Case Report

A Novel Percutaneous Screw Fixation of Postero-lateral Tibial Plateau Fracture using Posterior Cruciate Ligament Reconstruction Femoral Template: Technical Note

使用後交叉韌帶重建股骨模板重建後外側脛骨平台骨折的一種新的經皮螺釘固定法：技術說明

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A B S T R A C T

Percutaneous fixation method has been applied in Schatzker type III joint depressed-type lateral tibial plateau fracture. We report a 76-year-old man suffering from a small joint depressed-type posterolateral tibial plateau fracture with surgical reduction and fixation with a novel guidance of posterior cruciate ligament (PCL) reconstruction femoral template under X-ray and arthroscopic assistance. The concept of sequential tunnel drilling in ligament reconstruction has been applied in bone impaction tunnel creation beneath the articular step with the PCL jig. Avoidance of multiple bone guide pin drilling and accurate guide pin insertion and hence screw fixation was also achieved by use of the PCL template. As illustrated, we believe that the PCL jig is a good armamentarium and adjunct equipment to achieve a more precise minimally invasive operation in special anatomical positions such as the postero-lateral tibial plateau under careful surgical planning.

中 文   摘 要

經皮內固定方法已在外側脛骨平台骨折 (Schatzker type 3) 中得到應用。我們的報告中，一個76歲男子因了小關節凹陷型後外側脛骨平台骨折。我們在放射線和關節鏡的輔助下使用後交叉韌帶重建股骨模板 (Posterior Cruciate Ligament Jig) 做了手術復位和固定。使用後交叉韌帶重建股骨模板鑽探股骨隧道 (sequential tunnel drilling) 的概念早已應用在建立骨頭管的隧道了。這種模板固定法可以避免多發性骨導針鑽孔並允許準確的導鈎插入。我們認為這種方法是一個很好的固定法以實現在特殊解剖位置更精確的微創手術。我們在文章中提到的後外側脛骨平台骨折，是一個很好的例子。

Introduction

Tibial plateau fractures represent only 1% of all fractures and 5–8% of lower limb fractures.1–4 The incidence of this fracture shows a bimodal distribution—first peak in the 2nd–5th decade seen in motor vehicle accidents, while a second in the 5th–7th decade in osteoporotic fractures.2

The most widely accepted classification for tibial plateau fracture is the Schatzker classification.1 Types I–III are the most commonly associated with lower- to middle-energy trauma involving the lateral plateau with type II being the most frequent subtype.6

Managing tibial plateau fractures in osteoporotic patients can be very challenging with the need to address adequate grafting of the bone defect, restoring the anatomic joint congruency, and ensuring a stable fracture fixation. Percutaneous treatment of this type of fracture can be performed using arthroscopy as well as image intensification to achieve reduction of the joint surface.5 This is a known successful approach since it has a short operative time and minimal soft tissue damage.4 However, situations like posterolateral corner tibial plateau fractures may sometimes pose extra technical challenges in articular surface restoration and trajectory of implant fixation with the close vicinity of fibular head.
instrumentation such as an external jig may help to achieve better accuracy in articular reduction and fixation. We would like to share our experience of percutaneous fixation of posterolateral tibial plateau fracture with the aid of a posterior cruciate ligament (PCL) reconstruction femoral template under X-ray and arthroscopic guidance.

Case Report

A 76-year-old man, with premorbid independent walking ability and hypertension, fell from a one metre platform and landed on his left knee which resulted in valgus sprain injury. He could not bear any weight on it. On clinical examination, he had left knee joint effusion and tenderness over the lateral joint line. The knee was stable on varus and valgus stress examination and Lachman tests, with intact neurovascular status of the left lower limb and without sign of compartment syndrome. Plain X-ray showed a Schatzker type III left tibial plateau fracture at the posterolateral corner (Figures 1A and 1B), which was confirmed on computed tomography (CT) scan and the bone defect measured 15 mm × 15 mm in axial cut and 6-mm depth on sagittal cut (Figures 1C–F).

