Opening-Wedge Proximal Tibial Osteotomy

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Abstract: Varus knee malalignment caused by medial compartment arthritis results in progressive asymmetric wear of the tibiofemoral joint. This wear can cause progressively painful gonarthrosis. Surgical methods to address varus knee malalignment include lateral closing-wedge proximal tibial osteotomy, medial opening-wedge osteotomy, and arthroplasty. Medial opening-wedge proximal tibial osteotomy is an effective procedure for restoring proper coronal alignment and reducing knee pain. In this technical note, we present a reproducible technique for proximal tibial osteotomy.

Varus limb malalignment results in an imbalance of force transmission to the knee joint with load concentration in the medial compartment. This can accentuate arthritis pain and place unwanted stress on ligament, menisci, and articular cartilage.

Proximal tibial osteotomy serves as an acceptable treatment strategy for young, active patients with unicompartmental osteoarthritis of the knee. A valgus-producing tibial osteotomy can redistribute the weight-bearing forces, lessen the medial compartment load, and reduce the varus knee moment. Lateral closed-wedge osteotomy was once the gold standard in the late 1990s for correction of varus knee malalignment. This technique is fraught with shortcomings, including delayed union, loss of correction, patella baja, alteration of tibial slope, and peroneal nerve palsy. Modern techniques have since evolved and the medial open-wedge approach is now considered the standard. The goals of this procedure are to relieve pain, delay the time to arthroplasty, and decrease forces on ligament, meniscus, and osteochondral grafts.

Patients who typically undergo proximal tibial osteotomy are those who have isolated unicompartmental arthritis, are younger, and are active enough that total knee arthroplasty would be at risk of failure due to excessive wear. Patients who are significantly obese, have fixed flexion contractures, or with diffuse knee arthritis are generally contraindicated for this procedure.

Advantages of the opening-wedge technique (Table 1) include not violating the proximal tibiofibular joint, no change in the fibular collateral ligament length, and a precise intraoperative correction. In addition, the same incision can be used for concomitant procedures (anterior cruciate ligament reconstruction, osteochondral allografts, etc.) or subsequent knee arthroplasty.

Disadvantages of the opening-wedge technique include lengthening of the patellar tendon, elevation of the tibiofemoral joint line,[1] distal translation of the patella and lateral translation of the tibial tubercle, slower healing, and longer protection from weight bearing.

Preoperative Planning

Standard preoperative radiographic assessment include bilateral standing full-length alignment, weight-bearing anteroposterior in full extension, weight-bearing posteroanterior at 30° of flexion (Rosenberg view), lateral, and patellar views. The mechanical axis is the angle between a line from the center of the femoral head to the center of the tibial plateau and a line from the center of the talus to the center of the tibial plateau (Fig 1). An overcorrection of the mechanical axis of approximately 3° to 5° of valgus is typically performed to off-load the medial compartment.

The desired angle of correction is determined by static analysis of full-length standing mechanical axis radiographs. The weight-bearing line method is a simplified

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Table 1. Advantages and Disadvantages

Advantages	Disadvantages
• No violation of the proximal tibiofibular joint	• Lengthening of the patellar tendon and elevation of the tibiofemoral joint
• No change in fibular collateral ligament length	• Increased tensioning of the medial collateral ligament
• No prominent hardware	• Distal translation of the patella and lateral translation of the tibial tubercle
• Precise intraoperative correction	• Possible bone graft requirement, especially for large corrections
• A single incision can be used for concomitant procedures (anterior cruciate ligament reconstruction, osteochondral grafting, subsequent arthroplasty)	• Slower healing with longer protected weight-bearing status than arthroplasty

reproducible technique for determining the desired coronal plane correction angle. The lateral tibial plateau is divided from 0% to 100% from its medial to lateral margins. Lines drawn from the center of the femoral head and the center of the talus intersect at the desired tibial coordinate, typically 62% (range, 50% to 75%). The angle formed by these 2 lines determines the angle of correction to be achieved at the osteotomy site (Fig 2).

Fig 1. The mechanical axis is the angle between a line from the center of the femoral head to the center of the tibial plateau and a line from the center of the talus to the center of the tibial plateau.

Surgical Technique

Step 1: Setup

The patient is placed in the supine position on a radiolucent operating room table. Adequate fluoroscopic images ensure clear visualization of the hip, knee, and ankle.

