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Case Report

Intra and Extra Articular Proximal Tibial Osteotomies combined with Multi-Ligament Reconstruction using Patient Specific Instrumentation – a Rare Case Report

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Abstract

We report a case of a 19 year old presenting with a traumatic fracture dislocation of the knee joint. Managed initially in an external fixator, this patient was left with a malunited depressed articular fragment of the medial compartment with associated multi-ligament knee injury. A novel technique using four patient specific instrumentation guides to correct both intra and extra-articular deformities and multi-ligament injuries is described.

Keywords: Extra-articular osteotomy; Intra-articular osteotomy; Knee trauma; Multi-ligament reconstruction; Patient specific instrumentation

Introduction

Fracture dislocations of the knee joint associated with vascular trauma are devasting injuries. These can lead to considerable loss of function which may require amputation. Limb salvage is often complex and requires multiple surgical procedures. Fractures leading to malunion of depressed articular fragments pose further challenges especially in patients who would be too young to be considered for joint replacement surgery. Complex corrective osteotomies using 3-dimensional planning and patient specific guides can be used to treat intra-articular deformity with a high degree of accuracy [1,2]. To our knowledge, this is the first case report describing the use of Patient Specific Instrumentation (PSI) to elevate a depressed articular fragment through an intra-articular osteotomy in association with multi-ligament reconstruction surgery and an offloading extra-articular osteotomy.

Materials and Methods

A 19 year old male patient presented on the 19th June 2018 to the Major Trauma Centre on the South Coast of England after an injury whilst wakeboarding in a water park. Initial radiographs showed a posterior knee dislocation and a Schatzker 4 tibial plateau fracture. Multiple operations followed to reperfuse the limb and treat compartment syndrome. The knee was spanned with an external fixator and the patient referred to the local district hospital for plastics input and ongoing follow-up. The external fixator remained in place until the 6th August in view of a suppurating medial fasciotomy wound. At this point the tibial plateau fracture had malunited with a 5mm depression of the anteromedial quarter (Figure 1).

Figure 1: Malunited Tibial Plateau Fracture

Following intensive physiotherapy the range of movement improved from 10-40 degrees in August, to 0-120 degrees by October 2018. However the patient was unable to weight bear as the knee drifted to 10 degrees of recurvatum and 10 degrees of varus on attempted standing. Long leg alignment radiographs showed significant varus malalignment and subluxation of the medial femoral condyle into the depressed tibial plateau fragment. An MRI scan confirmed full ruptures of the ACL and PCL as well as the postero-lateral corner structures. The case was discussed at a number of multidisciplinary meetings and conferences and the consensus was to proceed with an intra-articular osteotomy to restore the articular surface congruity. PSI was used to combine this with an offloading extra-articular osteotomy and multi-ligament reconstruction surgery.

Virtual Surgical Planning (VSP)

A left knee CT scan was performed and image data was sent to Newclip Technics engineers in France to produce a 3D printed template of the proximal tibia. In the first VSP planning step the required correction was calculated by digitally cutting the tibia intra-articularly. This was then aligned to the goal template to reconstruct the medial tibial plateau. The second step, used a patient specific osteotomy guide to allow for correction of the medial proximal tibial angle from 83 to 88 degrees varus; and subsequent plate fixation of both the intra and extra articular osteotomy cuts. The third step used a patient specific guide for the PCL tunnel, in order to avoid the pre-made osteotomy cuts and the screws of their fixation. The osteotomies were performed on the bone model and fixed with the preselected Newclip plate to confirm plate and screw position and PCL tunnel placement. A thorough stepwise operative plan was then compiled, comprising every step of the procedure.

The patient was placed in the supine position, using a tourniquet around the upper thigh. An antero-medial incision was used, extending from the patella to distal to the tibial tubercle. A sub-medial meniscal arthrotomy was performed with medial capsular release to the deep MCL and the level of the coronal articular cut. The first PSI guide (Figure 2) was positioned medially using two k-wires equidistant from the fibula head measuring 57.5mm from the back surface of the k-wire hole guiding tunnel. Two further k-wires measuring 87mm and 76mm proximally and distally respectively were positioned into the anterior area. Another two k-wires were inserted into the medial area, 106mm proximally and distally from the back surface of k-wire hole guiding tunnel. The anterior (sagittal) cut was performed with a Stryker precision saw blade to a depth of 52mm from the anterior PSI to posterior k-wire, leaving the posterolateral cortex intact (Figure 3). The second (coronal) cut was medially, measuring 54.5mm from the medial PSI to lateral k-wires, protecting the lateral bone. The distal (axial) saw cut relied on a measurement of 33mm from the antero-medial part of the PSI. Once these three cuts were made, the anterior and medial k-wires were removed, leaving those on the postero-medial bone and the PSI was removed. The cut could then be finalised free hand. A second PSI was then slid over the remaining k-wires. The detached bone was elevated to allow two k-wires to slide into the original medial holes and drilled to a measured depth of 58.5mm (Figure 4).

