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Retraction

Retracted: 3D Printing Combined with Osteotomy of the Lateral Tibial Condyle for the Treatment of Tibial Plateau Fractures Involving the Lateral Posterior Condyle

Computational and Mathematical Methods in Medicine

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Computational and Mathematical Methods in Medicine has retracted the article titled "3D Printing Combined with Osteotomy of the Lateral Tibial Condyle for the Treatment of Tibial Plateau Fractures Involving the Lateral Posterior Condyle" [1] due to concerns that the peer review process has been compromised.

Following an investigation conducted by the Hindawi Research Integrity team [2], significant concerns were identified with the peer reviewers assigned to this article; the investigation has concluded that the peer review process was compromised. We therefore can no longer trust the peer review process and the article is being retracted with the agreement of the Chief Editor.

The authors do not agree to the retraction; author Yucheng Huang could not be reached by the publisher using the email address provided to the publisher with the article submission.

References

[1] Z. Xu, J. Jiao, F. Xiao, Y. Huang, and J. Wang, "3D printing combined with osteotomy of the lateral Tibial condyle for the treatment of Tibial plateau fractures involving the lateral posterior condyle," *Computational and Mathematical Methods in Medicine*, vol. 2022, Article ID 4245274, 2022.

[2] L. Ferguson, "Advancing Research Integrity Collaboratively and with Vigour," 2022, https://www.hindawi.com/post/advancing-research-integrity-collaboratively-and-vigour/.

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Research Article

3D Printing Combined with Osteotomy of the Lateral Tibial Condyle for the Treatment of Tibial Plateau Fractures Involving the Lateral Posterior Condyle

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The treatment of the fracture of the tibial plateau outside the posterior condyle is always a difficult problem in the clinical work of orthopedic surgeons. In this study, we aim to investigate the clinical effect of 3D printing combined with osteotomy of the tibial lateral condyle in the treatment of tibial plateau fractures involving the external posterior condyle. From January 2012 to February 2020, the data of 94 patients with fracture of tibial plateau external posterior condyle treated by 3D printing combined with osteotomy were retrospectively analyzed, including 38 males and 56 females. The 94 patients were divided into 2 groups (freehand osteotomy group and guided osteotomy group), with 47 patients in each group. All patients received preoperative CT 3D scan, and 3D printing was performed according to the converted data to make a 1 : 1 solid size fracture model. Two groups of patients were treated with anterolateral combined with posteromedial incision intraoperatively, and osteotomy lines were designed according to preoperative 3D model. After surgery, the fracture reduction was evaluated according to the Rasmussen knee scoring standard, and the knee function was evaluated by the Hospital for Special Surgery (HSS) score. One year after operation, the Rasmussen score of the knee joint was 13-18 points, with an average of 15.73 points, among which 66 cases were excellent, 24 cases were good, and 4 cases were fair, with an excellent and good rate of 95.7% (45/47). The HSS score is as follows: 67-94 points, with an average of 82.67 points, among which 62 cases were excellent, 26 cases were good, 4 cases were fair, and 2 cases were poor (joint stiffness caused by refusal of postoperative rehabilitation exercise), with an excellent and good rate of 89.9% (44/47). The range of motion of knee joint was -5°~0°~135°, and the average range of motion was 125.5°. At the last follow-up, there were no serious complications such as common peroneal nerve injury, popliteal vascular injury, postoperative infection, and failure of internal fixation. 3D printing combined with osteotomy of the tibial lateral condyle is an effective method for the treatment of fractures of the tibial plateau external posterior condyle, and the postoperative treatment results are satisfactory. The customized osteotomy guide plate is used for more accurate osteotomy, less injury, and more accurate fixation with support screws.

1. Introduction

The lateral posterior condyle of the tibial plateau is positioned backward, the anatomical position is deep, and the fibula is blocked here. The commonly used anterolateral approach in clinical practice cannot clearly expose the fracture blocks, leading to the failure of accurate reduction and strong fixation of the fracture [1–4]. In recent years, more and more doctors have used anterolateral approach combined with osteotomy of the lateral tibial condyle to expose the fracture of the external posterior condyle of the tibial plateau, and carried out the reduction and fixation of the fracture, and achieved a good clinical effect. However, the selection of the position of osteotomy line during the operation is mainly based on the doctor's experience judgment, and the precise positioning cannot be obtained. The deviation of the position of the osteotomy line will affect the exposure of the surgical field at the fracture site, and the existence of insufficient exposure or repeated osteotomy aggravation injury will further affect the surgical effect.