Figure 1. (A, B) Anteroposterior and lateral X-ray of the left knee showing joint-depression type tibial plateau fracture at the posterolateral corner; (C, D) coronal; (E) axial; and (F) sagittal reconstruction demonstrating the anatomical location of the fracture.
Surgical technique

We applied the PCL femoral template of the ACUFEX DIRECTOR Drill guide system (Smith & Nephew, Inc., Andover, MA, USA), which was composed of three components: the ACUFEX DIRECTOR 4-point Bullet, the ACUFEX DIRECTOR Drill Guide, and the ACUFEX DIRECTOR PCL Femoral Aimer with a ring at the tip allowing broader surface area of contact (Figures 2A–C). The Femoral Aimer allows 40–65° of adjustment. Not only could the wide diameter of the whole PCL femoral template allow guide pin insertion through the bullet from the proximal medial tibia to PCL foot-print at the posterior tibial plateau as in standard PCL reconstruction surgery, but also allows an accurate guide pin trajectory from the proximal medial tibia to the postero-lateral corner of tibial plateau, as illustrated in the saw bone model (Figure 2D) before execution. This jig was designed to be easily disintegrated, allowing guide pin left in situ and subsequent cannulated reamings. By repeating the same steps, multiple guide pins could be inserted in different directions with the PCL femoral template. With the PCL femoral template, the guide pin trajectory could be applied in a one-step three-dimensional manner instead of by resolving the direction into anteroposterior (AP) and lateral separately by multiple X-ray screening in the two planes taken alternately with gradual guide pin advancement. In our preoperative CT planning, the small bone defect over the postero-lateral tibial plateau would only accommodate two cannulated raft screws.

The surgical procedure was performed under general anaesthesia with the patient lying supine on a radiolucent operating table. The uninjured right leg was put on a leg elevator and thigh tourniquet of 280 mmHg applied pressure. An X-ray C-arm machine was positioned transversely from the same side as the injured limb, while the knee arthroscopy panel was positioned on the contralateral side with the equipment trolley at the end of the bed (Figure 3).

Anterolateral and anteromedial arthroscopy portal incisions were made and haemarthrosis was drained. Knee arthroscopy was performed confirming an intact anterior and posterior cruciate ligament. Drive-through sign was noted over the postero-lateral compartment with a marked depression of about 15 mm × 15 mm × 5 mm inferior to the lateral meniscus (Figure 4A).

Next, the intended bone impaction corridor and screw trajectory was outlined with skin marker under fluoroscopic guidance in the AP plane.

The PCL femoral template was applied in the following three crucial steps.

1) Bone impaction corridor creation

A small stab incision and blunt dissection was done over the midline region of the proximal medial tibia through the PCL jig with

Figure 2. (A) Components of the posterior cruciate ligament femoral template include ACUFEX DIRECTOR 4-point Bullet (Smith & Nephew, Inc., Andover, MA, USA); (B) the ACUFEX DIRECTOR Drill Guide; (C) the ACUFEX DIRECTOR posterior cruciate ligament Femoral Aimer; and (D) integrated with application on a saw bone model as demonstration with bullet anchoring at proximal medial tibia and aimer towards the postero-lateral corner.

Figure 3. Operating theatre set up with X-ray screening machine and knee arthroscopy panel incorporated.
Figure 4. (A) Arthroscopic view of the posterolateral compartment with positive drive through sign while the lateral meniscus remains intact; (B) under knee arthroscopy, the articular surface has been restored after closed reduction of the depressed bone defect by bone impactor followed by bone substitute; (C, D) axial and (E) sagittal and (F) coronal reconstruction computed tomography images showing the positions of the screws and complete restoration of the joint depression at the postero-lateral tibial plateau; three-dimensional computed tomography reconstruction images comparing the articular surface of the fracture site (G) before and (H) after fixation.
bullet anchored on to the bone surface. The jig was temporarily positioned under X-ray guidance in the AP plane (Figure 5A).

Adjustment of the jig was done in the lateral plane with further X-ray and secured at 60° with the ring tightly adhered to the skin surface at the intended guide pin exit site at the posterolateral corner of tibial plateau (Figure 5B).