Step 2: Exposure

The tourniquet is first inflated, and a 7-cm vertical incision is made, beginning 1 cm distal to the tibial joint line and extending to the tibial tubercle (Fig 3). This incision is centered midway between the tubercle and the posteromedial tibial border. The sartorial fascia is split in line with the hamstring tendons (Fig 4). The superficial medial collateral ligament is identified and incised distally in an inverted-L-type fashion. The tissue is elevated subperiosteally, while preserving the

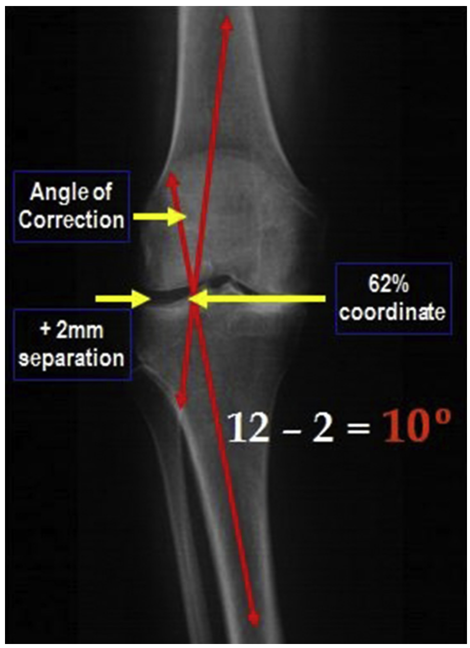

Fig 2. To determine the angle of correction, lines drawn from the center of the femoral head and the center of the talus intersect at the desired tibial coordinate, typically 62% (range, 50% to 75%). The angle formed by these 2 lines determines the angle of correction to be achieved at the osteotomy site.

Fig 3. Marking of the 7-cm vertical incision centered midway between the tubercle and the posteromedial tibial border.

Fig 5. The medial and lateral arms of the alignment bar should appear as one and are parallel with the tibial plateau slope to ensure accurate correction.

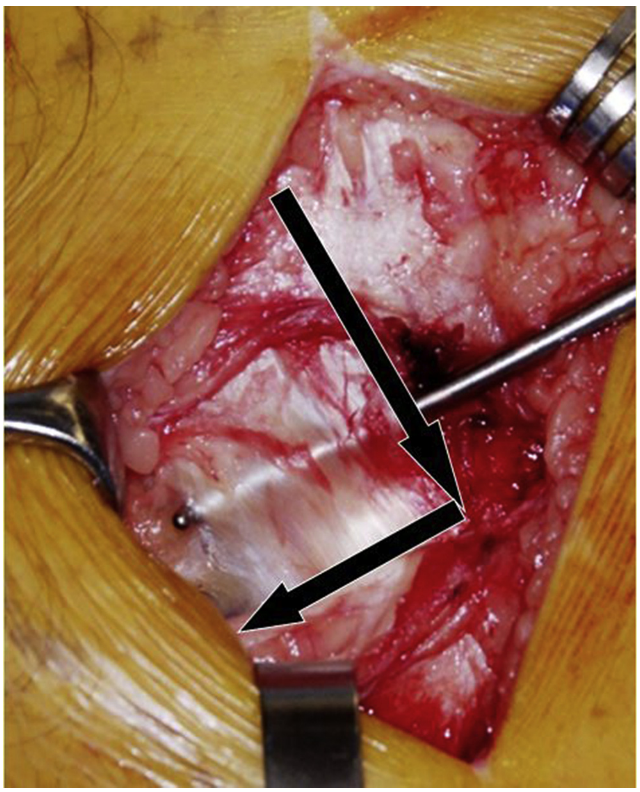

Fig 4. The sartorial fascia is split in line with the hamstring tendons, and the periosteum is incised in an "inverted-L" fashion to expose the osteotomy site.

proximal 2 cm of its tibial attachment. The knee is placed in 90° of flexion and the subperiosteal dissection is extended along both the anterior and posterior tibial cortices. The neurovascular structures are protected by placing a neurovascular shield around the posterior cortex of the tibia.