In view of this, since January 2012, we have used 3D printing technology to accurately produce a 1 : 1 solid fracture model preoperatively, so as to intuitively understand the complexity of the fracture, and on the fracture model, we have designed an accurate osteotomy line according to the position of the fracture block of the external posterior condyle of the tibial plateau and simulated the surgical operation. Digital virtual reduction technology was used in some of the patients, and osteotomy guide plate and front cannulated screw guide were designed. The model simulation operation can be used to determine in advance whether the exposure range of osteotomy is sufficient, whether the external posterior condyle bone block of the tibial plateau can be fully reduced, whether the type and placement of the plate can be selected in advance, and whether the screw can be fixed to the articular surface of the external posterior condyle, and detailed surgical planning and rehearsal operation can also be carried out with the help of the 3D model. Especially for some cases of the Schatzker IV fracture and dislocation, it can be clearer whether the external and posterior condyle bone block will affect the reduction of the medial platform, so as to determine the surgical method and save the operation time. Patients and their families can also clearly understand the condition through the model, which is convenient for medical staff to have a preoperative conversation and serves as a bridge of communication between doctors and patients. The personalized osteotomy combined with anterior subarticular hollow screw guide plate is simple and accurate operation technique and more accurate support and fixation, making the "Jail" screw fixation technology of the tibial platform more reliable [5].

However, clinical imaging data are often limited by two-dimensional plane [6–8], and preoperative osteotomy and exposure effect cannot be performed. Too large osteotomy area often damages the normal articular cartilage, or too small osteotomy area cannot effectively expose the collapse of the articular surface of the external posterior condyle of the tibia, thus affecting the surgical effect and increasing the difficulty of surgery. Therefore, we conducted a retrospective analysis on this group of patients in this paper. And we aimed to investigate the advantages of 3D printing technology and the feasibility of preoperative accurate design of osteotomy line and the feasibility of using osteotomy guide plate and front hollow screw guide. In addition, we focused on clear surgical matters and summarized the effects of bone grafting and reduction and fixation of 3D printing combined with osteotomy of the tibial lateral condyle in the treatment of fractures of the tibial plateau external posterior condyle.

2. Materials and Methods

2.1. Inclusion and Exclusion Criteria. Inclusion criteria are as follows: (1) in the fracture of tibial plateau external posterior condyle, Schatzker's classification was IV, V, and VI; (2) 3D printing combined with osteotomy technique of lateral tibial condyle was used for treatment; (3) the reduction of tibial plateau fracture and the function of the knee joint after operation were mainly evaluated; and (4) retrospective study.

Exclusion criteria are as follows: (1) over 70 years of age; (2) open fracture of tibial plateau; (3) complicated with important vascular and nerve injury; and (4) complicated with serious medical diseases.

2.2. General Information. From January 2012 to February 2020, 114 cases of fractures of the tibial plateau posterior condyle were treated by 3D printing technology combined with osteotomy of the tibial lateral condyle. A total of 94 patients were included in this study according to the inclusion and exclusion criteria. Among them, 38 were male and 56 were female. The average age was 50.3 years (21~69 years). There were 64 cases of traffic accident injury, 24 cases of falling injury, and 6 cases of falling injury. According to Schatzker's classification, 34 cases were type IV (Figure 1), 36 cases were type V, and 24 cases were type VI. All of them were closed fractures, of which 24 cases were combined with lateral meniscus tear and entrapment, without nerve and vascular injury. The time from injury to operation was 4 to 19 days, with an average of 6.7 days.

All the anterior and lateral knee X-rays were taken preoperatively, as well as plain CT+3D reconstruction and MRI examination of the knee (Figure 2). Among the 94 patients, there were 16 cases of complete fracture collapse of external posterior condylar and 78 cases of combined intercondylar fracture collapse. There were 58 cases with more than 2 fragments of intercondylar bone. There were 74 cases of simple fracture of the tibial medial condyle, and 20 cases of medial condyle were larger than 2 pieces. There were 10 cases of fracture of medial condyle with articular surface collapse. By preoperative MRI examination, 94 patients were all complicated with knee soft tissue injury of different degrees. There were 80 cases with a meniscus injury, of which 24 cases were lateral meniscus tear and entrapment. There were 50 cases of combined anterior cruciate ligament injury, 36 cases of apex avulsion, 10 cases of bodily injury, and 4 cases of complete rupture. There were 12 patients with combined posterior cruciate ligament injury; there were 42 cases with a lateral collateral ligament injury and 36 cases with avulsion at the insertion point of the lateral femoral condyle. Injuries of medial collateral ligament were reported in 16 cases.