A 2.4 mm × 15° Passing Pin (Endoscopy, Smith & Nephew, Inc.) was inserted through the PCL jig to the targeted site at the posterolateral tibial plateau with a single attempt. This allowed a cortical window to be created at the proximal tibia by a sequential 4.5-mm endobutton reamer towards 1 cm below the fracture site and a 9.5-mm reamer at the near cortex to open a cortical window for subsequent bone impaction. The guide pin was then removed. Bone impactor was gently hammered in the same trajectory to reduce the depressed articular fragment (Figure 5C). Reduction was confirmed under X-ray (Figures 5D–E). A 7 mm × 7 mm × 7 mm BIO 1 Substitut osteux/Bone substitute (BIOSORB TCP 95% mini-mum purity; S.B.M.S.A., Zi du Monge, Lourdes, France) was impacted through the metaphyseal region to the area below the articular surface to provide further bone support (Figure 5F). Further knee arthroscopy confirmed restoration of the articular surface of the posterior lateral tibial plateau (Figure 4B).

(2) Rafting screw guide-pins insertion

Under X-ray screening, the posterior rafting 2.4 mm × 15° Passing Pin was first inserted from medial tibial plateau towards laterally with PCL jig set at 55°, from proximal medial tibia about

Figure 5. (A, B) First guide pin insertion being executed for bone impaction corridor under posterior cruciate ligament jig guidance under X-ray. Note that the guide pin was drilled only after the three-dimensional position of the jig was confirmed and secured; (C) bone impactor inserted; (D, E) posterolateral tibial plateau articular surface being restored after gentle hammering of the bone impactor; (F) further bone substitute impacted into the bone impaction corridor for further stabilization and metaphyseal support to maintain the reduction.
1 cm below the articular surface (Figures 6A and B). The bullet was repositioned at a more anterior position with a 2-cm skin bridge while the ring of the aimer remain anchored over lateral tibia plateau region. Another 2.4 mm × 15° Passing Pin was drilled with PCL jig set at 50° for the anterior rafting guide pin.

(3) Metaphyseal subchondral screw guide-pin insertion

A third 2.4 mm × 15° Passing Pin was further drilled with PCL jig with the ring stabilized over lateral tibial plateau, into the bone graft corridor distally and with > 2 cm separation from the impaction corridor entry site to ensure adequate bone bridge for further subchondral metaphyseal bone support (Figures 6C and D).

All the guide pins were inserted within one single attempt by adjusting the PCL template.

(4) Cannulated screw fixation

Lastly, two stab incisions were made across the two rafting guide pin sites. Two rafting subchondral screws were inserted with washers (7.3-mm Arbeitsgemeinschaft für Osteosynthesefragen (AO) cannulated screw, 50 mm anteriorly then 60 mm posteriorly; Figures 6E and F) and another 65-mm AO cannulated screw inserted as subchondral metaphyseal support screw through another small stab incision. No breaching of articular surface by the screw head was seen on X-ray screening. On further evaluation with
arthroscopy, articular surface was restored and maintained (Figure 4B). All the small incisions were closed with interrupted skin nylon sutures (Figure 7).

The patient was put on long leg hinge brace 0–45° for 3 weeks then 0–90° for a further 3 weeks. Four weeks of nonweight bearing walking exercise was given and the fracture healed at 8 weeks. The patient regained full function and full knee range at 3-months postoperation.

Discussion

From the literature, conventional percutaneous reduction and fixation techniques of joint-depressed type lateral tibial plateau fracture with both arthroscopic and X-ray guidance with the rafting screws insertion were widely applied, particularly in cases of monocondylar tibial plateau fractures.1,4,6 Some modified methods to further enhance the subchondral bone impaction corridor under the reduced the articular surface have been applied, such as a bioabsorbable interference screw (BIORCSI screw; Smith & Nephew, Inc., Andover, MA 01810, USA) introduced through the bone impactor tunnel with the same vector as reduction and an additional 3.5-mm cortical anterior-to-posterior screw below the interference screws to prevent screw cut-out (jail technique),2 or subchondral support by percutaneous balloon-guided inflation osteoplasty.3 In our technique and from our previous experiences, we believe that the application of metaphyseal subchondral screw can achieve a more rigid support and accurate positioning at the desired anatomical site with guide pin technique and the longest available corridor support with the wide range of screw length available compared with the aforementioned techniques in literature.

