Jiang L , Zheng Q , Pan Z . Comparison of extended anterolateral approach in treatment of simple/complex tibial plateau fracture with posterolateral tibial plateau fracture[J]. Journal of Orthopaedic Surgery and Research, 2018, 13(1).
15. Frosch K H , Balcarek P , Walde T , et al. A new posterolateral approach without fibula osteotomy for the treatment of tibial plateau fractures.[J]. Journal of Orthopaedic Trauma, 2010, 24(8):515-520.
16. Sohn H S , Yoon Y C , Cho J W , et al. Incidence and fracture morphology of posterolateral fragments in lateral and bicondylar tibial plateau fractures.[J]. Journal of Orthopaedic Trauma, 2015, 29(2):91.
17. Shen QJ, Zhang JL, Xing GS, et al. Surgical Treatment of Lateral Tibial Plateau Fractures Involving the Posterolateral Column. Orthop Surg. 2019;11(6):1029-38.
18. Tekin AC, Cakar M, Esenyel CZ, et al. An evaluation of meniscus tears in lateral tibial plateau fractures and repair results. J Back Musculoskelet Rehabil. 2016;29(4):845-51.
19. Frosch K H , Korthaus A , Thiesen D , et al. The concept of direct approach to lateral tibial plateau fractures and stepwise extension as needed[J]. European Journal of Trauma and Emergency Surgery, 2020, 46(3).
20. Chen HW, Zhou SH, Liu GD, et al. An extended anterolateral approach for posterolateral tibial plateau fractures. Knee Surg Sports Traumatol Arthrosc. 2015;23(12):3750-5.
21. Sun H , Zhu Y , He Q F , et al. Reinforcement strategy for lateral rafting plate fixation in posterolateral column fractures of the tibial plateau: The magic screw technique[J]. Injury-international Journal of the Care of the Injured,2017;48(12):2814-26.
22. Wei, Zhang, Cong-Feng Luo, Sven Putnis, et al. Biomechanical analysis of four different fixations for the posterolateral shearing tibial plateau fracture[J]. The Knee, 2012, 19(2):94-98.

Tables

Due to technical limitations, table 1-3 xlsx are only available as a download in the Supplemental Files section.

Figures

Figure 1

The extended anterolateral approach exposure articular surface and use the “reduction rod” to restore depressed area, then the established tibial bone tunnel was filled with autogenous or allogeneic bone

Figure 2

In group of Schatzker type II, patients were treated with lateral tibial locking compression plate fixation

Figure 3

In Schatzker type V/VI group, patients were treated with lateral tibial locking compression plate plus medial locking compression plate fixation

Supplementary Files

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

- [table1.xlsx](#)
- [table2.xlsx](#)
- [table3.xlsx](#)