A Novel High Tibial Biplanar Osteotomy Technique for Simultaneous Coronal and Sagittal Correction: A Case Example

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ABSTRACT

Medial opening wedge high tibial osteotomy (HTO) can provide symptom relief, improved ligamentous stability, and lower failure rates in patients with symptomatic medial knee osteoarthritis, ligament instability, and varus alignment after ligament reconstruction. It has been reported that correcting coronal plane abnormalities with a medial opening wedge HTO has resulted in altered posterior tibial slope angle (PTSA). We describe a 38-year-old woman with a history of severe polytrauma who presented with an anterior cruciate ligament tear in the setting of increased PTSA and a posterolateral corner injury with varus deformity of the knee. A medial biplanar HTO was performed using plate position to correct varus malalignment and decrease PTSA simultaneously. This case describes a method for simultaneously correcting varus malalignment while deliberately changing PTSA.

Keywords: High Tibial Osteotomy, Biplanar Osteotomy, Posterior Tibial Slope Angle, Genu Varum, Anterior Cruciate Ligament

INTRODUCTION

High tibial osteotomy (HTO) is a well-established treatment method for correcting knee mechanical malalignment. The knee's biomechanical axis is commonly altered in isolated medial compartment osteoarthritis and when correcting coronal (varus and valgus) deformities in patients with ligamentous injuries of the knee.[1] The literature has shown that correction of coronal plane abnormalities with a medial opening wedge HTO also produces alterations in the sagittal plane, potentially increasing posterior tibial slope angle (PTSA).[2-4] Research has shown an increase in the incidence of failure and stress on the anterior cruciate ligament (ACL) to be associated with increased PTSA.[4-6] This increased incidence and added stress emphasize the importance of thorough preoperative and intraoperative assessment to recognize and address possible PTSA changes when evaluating patients for ACL reconstruction. Savarese et al[7] describe a technique for evaluating PTSA changes with HTO by measuring the size of the anterior and posterior aspects of the osteotomy site. This method can be used to purposefully make changes to the PTSA or minimize inadvertent PTSA changes with HTO. We describe a simple and reproducible surgical technique for correcting varus malalignment of the knee and an associated reduction of PTSA.

CASE REPORT

A 38-year-old woman presented to our clinic for chronic left knee instability after sustaining multiple traumatic injuries. Findings of the physical examination revealed varus thrust during gait and a positive Lachman with an increased opening to varus stress at 0° and knee flexion of 30°. Initial radiographs showed 7° of varus malalignment of the tibia (Figures 1A and 1B) and a 15° PTSA (Figure 1C) with retained intramedullary nail in the left femur. The posterior tibial slope was measured using the angle between a line perpendicular to the posterior cortex of the tibia and a line tangential to the tibial plateau. A staged procedure was planned to include femoral nail removal and a biplanar medial opening wedge HTO to correct varus malalignment to neutral and decrease PTSA to 7° simultaneously. This procedure would be followed by staged ACL and posterolateral corner (PLC) reconstruction after healing of the osteotomy.

During the index procedure, a diagnostic arthroscopy of the left knee confirmed ACL and PLC tears. The intramedullary nail was extracted without incident. A reamer irrigator aspirator was used to harvest an