The 94 patients in this group were all given routine intravenous drip of first-generation or second-generation cephalosporin antibiotics 30 min before dermectomy until 24 h after surgery. A total of 94 patients were randomly divided into two groups: unarmed osteotomy group and guided osteotomy group, with 47 patients in each group. There was no statistical difference in preoperative data between the two groups. All the patients in this group were operated on by the same group of physicians, and they all signed the informed consent before operation.

2.3. Preoperative Fracture Model Remarks and Preoperative Plan. All the 94 patients in this group received 64-slice dual-source spiral CT before surgery (manufacturer: Neusoft; Neuviz 64E 64I): line knee scanning, scanning layer thickness 0.699 mm, scanning voltage 120 kV, scanning current 205.50mAs, and scanning matrix 512×512. The

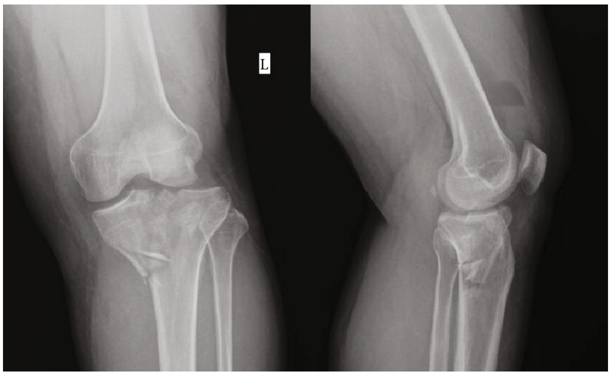

Figure 1: Typical case: a 44-year-old man with left tibial plateau fracture; preoperative X-ray Schatzker's classification: type IV.

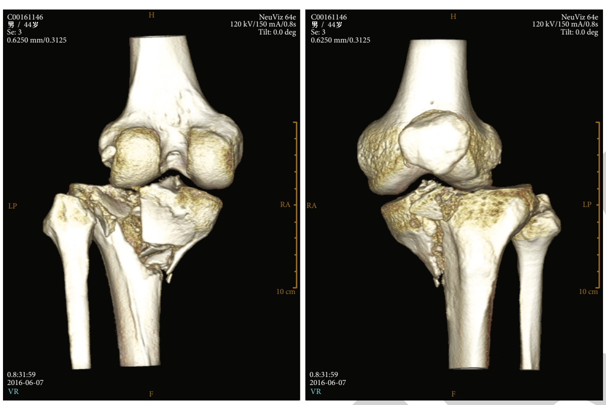

Figure 2: CT reconstructions of the above case: preoperative CT Schatzker's classification: type IV with fracture of the external posterior condyle of the tibia.

obtained images were stored in DICOM format and imported into the 3D reconstruction software Simple-Ware5.01P module. The knee joint model was separated by using threshold segmentation and region growth technology, and the STL format file was generated. The STL format file of the knee joint model output by 3D reconstruction was imported into the preprocessing software of the rapid forming machine, and the injured bone model was produced by using the laser RP rapid forming machine. The 3D printer model is Wentai-SLA400, and the printing material is SLA photosensitive resin. Print 1 : 1 tibial plateau fracture model. In the guide osteotomy group, the osteotomy guide plate and the front cannulated screw guide were designed and printed.

The 3D model was used to make the preoperative plan and determine the surgical plan. Through the model, we can determine the position and size of the fracture block of the external posterior condyle of the tibia and whether the fracture block has an effect on the reduction of the medial plateau before operation. (1) The osteotomy line can be accurately designed in advance to facilitate intraoperative exposure by identifying how to expose the external posterior condyle bone block. (2) And we can define the range of bone defect after fracture reduction and estimating the amount of bone graft. (3) It can be clear to effectively determine screw fixation range through the preset steel plate. The image data shown in Figure 3 can be used to print 3D models and make preoperative planning, the white line of the preoperative 3D model was the osteotomy line.

2.4. Surgical Methods

2.4.1. Anesthesia and Body Position. Subarachnoid block combined with epidural anesthesia was used for patients with no obvious lumbar skin damage or severe lumbar disease, who could cooperate with lateral decubitus position and tolerated lumbar puncture; otherwise, general anesthesia and tracheal intubation were used. In this group, 32 cases were treated with subarachnoid block combined with epidural anesthesia, and 15 cases were treated with general anesthesia plus tracheal intubation. All patients were treated with electronic automatic tourniquets and postures.

