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Surgical Technique

Acute Total Knee Arthroplasty for Unicondylar Tibial Plateau Fracture Using Metaphyseal Cones

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ABSTRACT

Tibial plateau fractures (TPFs) in older adults are increasing in incidence and now account for 8% of all fractures in patients over 60 years of age. Although primary fixation remains standard, the risk of fixation failure, loss of reduction, and the development of posttraumatic osteoarthritis are all markedly increased in this age group with higher rates of conversion to total knee arthroplasty (TKA) of 12%. When joint depression is severe with significant subchondral bone loss, up to half ultimately require TKA. TPFs with unicondylar depression can be managed primarily using tibial cones in acute TKA. In this study, we report the surgical technique for performing acute TKA using tibial cones for the primary management of TPFs in older adults and illustrate this technique with case examples.

Introduction

Similar to other fragility fractures, tibial plateau fractures (TPFs) in older adults are increasing in incidence [1] and account for 8% of all fractures in patients over 60 years of age [2]. Though across all patients, only 3%-7% of patients proceed to total knee arthroplasty (TKA) within 10 years of TPFs [3-5], this is higher in older adults, where 12% have undergone TKA within 5 years of TPF [6]. This higher TKA conversion rate is associated with articular comminution, pre-existing degenerative joint disease, and severe depression of the fracture [6].

Fixation failure, loss of reduction, and the development of posttraumatic osteoarthritis (PTOA) are all more common in older adults [5,7-9]. At the time of TPF, one-third of older adults (>60 years old) already have radiographic knee osteoarthritis (OA) [6]. Both pre-existing knee OA and inflammatory arthropathy are independently associated with TKA requirements after TPF. Osteoporosis can complicate both inflammatory arthropathy and older age. Furthermore, severe joint depression and comminution may render some osteoporotic TPFs unreconstructable. Fracture reduction can be difficult to maintain throughout union when bone quality or quantity is poor. TKA performed late for PTOA after TPF is associated with high complication rates of 26%-60% [10-13]. This includes a 10% rate of intraoperative complications [1,6]. Compared to TKA for primary OA, delayed TKA for TPF-related PTOA has been associated with higher risks of infection [12,14,15], stiffness [12,14,16], venous thromboembolism [14], and ultimately revision [15]. A recent systematic review and meta-analysis have demonstrated that late TKA after TPF is also associated with significantly higher complication rates compared to acute TKA performed as primary TPF management [17]. Intraoperative and postoperative complication rates were generally lower in acute TKA, with late TKA specifically associated with a significantly increased rate of stiffness requiring reintervention and patella tendon rupture [17].

Among patients over 60 years of age with displaced TPFs, the majority are unicondylar lateral plateau fractures [2,18], which are also the most common fracture type to undergo late TKA for PTOA [6,12]. Severe unicondylar depression with subchondral bone loss has been associated with TKA requirement in patients >60 years of age, where up to half of patients with severe unicondylar depression (>15 mm) require TKA by 5 years [6]. Such unicondylar depression can be managed acutely using tibial cones at the time of TKA.

This study reports the surgical technique for acute TKA using tibial cones for the primary management of TPFs in older adults with case examples and results of a case series.

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Surgical technique

When considering acute TKA for the primary management of TPFs, the fracture can be considered a bone defect and can be managed using zonal fixation theory. Schatzker II, III, and IV fractures therefore can be considered as Anderson Orthopaedic Research Institute [19] type 2a defects (uncontained defect in a single plateau) that can be managed acutely with metaphyseal fixation (Fig. 1). Bicondylar Schatzker V and VI fractures can similarly be considered as type 2b (uncontained affecting both plateaus) or type 3 (severe metaphyseal deficiency) defects and may require long stem diaphyseal fixation in addition to metaphyseal augmentation if acute TKA is to be performed (Fig. 1).

Lateral unicondylar fractures

Over half of TPFs in older adults involve unicondylar lateral plateau fractures [6]. It can be difficult to place lateral augments through a medial parapatellar approach due to the patellar tendon. The geometry of asymmetric metaphyseal cones [20-22] is well suited to filling the unicondylar lateral depression associated with TPFs (Fig. 2).