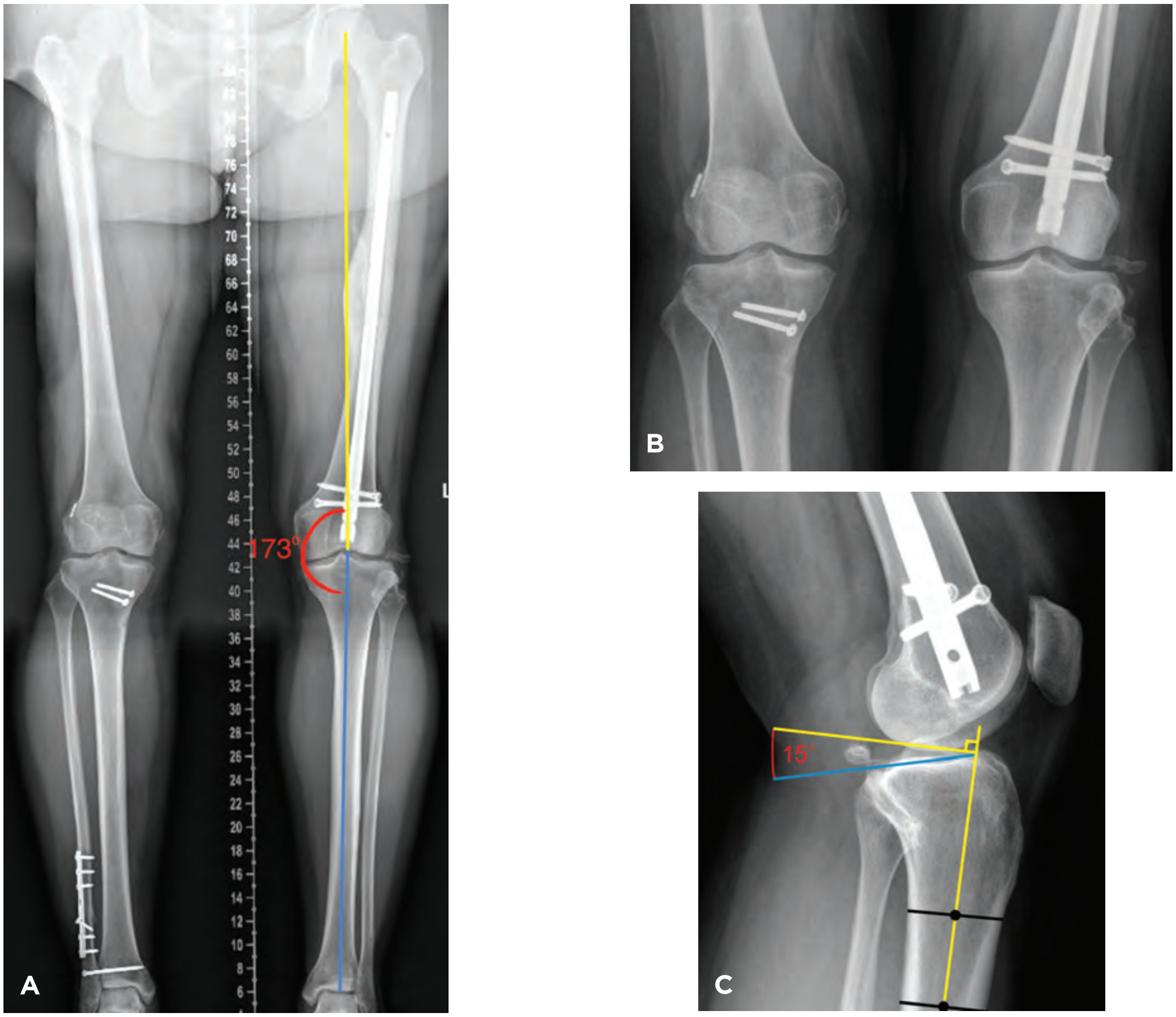
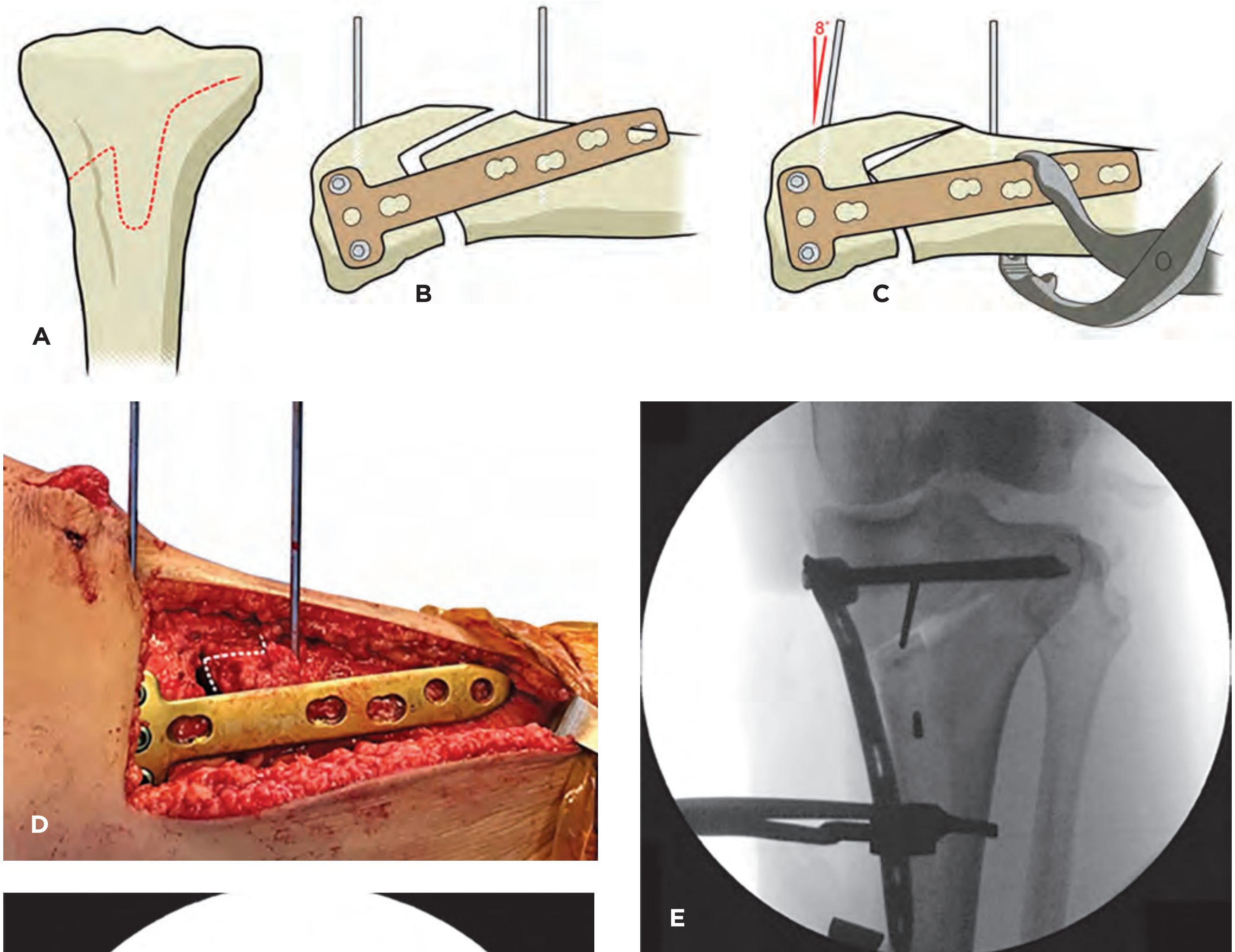