As reflected from the preoperative CT scans, medial tibia plating to fix the posterolateral corner of tibia plateau was not ideal as the screw purchase is poor.4 We believed that the posterolateral tibial plateau fracture, particularly with a small fracture fragment, is unique in surgical planning and execution with regard to its special anatomical considerations. We needed to minimise the risk of damaging the fibular nerve as the fracture was exactly medial and in close proximity to the fibular head region. It was important to have a good aiming device that could provide a good trajectory and avoid perforating the posterolateral corner and avoid fibular structures.5 Besides, we had to find ways to achieve good implant bone purchase, stable fixation, a safe metaphyseal corridor for instrumental manual elevation of the depressed bone fragment, and allow adequate bone substitute impaction to maintain the reduction.1 These considerations are especially important in osteoporotic patients. Therefore, we opted to change from a direct anterolateral approach with screws towards posterior direction to an anteromedial to posterolateral direction to gain more room for screw purchase and to put in as many subchondral screws as possible to give the best subchondral support.

It is standard key surgical step in arthroscopic knee ligament reconstruction surgery with external aimer for guide pin positioning followed by sequential tunnel reaming for bone tunnel creation. The PCL jig is a known reliable device and widely applied for creating accurate guide pin insertion for bone tunnel drilling for ligament reconstruction. The advantages of PCL femoral template in this specific fracture fixation scenario include the following. Firstly, it is modular with a degree guide, bullet, and a connecting component with small contacting area thus allowing dexterity and reliable repetitions of guide pin insertion. Secondly, the width of the instrument accommodates the whole transverse width of proximal leg as the intrinsic design allows long guide pin excursion in contrary to other jigs. Thirdly, the PCL femoral template has an aiming part in the shape of a ring which avoids concentrated contact pressure onto the skin and that will help reducing skin injury but at the same time maintaining the stable adherence to the skin by the jig, unlike other tip aimers such as the anterior cruciate ligament tibial jig without the ring-shaped aiming component that can penetrate the skin and possibly underlying vital neurovascular structures. Lastly, the bullet and ring are radio-opaque and provide a precise directional sense under X-ray in both AP and lateral planes.

With regards to our surgical execution, we extended the ligament reconstruction tunnel drilling concept as well as the application of PCL jig into fracture fixation condition, which was a new and innovative experience. The PCL guide provided ease, dexterity, and most importantly accuracy and therefore facilitated minimally invasive procedure. In the process, we utilised the knee arthroscopy to assess the intra-articular joint depression extent first before creating the corridor.4 Next we made a sequential drill with endobutton reaming under PCL jig guidance followed by a 9.5-mm near cortex tunnel reaming with a similar stepwise tunnel reaming in ligament reconstructions. By doing so, we created a corridor entry that gives a good direction and ease for subsequent bone impactor elevation of the depressed fragment. It was important to note that all the guide pin direction confirmation were made outside the bone with the PCL jig. By using the PCL jig, the guide pin could be well controlled in both AP/lateral planes under X-ray guidance and gave better three-dimensional sense than free hand technique under X-ray. We have avoided the necessity of multiple track findings within the bone and therefore avoided the creation of large bone void in the metaphyseal region.5 Therefore all the guide pin insertion and sequential screw fixation were done in single shot.

Figure 7. A total of six small incisions were made for the whole operation.
via the PCL jig guidance. Of course an alternative is navigation-guided guide pin insertion or by intra-operative three-dimensional CT scan guidance. However, computer navigation system may not be easily available in every orthopaedic centre and requires multiple skin incisions for tracker placement, which may pose further surgical site infection risks to the patients. Moreover, further operative time is required in the meticulous three-dimensional calibrations of the knee joint and proximal tibia before execution of guide pin and screws insertions. Errors can still arise on incorporating the preoperative fine-cut CT images into the navigation computer system, calibrations and guide pin insertion procedures. Whereas for intraoperative three-dimensional CT scan, the executing orthopaedic surgeon can be bounded by the CT resource availability, availability of an experienced radiographer operating on the CT system and also possible errors in calibration and guide pin insertion as well. In this context, our PCL jig assisted method is more direct and user-friendly but less computer dependence.

Tibial plateau fractures are conventionally treated via the percutaneous approach. In this case, we introduced the use of the PCL template for reduction and fixation of posterolateral tibial plateau fracture. We feel that it is a new and innovative experience. Our method can achieve a more accurate and reliable minimally invasive surgery with the availability of the PCL jig in well planned cases.

Conflicts of interest

The authors have nothing to disclose.

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