Surgical technique

This technique pertains to the Triathlon TKA system and tritanium 3D-printed metaphyseal cones (Stryker, Marwah, NJ, USA). A standard medial parapatellar approach is used. A tourniquet is optional. Femoral preparation is performed according to the surgeon's preferences. The medial femoral condyle will often have intact cartilage, and this needs to be considered when setting the distal femoral resection depth. The Triathlon TKA is designed to have an 8-mm resection of bone from the medial femoral condyle, which typically gives a distal femur resection that comes off in 2 separate pieces (medial and lateral) and is level with the base of the notch. A greater or lesser resection of distal femur may be desired depending on the bone and/or cartilage loss discovered intraoperatively. This depth is checked and confirmed with the angel wing prior to cutting. Preparing the femur-first facilitates easier access to the tibia. The fat pad is released from the anterior tibia behind the patellar tendon. The lateral meniscus may be punched down into the fracture and should be excised. Retractors are placed at the posterior cruciate ligament, anterolaterally after releasing the anterior horn of the lateral meniscus, and medially (Fig. 3). The fracture does not need to be further exposed (Fig. 3). The tibial resection can be planned and performed using either intra- or extra-medullary jigs, but an intramedullary rod is ultimately required for cone preparation. The entry point to the tibial canal is anterior on the plateau and should be planned from preoperative radiographs. A measured resection technique is used for the tibial resection. For the Triathlon TKA, a 9 mm resection is usually measured from the lateral tibial plateau at 1/3 across the plateau and 2/3 back, which coincides with the lowest part of the polyethylene. For medial fractures where the lateral plateau is intact, this can be performed as standard, but for lateral fractures, the resection depth needs to be measured either from the lowest part of the medial plateau (typically 4 mm) or 9 mm from the estimated lateral plateau height. Confirm adequate bony resection with trials, ignoring the fracture.

When flexion and extension gaps are balanced, continue with cone preparation. For cone preparation, reinsert the intramedullary reamer one diameter size down from maximal to a depth of ≥175 mm to allow some anteroposterior angulation of the rod. The cone is sized based on tibial component size and coverage using the contralateral asymmetric cone. Asymmetric cones require the tibia to be at least a size 3. In smaller patients with size 1 or 2 tibias, an augment with or without a central symmetric cone may be preferred. Preoperative templating can help identify patients who are not large enough for asymmetric cones. When the cone size has been selected, ream the proximal tibia over the intramedullary reamer, being mindful of the anteroposterior dimension so as not to undermine or fracture the tibial tuberosity. This typically involves pulling back on the reamer to angle it away from the anterior cortex. Ream the asymmetric lobe according to the desired tibial rotation.

The geometry of the fracture and requirement for a cone are determined from preoperative computed tomography scans. As unicondylar fractures typically involve depression localized to the condyles rather than centrally, the lobe of an asymmetric cone is usually best matched to the geometry of the fracture-related bone defect. The fracture does not need to be exposed intraoperatively. The act of lobe reaming impacts the subchondral bone. Trial with a cone trial and a 9 × 50 mm stem. Using a narrow stem allows for maximum translation within the cone to optimize coverage. When happy with balance, sizing, and coverage proceed with uncemented cone impaction (Fig. 4) and standard tibial and femoral cementation. We typically use a short 9 × 50 mm cemented stem with a cement restrictor with a flat top so as not to inadvertently deviate the stem tip. Ensure there is cement between the baseplate and cone with no metal on metal. The split element of the fracture does not require buttressing, provided the central part of the cone has circumferential coverage and support. The asymmetric cone