Figure 1. *Preoperative A) anteroposterior (AP) radiograph of bilateral hip to ankle alignment showing varus malalignment of the left knee and retained left femur intramedullary nail, B) AP bilateral knee radiograph, and C) lateral radiograph of the left knee showing an excessive posterior slope of 15°.*

intramedullary bone autograft from the left femur to graft the osteotomy. A medial approach to the proximal tibia was then performed, maintaining the pes anserine insertion. Two parallel guide pins were placed from anterior to posterior in the tibia using a parallel drill guide. To allow a visual guide during PTSA correction, we positioned one pin proximally and one pin distally to the planned osteotomy. The biplanar osteotomy was performed using an inverted-L technique previously published by Monllau et al[8] (Figure 2A).

Correction of varus malalignment was accomplished by manipulating the horizontal plane of the HTO, which was performed using a 7-mm iliac crest allograft bone wedge soaked in the intramedullary bone autograft. Allograft chips and demineralized bone matrix were also placed in the osteotomy opening. An AO TomoFix plate (Depuy Synthes; Warsaw, IN) was secured to the proximal tibia with locking screws. The plate was secured so that its distal aspect was angled slightly anterior to the anterior cortex of the tibia, allowing for posterior translation of the plate and a resultant decrease of the PTSA (Figure 2B and 2C). A Verbrugge clamp was used to rotate and compress the plate down to the tibia shaft, bringing the distal aspect of the plate posteriorly and thus reducing the PTSA (Figure 2D). Convergence of the previously placed parallel guide pins indicated successful PTSA reduction (Figure 2D). Fluoroscopy and a sterile goniometer were then used intraoperatively to measure the planned 8° of PTSA reduction precisely, resulting in a final PTSA of 7° (Figure 2E). The sterile goniometer was used to measure the change in angle of the parallel pins, plate translation off the anterior cortex of the tibia, and angle of the PTSA on fluoroscopic images. The plate was then fixed distally with bicortical locking screws (Figure 2F).

The osteotomy site was radiographically healed 3 months postoperatively, and the patient underwent ACL and PLC reconstruction 23 months later. The staged procedure was delayed for social reasons. The HTO plate was removed. ACL reconstruction with