All patients were placed in a supine position with a sterile sheet placed under the knee joint to keep the knee joint slightly flexed. A posteromedial incision was made first to restore the line of support force of the medial tibial column. Then, the anterolateral incision was made, and the articular surface of the external posterior condyle of the tibia was treated by osteotomy of the lateral condyle of the tibia.

2.4.2. Exposure. The anterolateral knee incision was combined with a posteromedial knee incision. The anterolateral incision was made along the outer edge of the patella, and a small amount of tibial anterior muscle attachment was removed along the lateral side of the tibial crest downward. The joint capsule was cut open to protect the lateral meniscus, and if there was any damage, it was retained and repaired [9]. The articular surface of the meniscus exposed platform was retracted upward. In the freehand osteotomy group, longitudinal osteotomy of the tibial lateral condylar was performed by osteotomy with osteotomy tool referring to the osteotomy position practiced on the 3D printing model before surgery. In the guided osteotomy group, the osteotomy guide plate was used to osteotomy along with the guide plate, and the lateral condyle was turned outwards to expose the fracture fragment of the posterior condyle. A posteromedial incision was made to protect the medial soft tissue and expose the fracture line of the medial condyle. After reduction of traction, Kirschner wires were used to temporarily fix it to restore the line of the medial tibial column support.

2.4.3. Restoration and Fixation. The collapsed articular surface of the external and posterior condyle of the tibia was pried up through the external tibial condyle osteotomy window. After the osteotomy block was reduced, the reduction of the articular surface was observed through the lateral joint space. If the articular surface recovered well, the fracture fragment of the external posterior condyle was temporarily fixed with Kirschner wires from the anterior and posterior direction of the subchondral bone region in front of the platform. The osteotomy was opened again, and according to the condition of the bone collapse defect, an appropriate amount of autogenous iliac bone and/or allogeneic bone were taken to fill the defect cavity, and the lateral tibial

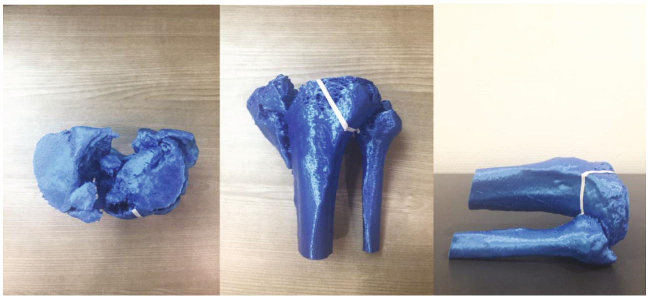

Figure 3: The computed tomography- (CT-) reconstructed image data.

condyle was reduced and fixed with Kirschner wire. In the guided osteotomy group, the guide wire was implanted with a prepositioned cannulated screw guide. After satisfactory fracture reduction, the medial column of the tibial plateau was fixed with a "T"-shaped plate to obtain immediate stability. Then, the lateral plateau was fixed with a T-shaped plate of the lateral tibial plateau or a locking plate of the proximal tibia.

2.4.4. Close the Incision. Of the 47 patients, 4 cases of torn and pressed lateral meniscus were repaired, the anterior cruciate ligament insertion avulsion was fixed with screws or steel wires, and the lateral femoral insertion of the lateral collateral ligament avulsion was fixed with screws. No primary repair was performed for the ruptured anterior cruciate ligament, and other soft tissue injuries were treated conservatively. After the operation, the joint capsule was sutured to repair the iliotibial band, an isopod, and the superficial layer of the medial collateral ligament, and one drainage tube was placed for both the medial and lateral wounds.

2.5. Postoperative Management. After the operation, the wound was subjected to suction drainage under negative pressure, and the drainage tube was removed 48 hours later. The wound was wrapped with an aseptic dressing and fixed with functional plaster support, and the affected limb was elevated. The quadriceps muscle strength training and ankle flexion and extension function training were encouraged and guided. After wound healing and suture removal, the adjustable knee brace was used to fix the knee joint, and the functional exercise of the knee joint was gradually carried out under the protection of the brace. The suture was removed 14 to 18 days after the operation, 12 weeks walking on crutches without weight, and knee joint functional exercise under the guidance of physicians. The knee flexion should be greater than or equal to 90° within 8 weeks. The knee joint rehabilitation training should be guided by rehabilitation physician and assisted by drugs. X-ray reexamination was conducted at an interval of 4 weeks. According to the results of X-ray reexamination, fracture healing was observed 12 to 16 weeks after surgery, and the patients were instructed to walk with weight gradually. Figure 4 shows that the fracture had healed and the reduction of the fracture was not lost.