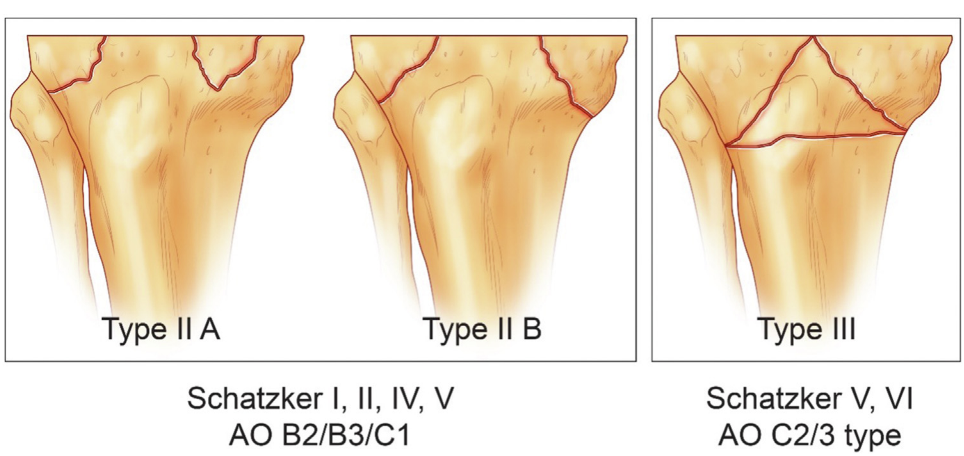

Figure 1. Classification of tibial plateau fractures as bone defects according to the Anderson Orthopaedic Research Institute (AORI) classification.

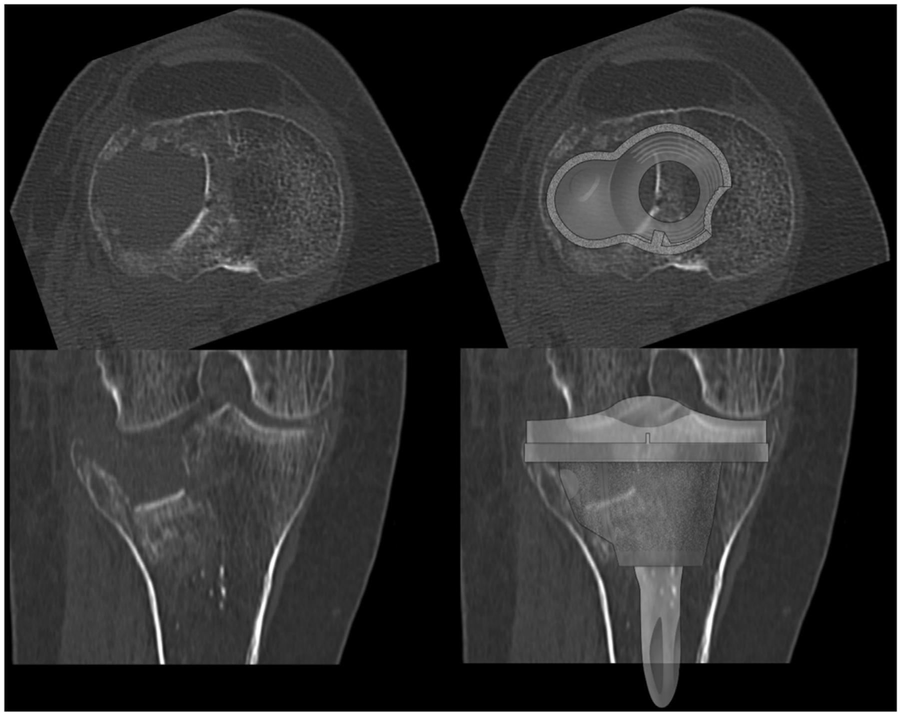

Figure 2. Coronal and axial plane computed tomography scan images of a severely depressed tibial plateau fracture demonstrating how cone geometry can be used to treat this defect.

prevents cement from extruding into the fracture split. In our experience, the split can be ignored and has gone on to unite around the cone in all cases (Fig. 5).

Medial unicondylar fractures

A fifth of TPFs in patients >60 years of age involve failure of the medial subchondral bone [6], half of which are unicondylar injuries. In some of these fractures, the proximal fragment can be too thin to support adequate fixation, and TKA may be considered (Fig. 6). Medial augments or cones can be used depending on the fracture pattern and the resulting bone defect. Where the fracture is very proximal and the affected bone can easily be excised and replaced with an augment, then this is recommended. However, where there is deeper subchondral bone involvement/loss or very poor bone quality, a cone is recommended instead of an augment in order to achieve stable metaphyseal fixation.