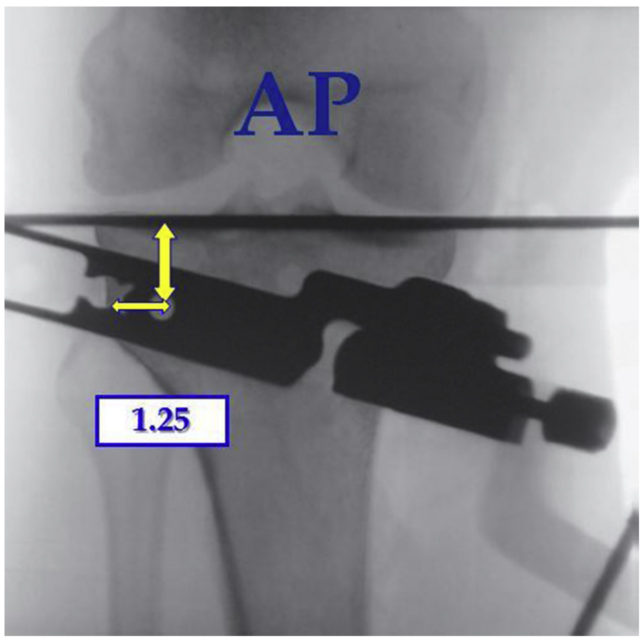

Fig 6. The distance from the hinge pin in relation to the lateral plateau should be at least 1.25 times greater than the distance from the pin and the lateral cortex. (AP, anteroposterior view of the knee.)

Fig 7. The keyhole reamer is used to drill the medial cortex in preparation for placement of the cutting guide.

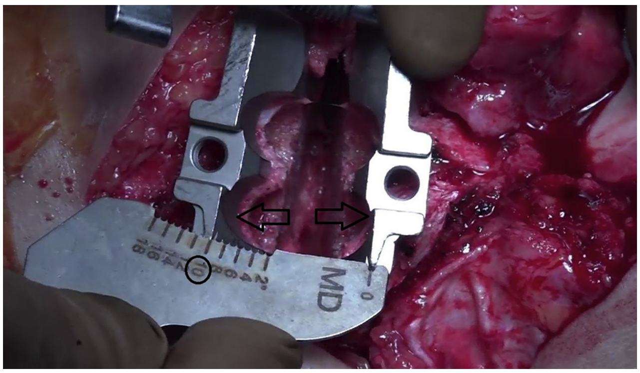

Fig 8. After the osteotomy has been made, the jack is opened slowly until the desired amount of correction is achieved.

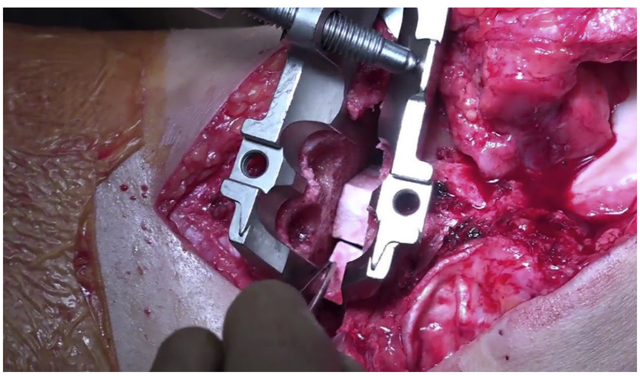

Fig 9. After opening the osteotomy site, the defect is packed with Osferion wedges, and cancellous allograft and autograft to supplement the implant and maintain degree of correction.

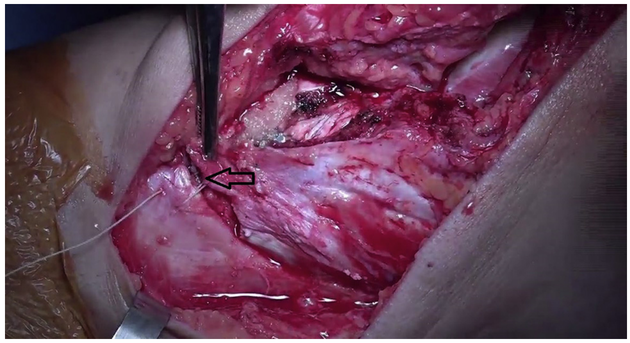

Fig 10. The superficial medial collateral ligament is loosely repaired and retensioned, and then the overlying sartorial fascia (arrow) is reapproximated to cover the implant and osteotomy site.