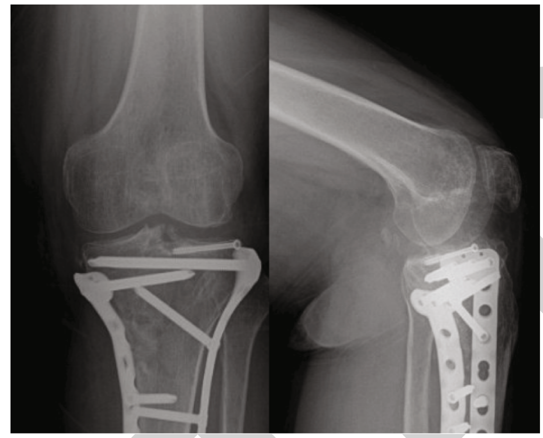

Figure 4: X-ray reexamination of the above case at 5 months postoperatively.

2.6. Efficacy Evaluation. Fracture reduction was evaluated according to the Rasmussen score of the knee joint. The evaluation method was to evaluate the reduction quality of the tibial condyle by radiological data. The scoring items included the following: whether the articular surface collapsed, whether the condyle was widened, and whether there was varus or valgus deformity, with 6 points for each item and a total score of 18 points. Among them, 18 is excellent, 12 to 17 is good, 6 to 11 is fair, and <6 is poor.

Knee function was evaluated by Hospital for Special Surgery (HSS) score. This evaluation method mainly evaluated patients' joint function and pain after surgery, mainly including 6 items: pain perception, walking function, range of motion, muscle strength, knee flexion deformity, and knee stability. The total score was 100 points, of which 85 points or above was considered excellent, 70-84 points as good, 60-69 points as fair, and 60 points or below as poor. Figure 5 shows that the knee joint had a good range of motion, and the patient could squat and walk painless and resume normal work and life.

3. Results

3.1. General Results. The operation time of patients in this group was 80-170 minutes, and the mean operation time was 106.7 minutes. The intraoperative blood loss was 120~460 ml, and the average blood loss was 167.3 ml. The posterior medial incision was about 12~15 cm long, with an average length of 13.2 cm. The anterolateral incision was about 14~19 cm long, with an average length of 14.1 cm. All lateral meniscus tears and medial collateral ligament injuries were sutured in one stage. All 47 patients were followed up for 7 to 19 months, with an average follow-up time of 13.2 months.

3.2. Fracture Healing. All patients achieved complete fracture healing, and the healing time was 12-18 weeks, with an average of 14.7 weeks. The time of full weight-bearing was 12 to 16 weeks, with an average of 13.8 weeks.

Figure 5: The functional photos of the patient at the review 5 months after surgery.

3.3. Evaluation of Range of Motion and Function of Knee Joint. The Rasmussen score of the knee joint was 13-18 points, with an average of 15.73 points, among which 66 cases were excellent, 24 cases were good, and 4 cases were fair, with an excellent and good rate of 95.7% (45/47). The HSS scores ranged from 67 to 94, with an average of 82.67. Among them, 62 cases were excellent, 26 cases were good, 4 cases were fair, and 2 cases were poor. The excellent and good rate was 89.9% (44/47). The range of motion of the knee joint was -5°~0°~135°, and the average range of motion was 125.5°.

Rasmussen scores are low. Two patients are elderly patients (68 and 69 years), with severe osteoporosis and V and VI fractures, respectively, because of the degree of joint surface grinding and trabecular bone osteoporosis that is serious, leading to bone graft after unable to get strong support, and unable to pressure inside and outside the fixed, causing the condyles broadening 4~10 mm. Among them, 1 patient with type VI had a 4 mm collapse on the articular surface and a valgus of 5° due to poor reduction of the posterior condylar fracture.

The HSS scores of the above two patients were also low, respectively: 66 points and 61 points, indicating that the surgical effect was fair. Another patient with a type VI fracture of tibial plateau, for youth and obese women (26 and 80 kg, respectively), refused to cooperate with functional recovery after exercise; after 2 months, stiff joints, with a flex range of only 10°~60°, and claudication appear; HSS score was only 56 minutes. After two months, the patients returned to the hospital again, with anesthesia induction downward knee technique release. During the operation, the range of motion of extension and flexion was 0°~110°. After the operation, the doctors in the rehabilitation department of our hospital were asked to provide functional exercise guidance and supervision. Finally, a relatively satisfactory range of motion of joint was obtained.