Surgical technique

Medial unicondylar fractures differ from lateral-sided injuries in several ways. The medial parapatellar approach for TKA involves partial dissection of the fracture, and care must be taken not to over-release medially. As for lateral plateau injuries, a femur-first measured resection technique is used. If an augment is intended, then an extramedullary tibial jig with 0° cut can be used. If planning a medial asymmetric cone due to excessive depression or metaphyseal bone loss, then intramedullary referencing can be used. Tibial resection depth is measured from the intact lateral tibial plateau, typically 9 mm. Medial plateau fractures with subchondral failure can fragment quite easily during tibial resection, and for that reason, we recommend a narrow gauge saw or precision saw to maximize control during cutting. The asymmetric cone is then sized, reamed, and trialed in the same way as the lateral cone. Again, small splits can be ignored if a cone is otherwise well supported, but fractures that extend distally or are significantly displaced may affect the medial collateral ligament and coronal plane stability and necessitate additional constraint.

Figure 3. Intraoperative appearance and retractor positioning. No additional exposure of the lateral plateau fracture is required. Preoperative and postoperative imaging of this case is provided in Figure 5.

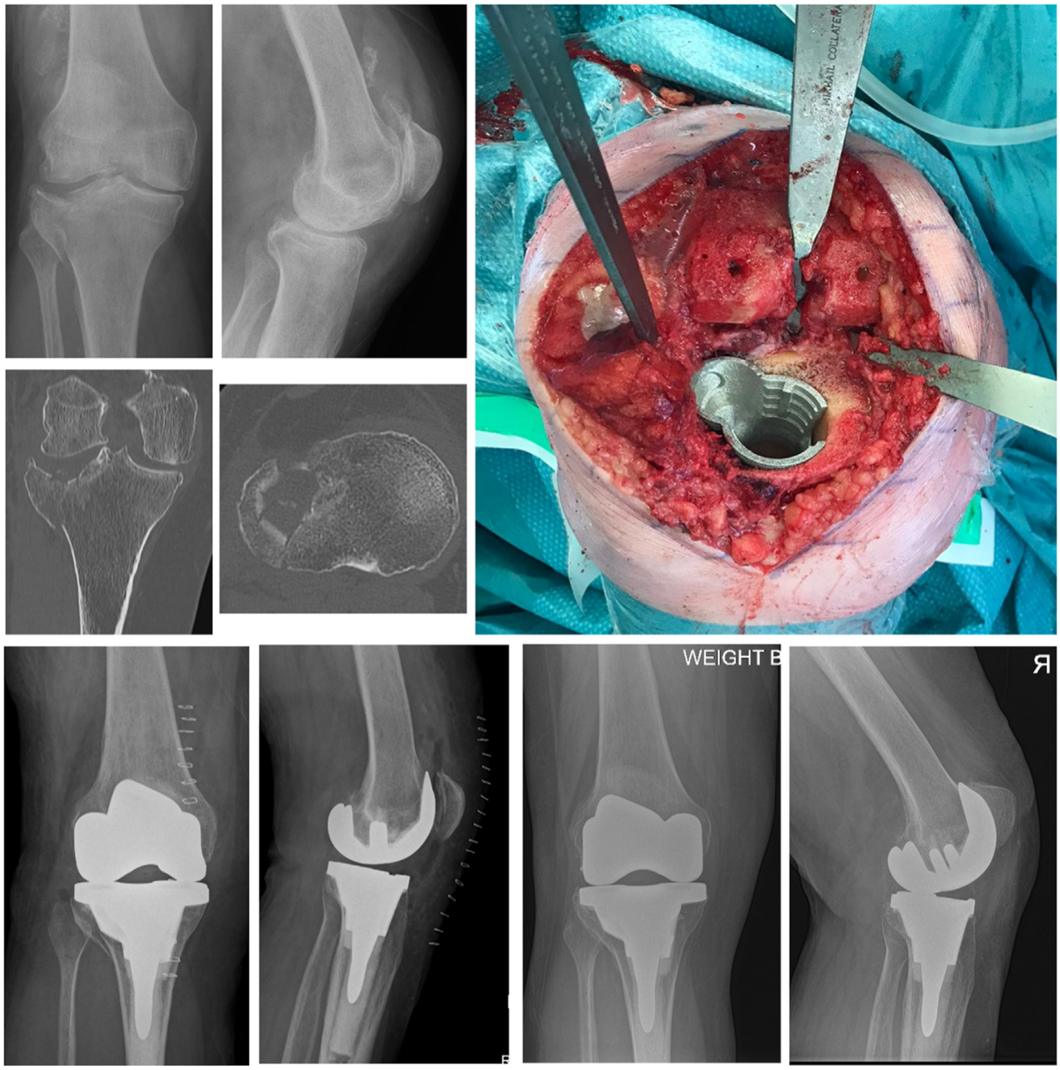

Figure 4. Split depression lateral plateau fracture with pre-existing osteoarthritis demonstrating fracture pattern, intraoperative exposure and cone positioning, and healing of the split at 1 year postoperatively.

Case series

During 2021 and 2022, 10 acute TKAs for TPFs were performed at the study center by 2 arthroplasty surgeons. Seven fractures were unicondylar, of which 5 were managed using a tibial cone for metaphyseal fixation: 3 lateral unicondylar and 2 medial unicondylar. All patients were female with mean age of 70.5 ± 2.2 (range 67-72). The indication for TKA included severe lateral joint depression in 2 patients, pre-existing OA plus severe lateral joint depression in one patient, and unreconstructable medial subchondral failure in 2. All patients were operated on acutely within a week of injury. A cemented cruciate-retaining TKA with an asymmetric tibial cone, 9 × 50 mm tibial stem, and cruciate substituting polyethylene was used in all cases. There were no intraoperative complications. Postoperatively, no weight-bearing restrictions were prescribed, and patients followed routine TKA rehabilitation protocol. There were no wound complications postoperatively. At a minimum of 1-year follow-up, all fractures had healed clinically and radiographically around the cones with no cases of superficial or deep infections. All patients were satisfied with their TKA.

