Depressed tibial plateau fractures remain challenging with regard to restoration of anatomic joint congruency, adequate grafting of the metaphyseal bone defect, stable fracture fixation, and allowing early knee range of motion to achieve excellent long-term functional outcomes. The concept of indirect fracture reduction by balloon-guided inflation osteoplasty has been established for many years in the management of osteoporotic vertebral compression fractures. Recently, this technique was extrapolated to its application for other indications, including the indirect joint reduction of distal radius, calcaneus, cuboid, tibial pilon, and tibial plateau fractures. However, until now, no long-term outcome has been described for tibial plateau fractures treated by inflation osteoplasty.

**Case Report**

A 51-year-old woman sustained a lateral tibial plateau depression fracture after a low-energy trauma when falling and twisting her left knee. The patient was otherwise healthy and had no preexisting medical conditions. On clinical examination, she had a left knee joint effusion and tenderness on palpation on the lateral side. The knee was stable to varus/valgus stress examination and she had a normal neurovascular status to the left lower extremity. Plain radiographs and a computed tomography scan of the left knee demonstrated a Schatzker type III (AO/OTA 41-B2.2)–equivalent lateral tibial plateau depression fracture (Figure 1). The patient was placed in a knee immobilizer and was allowed to use crutches with touch-down weight bearing to the left lower extremity. She was scheduled for elective surgical fracture fixation within 10 days after injury.

**Surgical Technique**

Standard precautions are applied regarding identification and marking of the correct surgical site and ensuring a standardized preverification process according to the Universal Protocol, prior to bringing the patient to the operating room. The surgical procedure is performed while the patient is under general anesthesia and placed on a radiolucent operating table in the supine position. A thigh tourniquet is applied but not inflated during the balloon osteoplasty part of the procedure.

Under fluoroscopic guidance, the trocar for the inflatable bone tamp is placed in a medial-to-lateral fashion, using a small percutaneous skin incision on the medial side. The tip of the trocar is placed center-center approximately 2 to 3 mm below the depression, in the anteropos-
terior and lateral planes (Figure 2). To avoid subsidence of the inflatable tamp away from the depressed fragment into the cancellous metaphyseal bone, a second trocar can be placed with the tip just adjacent to the other trocar (Figure 3), which allows for the lower balloon to support the reduction pressure from the more cranial balloon. Other authors have recommended placing 2 or 3 rafting K-wires just below the balloon to achieve the same effect and avoid subsidence of the bone tamp pressure into the weaker metaphyseal bone, particularly in young patients (C Mauffrey, oral communication, January 2012). A large, pointed reduction clamp is applied in a percutaneous fashion to avoid displacement of the lateral split fracture fragment during inflation of the balloons (Figure 4). Attention must be paid not to overcompress the lateral condyle because this may lead to entrapment of the depressed fragment and the inability to achieve an anatomic articular congruence (so-called trap door effect).

In the current case, 2 balloons with a volume of 15 and 20 cc, respectively, were deemed appropriate, using the KyphX Xpander Inflatable Bone Tamp system (Kyphon, Inc, Sunnyvale, California). As a trial, the balloons are inflated to approximately 50 psi. The stepwise inflation is then performed under fluoroscopic guidance (Figure 3), until the depressed fragment is anatomic ally reduced, without exceeding a maximal pressure of 250 to 300 psi.

Fluoroscopic images should be taken every 0.5 to 1.0 cc (or 30 to 50 psi) of progressive inflation to ensure proper positioning of the balloon, and adequate metaphyseal void formation and to avoid overcorrection of the articular fragment into the joint space. After ensuring anatomic reduction, 2 subchondral 1.6-mm K-wires are placed to hold the articular reduction and avoid a secondary subsidence as the balloons are deflated and withdrawn (Figure 5).

After applying a lateral buttress plate of choice, the metaphyseal void is filled with a fluid-phase hydroxyapatite (eg, Hydroset; Stryker, Mahwah, New Jersey) injected through the trocars. Three to 4 rafting screws should be placed as a subchondral raft to hold the articular reduction (Figure 5). The authors recommend filling the residual canal of the removed trocar with the bone substitute as the trocars are withdrawn, although no data suggest that this minor void could be a potential stress riser (Figure 6A, arrows).

**RESULTS**

Postoperatively, the patient was mobilized with touch-down weight bearing on the affected lower extremity and allowed knee range of motion as tolerated. She was followed up at 2 weeks for a wound check and staple removal. At 6 weeks, radiographs demon-
strated a maintained anatomic articular reduction (Figures 6A, B). The patient was then allowed to progressively increase her weight-bearing status to weight bearing as tolerated by 10 weeks. She had an excellent long-term outcome and was free of symptoms with full active range of motion of her left knee (0°-140°) at 3 months. The patient was last seen for a scheduled 1-year follow-up (14 months postoperatively), at which point final radiographs demonstrated a maintained long-term reduction and fixation (Figures 6C, D).

**DISCUSSION**

Recently, balloon-guided reduction techniques for cancellous bone fractures have emerged in various indications, including vertebral fractures, foot and wrist injuries, and tibial plafond and plateau fractures.\(^4\)\(^\text{-}^\text{10,12,13}\) For articular depression fractures of the proximal tibia, the technique of fluoroscopy-guided percutaneous inflation osteoplasty appears to have several advantages over conventional open reduction techniques. These include minimal soft tissue compromise, improved accuracy of articular reduction, and a lower risk of joint penetration. A further advantage, as described for balloon-guided kyphoplasty for vertebral fractures,\(^5\)\(^,\)\(^12\) is the creation of a cancellous bone void, which allows an improved fluid-phase bone cement distribution.

To the current authors’ knowledge, this report is the first of a patient with a 1-year follow-up after successful management of a depressed tibial plateau fracture using this novel technique. As outlined in this case report, the technique is minimally invasive, safe, accurate, and associated with excellent radiological and clinical long-term results. The percutaneous reduction technique spares the soft tissue envelope, which is usually compromised by the trauma and associated inflammatory response. Also, the open operative time is shortened, which decreases the risk of a postoperative infection.

Posttraumatic osteoarthritis is a common sequelae of depressed tibial plateau fractures, leading to long-term morbidity and the potential need for revision surgery and joint replacement.\(^\text{14,15}\) A residual articular step-off in the tibial plateau has been recognized as a major risk factor for developing posttraumatic knee arthritis.\(^\text{16,17}\) The accuracy of inflation osteoplasty-guided articular reduction, as outlined in the current report (Figure 3), may facilitate the ease and quality of reduction and may contribute to improved long-term outcomes.

Some potential limitations of this new technique must be addressed. Incontestably, the costs related to the single-use instruments for the balloon inflation technique, as opposed to using a conventional bone tamp, are drastically increased. However, a lack of data exists that analyze whether indirect costs related to decreased operative time and reduced incidence of complications, which may warrant an unplanned return to the operating room for revision surgery, may offset the overall cost factor. The latter notion is of particular importance in the current age of nonreimbursable never events, such as postoperative infections.\(^\text{18}\) Finally, as for any newly introduced technique, an individual learning curve will be associated with an increased complication rate in the early phase until a provider’s proficiency is achieved.

**CONCLUSION**

The new technique of balloon-guided inflation osteoplasty represents an improved,
safe, and accurate modality for anatomic restoration of articular congruence in depressed tibial plateau fractures, which is likely associated with improved radiological and clinical outcomes. Future prospective controlled studies are needed to compare the safety and efficiency of this new modality with established conventional reduction techniques.

REFERENCES