3.4. Complications. Seven patients in this group developed local cutaneous blackening and scattered tension small blisters 1 day after surgery and were treated with enhanced dressing change and 10% sodium chloride saline wet compress. All wounds healed and sutures were removed 15 to 18 days after surgery. Three patients developed local skin hypoesthesia and numbness of the dorsal foot immediately after surgery, but there were no muscle strength and movement abnormality. They were treated with mecobalamin and ganglioside drugs, and all three patients felt normal before discharge. In this group of patients, no serious complications occurred, such as common peroneal nerve injury, important vascular injury, postoperative infection, and failure of internal fixation.

4. Discussion

The fracture of the external posterior condyle of the tibial plateau is located behind, the anatomical location is deep, and the fibula is blocked. The osteotomy method of the external posterior condyle of the tibial plateau can clearly reveal the fracture of the external posterior condyle of the tibial plateau. Therefore, the reasonable design of the osteotomy line and the full exposure of the fracture ends are the preconditions for strong internal fixation. The osteotomy location of the lateral condyle of the tibia should be determined according to the location of the main fracture block of the external and posterior condyle of the tibia and the placement of the lateral internal fixation material. It is required to avoid the weight-bearing articular surface and reach the fracture block of the posterior condyle [10–13]. However, due to the differences of individual patients in bone morphology and fracture, that is, individualized differences, accurate osteotomy that meets the surgical requirements often needs to be personalized design. Before the development of 3D printing technology, the surgeons can only perform osteotomy with the help of preoperative imaging data and clinical experience. With the help of 3D printing technology, the position of osteotomy line can be designed in advance through preoperative operation drill of 1:1 printed solid model. Appropriate bone reference was selected to test the exposure range and the feasibility of osteotomy line after osteotomy. Fracture reduction was performed on the model, and possible problems during surgery were found and pretreated to achieve accurate osteotomy. The solid model also enables patients and their family members to intuitively understand the complexity of the lesions. The simulation can save operation time, reduce surgical trauma, intraoperative blood loss, and the number of intraoperative fluoroscopies by C-arm X-ray machine, and find out possible intraoperative problems in advance so that the complex operation is relatively simple and the safety of the operation is improved [14].

In addition, a good match between the plate and the bone surface will provide better fixation and biomechanical properties. The fixation and support of the proximal screw plate on the osteotomy surface and the articular surface of the reposition of the external posterior condyle of the tibia is one of the key factors to determine the success of the operation and postoperative functional recovery. However, due to the differences of bone morphology and fracture in patients in clinical work, it often happens that the position of internal fixation plates and screws is not ideal for the bone surface. So all possible plate types and specifications must be prepared before surgery. But even then, anatomic plates are often found to be "nonanatomic." Temporary remolding is often required during surgery, which not only increases the arbitrariness of surgery and the difficulty of operation but also makes it difficult to ensure the anastomosis between bone plate and bone surface and the stability of screw fixation and support [15–17]. In the physical model, the type of bone plate, the best placement of the bone plate, and the direction of the main fixation screws can be selected in a personalized manner, and the problems that may be encountered in the operation can be found in advance, which makes the complicated operation relatively simple and improves the safety of the operation.

As a traditional and common surgical approach for comminuted fractures of the proximal tibia, the anterolateral tibial approach has been recognized by the most orthopedic surgeons for its safety, simplicity, and practicability [18, 19] and has been vigorously promoted and applied in clinical practice. Clinically, the treatment of fractures involving posterolateral tibial plateau splitting or collapse is often performed by pry reduction by opening a window. However, in practice, this method is difficult to achieve satisfactory exposure and reduction of the posterolateral plateau, and it is impossible to obtain stable supporting fixation. Therefore, on the basis of the traditional principle of the window opening, all patients in this group adopted the mode of external tibial condyle osteotomy to reduce, support, and fix the fracture block of posterior condyle under the condition of direct vision and achieved satisfactory results. Compared with the traditional methods such as window and fibular head osteotomy, the osteotomy of the lateral tibial condyle has the following advantages: (1) the operation is simple and direct, which can avoid the further trauma of the soft tissue around the knee joint and maintain the integrity of the soft tissue. (2) This approach is a traditional surgical approach, with no important blood vessels and nerves passing through, low risk of nerve and blood vessel injury, and high surgical safety. (3) Full exposure can reduce the articular surface under direct vision, which is convenient for bone grafting and bone defect repair. (4) The incision of the approach is located outside the knee joint, which can avoid contracture of the knee joint caused by the scar of the surgical incision.