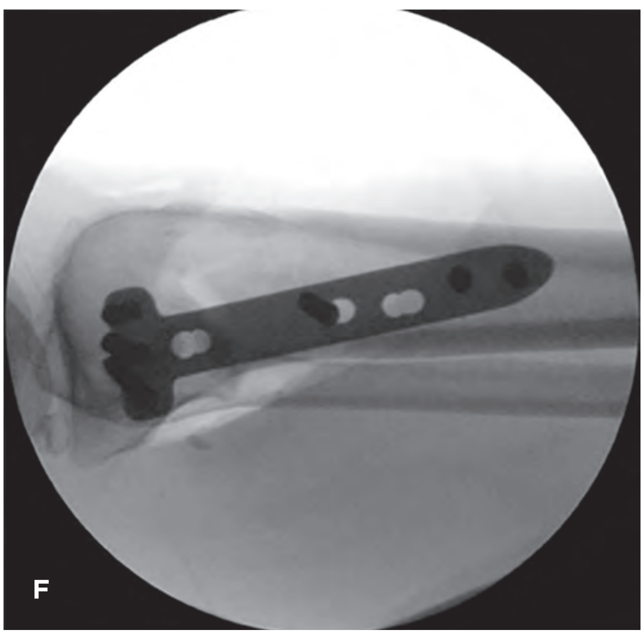


__Figure 2.__ A) A digital illustration of an L-type biplanar osteotomy. B) An intraoperative photograph of the placement of the initial plate placement before posterior tibial slope angle (PTSA) correction. The dashed white line represents the osteotomy plane. C) A digital illustration of the placement of the initial plate with the distal aspect angled anterior to the anterior tibial cortex. Note the parallel guide pins. D) A digital illustration showing the use of a Verbrugge clamp to pull the distal aspect of the plate posteriorly, thereby decreasing PTSA. Note the guide pins now converge. An intraoperative fluoroscopic radiograph of the left knee showing E) improvement in varus malalignment and F) a decreased PTSA with bicortical distal screws in place.

the quadriceps autograft tendon and LaPrade-type reconstruction of the PLC were performed. At 2-year follow-up, the patient had excellent subjective function of the left knee with resolution of her instability both clinically and subjectively. Radiographs at 2 years showed maintained improved alignment (Figure 3A through 3C).

DISCUSSION

Several studies have shown increased rates of ACL graft failure in patients with uncorrected varus malalignment, even as little as 5°.[9,10] Multiple studies have also reported increased rates of ACL graft rupture in patients with increased PTSA.[4,11,12] In general, PTSA greater than 12° is accepted as an indication for a