Step 3: Alignment

The biplanar alignment guide with the patellar tendon protector (Arthrex, Naples, FL) is placed on the proximal tibia ensuring the anteromedial tab and the medial locator rest on the cortical surface. The guide is

Fig 11. Postoperatively, a rehabilitation brace is applied and locked in extension.

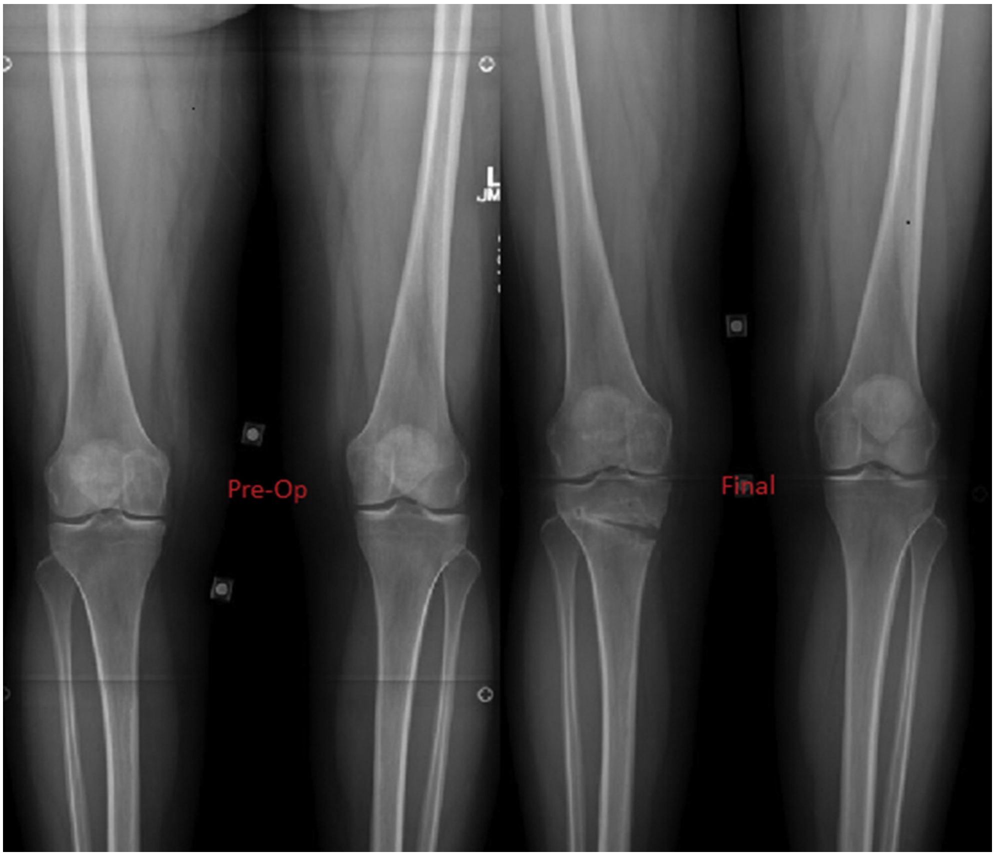

Fig 12. Preoperative (left) and postoperative (right) radiographs showing the newly performed osteotomy in a patient.

positioned with a lateral fluoroscopic view. A pin is inserted when the medial and lateral arms of the alignment bar appear as one and are parallel with the tibial plateau slope (Fig 5).

Step 4: Hinge Pin

The fluoroscope is then aligned in an anteroposterior view until the lateral hinge pinhole appears as a perfect circle. The distance from the hinge pin in relation to the lateral plateau should be at least 1.25 times greater than the distance from the pin and the lateral cortex (Fig 6). This step is crucial in that it will ensure that there is adequate distance from the eventual osteotomy and the lateral cortex to minimize the risk of lateral cortical breach or lateral tibial plateau fracture. The hinge pinhole is then drilled, the hinge pin is inserted, and the alignment guide is removed.

Step 5: Cutting Guide

The keyhole reamer (Arthrex) is used to drill the medial cortex in preparation for the placement of the cutting guide. The bone material from the reaming is collected and used for later grafting at the osteotomy site (Fig 7). The cutting guide is secured to the base, and the neurovascular shield is placed. This patellar tendon protector, hinge pin, and neurovascular shield create a rectangular zone of safety when performing the osteotomy.