The anterior muscle of the tibial plateau is less covered and is a relatively ischemic area with poor skin healing ability. Dissection through the paramedical incision of the patella may have a greater risk of soft tissue injury [20]. Our experience is that the narrowest part of the mesodermal bridge of the medial and lateral incisions should be ≥7 cm, and the full-thickness skin flap should be retained intraoperatively, so as to reduce the use of electrotomes, avoid clamping the skin margin, and reduce the damage of blood supply, thus reducing the risk of skin flap necrosis. Complex tibial plateau fractures often involve medial and lateral bicondylar, and the stability of medial plateau fracture fragments is extremely important. Since the fracture of the medial condyle of the tibia tends to shift downward, it is difficult to obtain sufficient support strength by fixing the fracture block of the medial condyle with only the lateral plate and fixation with the tension screw. Therefore, the medial plate is often required to provide stable support to prevent varus deformity and chronic posterior dislocation of the posterior articular surface caused by loss of reduction [21].

Bone grafting after osteotomy and reduction is considered to be a key step to maintain a satisfactory reduction of the tibial plateau. In this group of cases, we found that for patients with lateral platform widening, if there is no obvious bone defect after osteotomy reduction, there is no need for bone grafting. For patients with lateral tilt of the joint due to platform edge fracture, a wedge bone defect can be found at the site of the previous collapse after the osteotomy is turned over and the edge of the joint is elevated. In this case, bone grafting is required. In this case, bone grafting can be performed using artificial bone combined with osteoinduction materials, without the need for bone grafting from the body. However, for patients with compression collapse in the central region of the articular surface, after lifting the sunken articular surface with a bone knife under direct vision, an obvious bone defect will appear. In this case, not only bone grafting is required, but also fully impaction bone grafting is required. Our experience is to use the top bar crackdown graft, which cannot leave any cavity, in order to avoid the risk of loss tibia platform height to reduction. With an upgrade to the graphics software system, physicians can perform the virtual reduction of comminuted fractures on a computer in advance. After reduction, the "blind area" fracture fragment can be clearly found, and the most accurate and least injurious osteotomy method can be designed to expose the "blind area." You can also design the guide needle of the hollow nail in advance to accurately support and fix the fracture block.

5. Conclusion

In summary, for complex tibial plateau fractures involving the external posterior condyle, the tibial plateau lateral condyle osteotomy provides sufficient surgical space for reduction of the articular surface of the external posterior condyle, without the need for fibula microcephaly osteotomy, and avoids further knee soft tissue injury. And 3D printing technology helps to accurately display outside after tibial condyle fracture. And good performers make repair plan and undertake precision cut bone. Fully exposed operative field is the escort operation smoothly, so the 3D printing combined with osteotomy of the lateral tibial condyle for the treatment of tibial plateau fractures involving the lateral posterior condyle can yet be regarded as an effective method. The restoration of the medial anatomical structure can provide a good reference for the reduction of the lateral column, which is conducive to the accurate reduction of the lateral platform and the determination of the bone defect of the lateral posterior condyle.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgments

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References

[1] H. T. Zhu, W. Y. Wang, J. Wang, J. Hu, and H. Liu, "The modified posterolateral curved incision with double intermuscular approach in treating posterolateral tibial plateau fractures," *Chinese Journal of Orthopaedics*, vol. 34, no. 7, pp. 703–708, 2014.

[2] P. S. Rasmussen, "Tibial condylar fractures," *Journal of Bone and Joint Surgery*, vol. 55, no. 7, pp. 1331–1350, 1973.

[3] D. A. Garlson, "Posterior bicondylar tibial plateau fractures," *Journal of Orthopaedic Trauma*, vol. 19, no. 2, pp. 73–78, 2005.

[4] C. F. Luo, Y. Jiang, and B. Zhong, "Open reduction and internal fixation with buttress plating via a posterior approach for posterior shearing fractures of tibial plateau," *Chinese Journal of Orthopaedic Trauma*, vol. 9, no. 1, pp. 6–9, 2007.

[5] J. Jing, X. Fei, H. Yucheng et al., "3D printing combined with lateral tibial condyle osteotomy for the treatment of lateral tibial plateau posterior condyle fractures," *Chinese Journal of Orthopaedic Surgery*, vol. 38, no. 15, pp. 913–918, 2018.