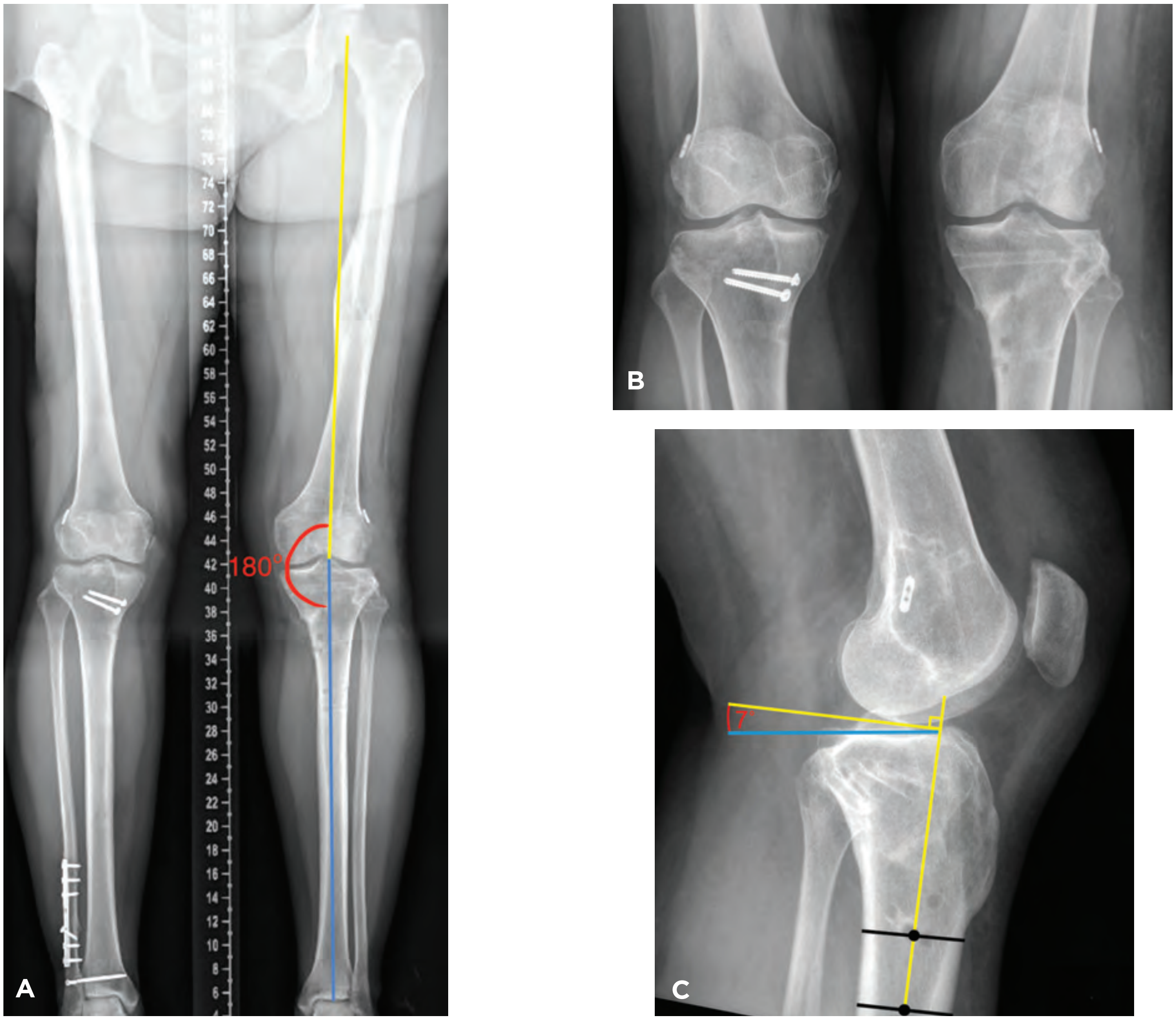


Figure 3. *Radiographs at 2 years postoperatively, including: A) bilateral anteroposterior (AP) hip to ankle alignment radiographs showing improvement in varus malalignment of the left knee. B) Bilateral knee AP radiograph. C) Lateral radiograph of the left knee showing healed osteotomy site and maintained improvement in coronal and sagittal alignment with a posterior tibial slope angle of 7°.*

proximal tibia osteotomy to decrease the slope and reduce rates of graft failure.[11] In a biomechanical study, Bernhardson et al[4] showed a linear relationship between PTSA and the amount of force placed on an ACL graft, which supports prior clinical studies[11,12] showing increased graft failure rates in patients with increased PTSA.

Studies have shown that medial opening wedge HTO inadvertently increases PTSA from 2.5° to 4°, which can be unfavorable in the setting of ACL deficiency.[2,3,13] Lateral knee radiographs should be carefully evaluated in patients where a medial opening wedge osteotomy is planned. The technique described in this paper can be used in patients with increased PTSA to simultaneously address coronal and sagittal plane deformities and maximize knee function. This technique reduces the likelihood for lateral cortical fractures in the intact portion of the medial opening osteotomy.

Novel techniques are needed to correct or ensure the preservation of PTSA in patients undergoing medial opening wedge HTO. As described in our case, parallel pins placed before the osteotomy can provide visual feedback on PTSA, in which convergence of the pins indicates a decrease in PTSA. Additionally, the alignment of the plate on the distal aspect of the tibia can provide another source of visual feedback intraoperatively. If the plate is fixed proximally and lying anteriorly with regard to the tibia shaft, the posterior pull of the plate will decrease PTSA.

Lateral closing wedge osteotomy may also be considered as an alternative to medial opening wedge osteotomy. Ranawat et al[14] reported that lateral closing wedge HTO allows greater PTSA neutralization when compared to medial opening wedge HTO. However, lateral closing wedge HTO allows less fine-tuning of the coronal malalignment correction and has a higher risk of altering the patellofemoral joint biomechanics.[14] Ranawat et al[14] also showed that lateral closing wedge HTO, when compared to medial opening wedge HTO, was associated with increased external tibial rotation and lateral patellar tilt.

In the case presented in this technique article, a nearly 2-year delay to ligament reconstruction occurred after HTO. Correcting alignment is the priority in managing knee instability and malalignment. HTO alone slows progression to total knee arthroplasty in patients with symptomatic coronal malalignment. It is the authors' preference to perform a two-stage procedure. The first stage is to correct malalignment, and the second stage is to perform ligamentous reconstruction. The target timeframe for ligamentous reconstruction is typically as soon as possible after radiographic healing of the osteotomy. In the case presented, the HTO was radiographically healed at 3 months. However, the patient delayed ligamentous reconstruction because of social reasons. Ligamentous reconstruction was undertaken 23 months after HTO because the patient continued to have symptomatic instability. Radiographs did not show progression of osteoarthritis nearly 2 years after undergoing HTO and reconstruction of the ACL and PLC.

Although HTO has shown utility in correcting coronal and sagittal plane malalignment, the literature showing simultaneous correction of coronal and sagittal plane deformity with a single osteotomy is limited. We describe a unique technique for treating patients with ligament insufficiency and complex deformity that can potentially decrease both graft failure rates and the progression of osteoarthritis. Further studies are needed to better understand and ultimately compare different techniques for altering coronal and sagittal alignment in simultaneous or staged procedures.

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