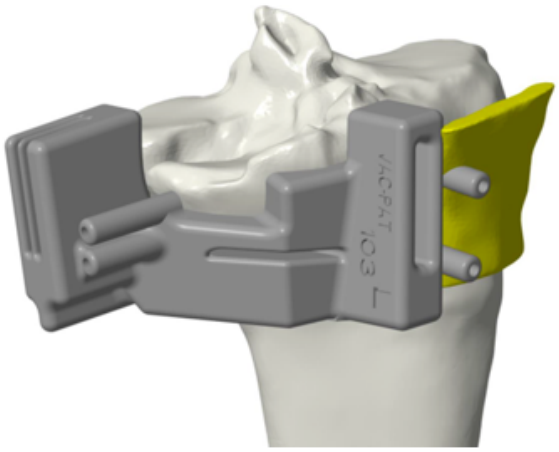

Figure 2: First PSI guide.

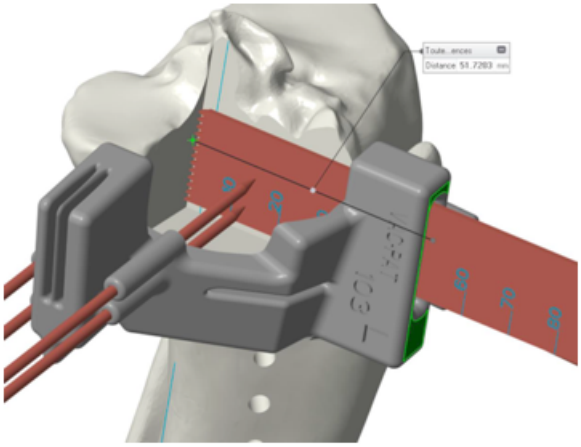

Figure 3: Intra-articular osteotomy cut.

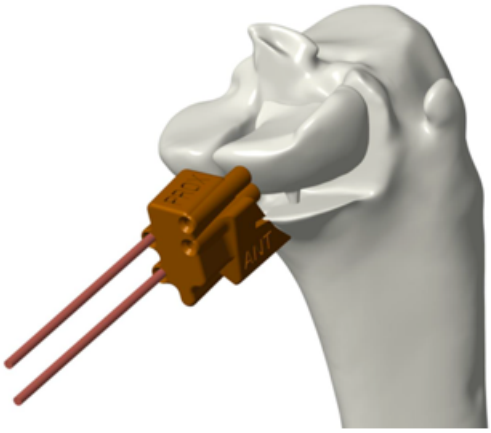

Figure 4: Elevation of the depressed fragment using second PSI guide.

The second step was the medial opening wedge extra-articular osteotomy cut. This used a PSI guide placed 8mm from the tibial plateau surface (Figure 5). A cutting k-wire was inserted measuring 72mm from the back surface of the k-wire hole guiding tunnel, and a second golden k-wire aimed towards the fibula head measured 50mm. Three of the four original k-wires from the intra-articular cut were then pulled back to measured lengths, in order to allow the holes on the PSI to be drilled and filled with pins and the extra-articular cut to be made. The coronal correction was checked with fluoroscopy, then the PSI upper part and proximal pins removed before the cutting k-wire, lower PSI and distal pins to finish the cut (Figure 6). The NewClip Activmotion Left AC plate was positioned over the osteotomy (Figure 7), the proximal holes filled with pins and the opening of the wedge completed free hand by pushing the ankle laterally. All three proximal holes and one distal hole were filled with pre-measured locking screws.

Figure 5: Third PSI guide for extra-articular osteotomy.

Figure 6: Third PSI guide removed once cuts made, prior to plate application.

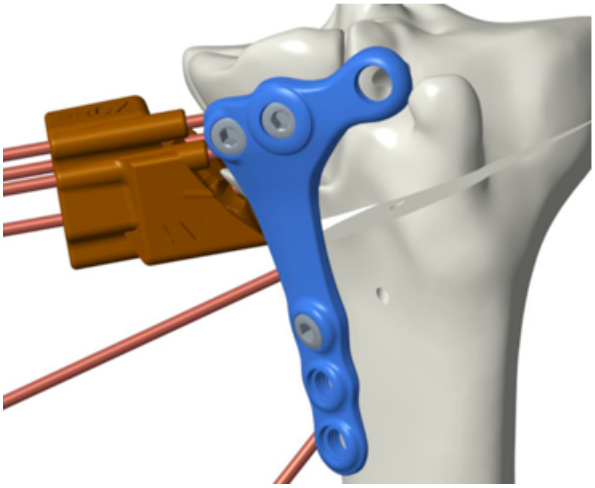

Figure 7: NewClip Activmotion Left AC plate.

The third step was ligament reconstruction including PCL tunnel. To reconstruct the PCL, a 7mm folded semitendinosus allograft was used. A 7mm femoral PCL socket was prepared using standard anteromedial and anterolateral arthroscopy portals. A tibial PCL tunnel was marked using a fourth PSI (Figure 8) and completed with a posteromedial portal, entering through the initial wound. Suspensory fixation with a 15mm Endobutton was used in the femur and interference screw fixation in the tibia with a 8mm x 35mm PK Biosure interference screw.