[6] Y. A. Weil, M. J. Gardner, S. Boraiah, D. L. Helfet, and D. G. Lorich, "Posteromedial supine approach for reduction and fixation of medial and bicondylar tibial plateau fractures," *Journal of Orthopaedic Trauma*, vol. 22, no. 5, pp. 357–362, 2008.

[7] A. Brunner, P. Honigmann, M. Horisberger, and R. Babst, "Open reduction and fixation of medial Moore type II fractures of the tibial plateau by a direct dorsal approach," *Archives of Orthopaedic and Trauma Surgery*, vol. 129, no. 9, pp. 1233–1238, 2009.

[8] C. F. Luo, J. Chen, and H. Sun, "Treatment of posterior column fracture in tibial plateau injury," *Chinese Journal of Orthopaedic Trauma*, vol. 10, no. 9, pp. 804–807, 2008.

[9] G. M. Georgiadis, "Combined anterior and posterior approaches for complex tibial plateau fractures," *Journal of Bone and Joint Surgery (British)*, vol. 76-B, no. 2, pp. 285–289, 1994.

[10] D. P. Barei, T. J. O'Mara, L. A. Taitsman, R. P. Dunbar, and S. E. Nork, "Frequency and fracture morphology of the posteromedial fragment in bicondylar tibial plateau fracture patterns," *Journal of Orthopaedic Trauma*, vol. 22, no. 3, pp. 176–182, 2008.

[11] P. J. Papagelopoulos, A. A. Partsinevelos, G. S. Themistocleous, A. F. Mavrogenis, D. S. Korres, and P. N. Soucacos, "Complications after tibia plateau fracture surgery," *Injury*, vol. 6, no. 6, pp. 475–484, 2006.

[12] H. S. Dang, "Treatment of coronal surface fracture of posterior tibial plateau," *Chinese Journal of Orthopaedics*, vol. 28, no. 4, pp. 344–346, 2008.

[13] Y. Zhuang, P. F. Wang, K. Zhang et al., "Treatment of posterolateral tibial plateau fractures via the fibular osteotomy approach," *Chinese Journal of Orthopaedics*, vol. 32, no. 8, pp. 732–738, 2012.

[14] H. W. Chen, G. F. Zhang, J. Pan, G. Zhao, and G. Yu, "Locking compression plate fixation through a modified anterolateral approach for posterolateral tibial plateau fractures," *Chinese Journal of Orthopaedics*, vol. 33, no. 9, pp. 935–940, 2013.

[15] Z. M. Zeng, C. F. Luo, C. F. Hu, and B. F. Zeng, "Posteromedial tibial plateau split fractures: a biomechanical study," *Chinese Journal of Orthopaedic Trauma*, vol. 12, no. 3, pp. 252–255, 2010.

[16] W. L. Mu, J. Y. Chang, D. S. Jia, Q. Fu, J. Feng, and W. Hou, "Surgical technique of iliosacral screws placement guided by 3D printing template in sacral fractures," *Chinese Journal of Orthopaedics*, vol. 35, no. 7, pp. 767–773, 2015.

[17] Y. Liu, G. H. Liu, T. Xia et al., "Application of 3-dimension printed guide plate technology in sacroiliac screw fixation," *Chinese Journal of Orthopaedics*, vol. 38, no. 2, pp. 86–92, 2018.

[18] J. W. Wang, Y. C. Huang, W. J. Cheng, J. Jiao, and W. S. Kan, "Treatment of posterior condylar fracture of tibia platform by external tibial osteotomy and internal and lateral double steel plate fixation," *Chinese Journal of Orthopaedic Trauma*, vol. 8, no. 14, pp. 723–725, 2012.

[19] L. Yang, J. J. Wang, Q. Sun et al., "Auxiliary application of three-dimensional printing technology of implant fixation for tibial plateau fracture," *Chinese Journal of Tissue Engineering Research*, vol. 20, no. 13, pp. 1904–1910, 2016.

[20] X. T. Xie and C. F. Luo, "General guidelines for surgical treatment of intra-articular fractures," *International Journal of Orthopaedics*, vol. 37, no. 4, pp. 205–209, 2016.

[21] W. J. Qiu, D. M. Bao, C. F. Luo, and Y. K. Wang, "Treatment of complex tibial plateau fractures with multiplates through two combined approaches," *Chinese Journal of Orthopaedic Trauma*, vol. 18, no. 10, pp. 840–844, 2016.