Discussion

When considering unicondylar fractures with severe depression in older adults, acute TKA utilizing metaphyseal tibial cones appears to be safe with a low risk of complications and the advantage of facilitating immediate and unrestricted weight-bearing. Older patients can present unique challenges for the fixation of complex periarticular fractures, which place them at increased risk of late TKA requirement after TPF compared to the younger population. Loss of reduction and fixation failure are more common in older adults who display greater rates of osteoporosis and comminution [5,7-9,23]. If patients at significant risk of requiring late TKA can be identified preoperatively, they can potentially be offered TKA as acute management for their fracture. Both pre-existing degenerative joint disease (OA or inflammatory arthropathy) and severe joint depression are known risk factors for conversion to late TKA, and up to half of patients over 60 years of age with severe joint depression (>15 mm) ultimately require TKA [6]. Offering acute TKA to well-defined patients at high risk of fixation failure may reduce morbidity and hasten patient recovery.

Figure 5. A lateral tibial plateau fracture with severe depression managed with asymmetric cone TKA with healing of the split at 1 year.

Figure 6. A medial tibial plateau fracture considered too proximal to achieve adequate fixation managed with asymmetric cone TKA with healing of the fracture at 6 months.

Among patients over 60 years of age, conversion rates to TKA vary from 8%-12% [2,6]. The difficulty in interpreting these figures is that in older age groups, nonoperative management or reluctance for reoperation may be dictated by frailty or comorbidity rather than by fracture characteristics. Where only operatively managed fractures in patients >60 years were included, the higher rate of 12% was found [6]. The lower rate of 8% was reported in a study where 40% of cases had initially been managed nonoperatively. Studies repeatedly show radiographic PTOA in 25%-40% of patients after TPF [6,12]. While this does not necessarily infer significant symptoms, among older adults, it is possible that a number of patients do not undergo late TKA due to frailty or comorbidities rather than an absence of clinical symptoms. Rates of TKA after TPF in older patients may therefore be falsely reassuring; patient-reported outcome measures would provide more information [24].