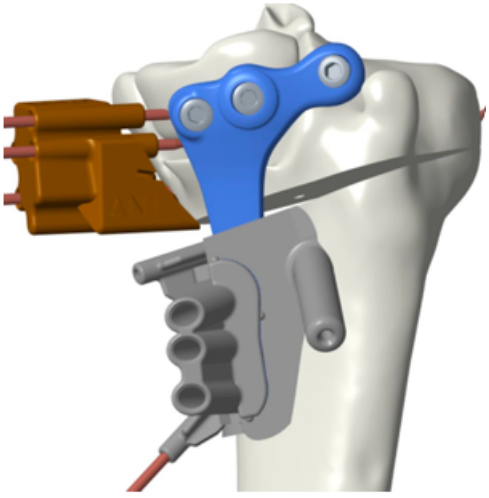

Figure 8: Fourth PSI guide for PCL tunnel.

The PLC was reconstructed through a separate lateral incision from the lateral femoral epicondyle to a midpoint between Gerdy's tubercle and the fibular head. Larson's reconstruction technique was performed using a 6mm Peroneus Longus allograft through the fibula and into a single femoral tunnel. This was fixed with a 7mm x 25mm PK Biosure interference screw. A modified Lemaire lateral extra-articular tenodesis was performed in order to improve rotational stability. This was fixed with a 4.75mm Arthrex Swivelock in a 4.5mm x 20mm femoral socket. After closing the wound in layers, a pressure bandage and a Jack PCL brace were applied. Toe-touch weight bearing on crutches was allowed for the first six weeks with a full range of movement.

Results

The patient was pain-free six weeks postoperatively. Long leg alignment x-rays showed satisfactory implant positioning with evidence of ongoing union of the osteotomies and no collapse. Weight bearing was increased to 50% bodyweight. At three months, he was allowed to weight bear fully using the PCL brace. Knee range of motion was symmetric to the contralateral leg, 0-120, extension-flexion; good coronal stability; negative dial test at 30 and 90; no posterior sag; grade 2 Lachman's with firm end point and no pivot shift in the left knee. Wounds healed well with no signs of infection. Radiographs demonstrated progressing consolidation and union of the previously malunited plateau in the elevated anatomically reduced position (Figure 9). At six months, the patient was mobilising independently, fully weight-bearing out of the brace and without crutches. The knee had regained full range of movement with no pain and no symptoms or signs of instability. Radiographs showed complete union of the osteotomies, with no residual articular step in the medial compartment of the left knee (Figure 10).

Figure 9: 3 months post-operatively.

Figure 10: No residual articular step in the medial compartment left knee 12 months post surgery

Discussion

We have presented a surgical technique combining intra-articular osteotomy and opening wedge high tibial osteotomy using 3D planning and patient specific instrumentation guides, alongside multi-ligament reconstruction, in order to successfully manage a complex fracture dislocation of the knee joint. Intra-articular tibial plateau fracture malunion is challenging to treat and technically demanding surgery. Pre-operative planning to quantify the malunion has been emphasized [3], either through 2D radiographs or 3D reconstructed CT scans [4]. Mast et al [5] reported on the use of the contralateral tibia as a 2D reconstruction template. Since then 3D models of the contralateral bone have been used as reconstruction templates in upper [6] and lower limb surgery [7]. In these studies, patient specific guides were applied to accurately reproduce preoperative planning during surgery. This use of 3D planning and patient specific surgical guides are slowly starting to be used in intra-articular tibial plateau fracture malunions with encouraging results [1,2]. Similar positive results have been demonstrated when using patient specific guides in extra-articular opening wedge high tibial osteotomy surgery. Correction, to within one degree, in the sagittal and coronal planes in a cadaveric study [8] was replicated by Chaouche et al [9] on a cohort of 100 patients, with a plane accuracy of less than one degree of error and good functional outcomes at 2 years. PSI for the pathological correction of genu valgum recurvatum has also been described [10].

This case presented significant challenges as two osteotomy cuts were made prior to ligament reconstruction. In an isolated PCL reconstruction, a standardised tibial tunnel guide is used to accommodate surgeon's preference and patient's anatomy to target the PCL insertion site. For this case, an additional patient specific instrumentation guide was used to direct the position of the PCL tibial tunnel. This novel technique and the use of a fourth PSI guide thus enabled us to perform complex intra and extra-articular osteotomies and ligament reconstruction, restoring the mechanical axis of the knee joint.

Conclusion

The use of PSI in this complex intra- and extra-articular osteotomies case allowed for an accurate and reproducible correction of the depressed segment in this malunited tibial plateau fracture. In patients with associated complex multi-ligament knee injuries PSI also guides the position of ligament reconstruction tunnels to avoid pre-made osteotomy cuts and fixation devices.

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