Step 6: Osteotomy and Implant Placement

An oscillating saw and osteotomes (Stryker, Kalamazoo, MI) are used to create the osteotomy. The cutting guide is then removed and the opening jack inserted in the closed position. The jack is opened slowly until the desired amount of correction is achieved (Fig 8). The defect is packed with Osferion wedges, and cancellous allograft and autograft (Fig 9). The iBalance implant is inserted and secured with 2 proximal cancellous and 2 distal bicortical PEEK (polyether ether ketone) screws. Additional bone graft is placed anterior to the plate filling the osteotomy site.

Step 7: Wound Closure

Loosely repair the retensioned superficial medial collateral ligament and reapproximate the fascia to cover the implant (Fig 10). The subcutaneous tissue is closed with monofilament absorbable interrupted sutures and the skin with a running monofilament absorbable subcuticular suture, and Steri-Strips. A rehabilitation brace, locked in full extension, is applied (Figs 11 and 12).

Discussion

Studies show promising results regarding alignment correction, pain relief, and functional outcome, with excellent or good results identified in 90% to 96% of patients at 5 years, 45% at 10 years, and failures occurring at an average of 7 years after surgery because of recurrent knee pain.[2,3] The importance of adequate correction has been established, but it can be difficult with some techniques showing either over- or undercorrection in up to 50% of patients.[4] Radiographic analysis of the iBalance system identified a 38% overcorrection and 0% undercorrection defined as >10% difference compared with the target weight-bearing line ratio. The biplanar alignment guide helps reduce the amount of over- and undercorrection of knee misalignment. This system did not alter the tibial slope and only slightly decreased patellar height.[5]

The literature regarding mid- and long-term survival rates using current internal constructs for proximal tibial osteotomy remains limited. Encouraging results thus far have been seen, however, with improvements seen in visual analog scale, Knee Injury and Osteoarthritis Outcome Score, and Western Ontario and McMaster Universities Osteoarthritis Index scores, and only slight progression of osteoarthritis in the affected compartment.[6]

This technical note presents a technique for a safe and efficient surgical procedure using the Arthrex iBalance system (Arthrex). This system offers an accurate and reproducible mechanism to ensure correct biplanar alignment for opening-wedge osteotomies, while offering certain advantages such as less hardware prominence and irritation, requiring hardware removal.

The valgus-producing proximal tibial osteotomy remains a viable option for medial unicompartmental arthritis and varus malalignment. The indications for osteotomy continue to expand because varus correction is an essential adjunct for ligament reconstruction, medial meniscus transplantation, and medial femoral condyle cartilage restoration procedures. Success depends on careful patient selection, precise preoperative planning, and meticulous surgical technique.

References

1. Chae DJ, Shetty GM, Lee DB, Choi HW, Han SB, Nha KW. Tibial slope and patellar height after opening wedge high tibia osteotomy using autologous tricortical iliac bone graft. *Knee* 2008;15:128-133.
2. Hernigou P, Medevielle D, Debeyre J, Goutallier D. Proximal tibial osteotomy for osteoarthritis with varus deformity. A ten to thirteen-year follow-up study. *J Bone Joint Surg Am* 1987;69:332-354.
3. Bode G, von Heyden J, Pestka J, et al. Prospective 5-year survival rate data following open-wedge valgus high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 2015;23:1949-1955.
4. Marti CB, Gautier E, Wachtl SW, Jakob RP. Accuracy of frontal and sagittal plane correction in open-wedge high tibial osteotomy. *Arthroscopy* 2004;20:366-372.
5. Blackman AJ, Krych AJ, Engasser WM, Levy BA, Stuart MJ. Does proximal tibial osteotomy with a novel osteotomy system obtain coronal plane correction without affecting tibial slope and patellar height? *Knee Surg Sports Traumatol Arthrosc* 2015;23:3487-3493.
6. Schallberger A, Jacobi M, Wahl P, Maestretti G, Jakob RP. High tibial valgus osteotomy in unicompartmental medial osteoarthritis of the knee: A retrospective follow-up study over 13-21 years. *Knee Surg Sports Traumatol Arthrosc* 2011;19:122-127.