Though the vast majority of older adults with TPFs do well following fracture fixation, the role of TKA in the management of TPFs in older adults may be greater than has previously been explored, similar to the experience in both elbow [25] and shoulder trauma [26]. Getting it right the first time is paramount in the management of fractures in older adults, where immobility can be devastating and patients may not be fit enough for further surgery. Waiting until fixation or nonoperative management has failed before proceeding to late TKA is associated with significantly more complications than performing TKA acutely, according to a recent systematic review and meta-analysis of primary vs secondary TKA (sTKA) following TPF [17]. The ability to predict those at high risk of late TKA conversion in order to potentially change their primary management is key to appropriately targeting acute TKA to those who would benefit most. The identification of pre-existing knee osteoarthritis, inflammatory arthropathy, and unreconstructable depression in osteoporotic bone as risk factors for late TKA requirements potentially facilitates targeting of acute TKA to minimize complications and recovery time.

Lateral unicondylar split depression (Schatzker II) fractures predominate in patients ≥60 with TPFs [2,18] and also predominate in those who go on to require late TKA [12] rather than more complex bicondylar patterns. The degree of joint depression rather than bicondylar involvement appears to be the most important factor in late TKA requirements.

Late TKA performed for PTOA after TPF brings numerous challenges. Compared to TKA for primary OA, sTKA for TPF-related PTOA has been associated with higher risks of infection [12,14,15], stiffness [12,14,16], venous thromboembolism [14], and ultimately revision [15]. Intraoperative complications occur in 10% of late TKAs after TPF [12,27] and these can often be attributed to the extra issues that often need to be managed such as previous skin incisions, scarring and soft tissue tethering, knee stiffness, retained metalwork, instability, bone defects, and patient deconditioning. Though metalwork removal can be staged or selective [12], and extensile approaches can be used [6,28], these complexities increase the risk of complications, especially those related to stiffness. Stiffness, scarring, and difficult access predispose to iatrogenic patellar tendon avulsions and medial collateral ligament divisions [10,12,27] in particular, in addition to higher rates of early wound complications or intraoperative fracture. Compared to sTKA after TPF, there are fewer reports of primary TKA in the literature with few small retrospective case series. However, a recent systematic review and meta-analysis that incorporates these series has demonstrated lower complication rates when TKA is performed as primary management for TPF compared to when TKA is delayed and performed late [17]. Offering acute TKA to those at risk of early fixation failure and conversion to late TKA may reduce complications and hasten recovery and should be considered for some patients as part of the shared decision-making process.

Lower limb trauma in older adults is often complicated by poor bone stock and pre-existing degenerative joint disease. The risk of late TKA is higher than in younger patients with results inferior to TKA for both degenerative joint disease and acute TKA for TPFs across the literature. The majority of TPFs in older adults are unicondylar, and in the presence of severe joint depression, pre-existing OA or inflammatory arthropathy can be safely managed with acute primary TKA using metaphyseal cones.

Summary

In this study, we describe the surgical technique for performing acute TKA using tibial cones in the primary management of tibial plateau fractures in older adults. We illustrate this technique with case examples from a case series of 5 patients.

Lower limb trauma in older adults is often complicated by poor bone stock and pre-existing degenerative joint disease. When managing tibial plateau fractures in older adults, the option of offering acute TKA to those at risk of early fixation failure may reduce complications and hasten recovery and should be considered for some patients as part of the shared decision-making process. The majority of TPFs in this demographic are unicondylar, and in the presence of severe joint depression, pre-existing OA, or inflammatory arthropathy, these fractures can be safely managed with acute TKA using metaphyseal cones.

Conflicts of interest

C. Scott is a speaker for DePuy-Synthes and a paid consultant for Stryker, Smith and Nephew, and Pfizer. M. Moran is a paid consultant for Stryker. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101209.

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