Osteotomies in the Multiple Ligament Injured Knee

When Is It Necessary?

Niv Marom, MD[a], Norimasa Nakamura, MD, PhD[b], Robert G. Marx, MD[a,*], Michael J. Stuart, MD[c]

KEYWORDS

• Multiple ligament-injured knee • Osteotomy • Posterior tibial slope • Varus thrust • Triple varus • Coronal malalignment • Opening wedge osteotomy • Closing wedge osteotomy

KEY POINTS

- In the setting of the unstable and malaligned knee, isolated reconstructive ligament procedures are prone to failure if the limb is not realigned.
- Literature supports osteotomy in addition to ligament reconstructive procedures in knees with complex double/triple varus injury patterns and have shown good outcomes after combined or staged procedures.
- Corrective osteotomies of the tibial slope, either in isolation or combined with coronal realignment, are an additional important tool that addresses and treats anterior-posterior instability.
- In revisions of failed multiple ligament reconstruction surgery, a corrective osteotomy should be considered with any coronal malalignment greater than 5°.
- In some unstable and malaligned multiple ligament injured knees, corrective osteotomies may provide sufficient stability, functionality, and pain reduction, and additional soft tissues procedures may be unnecessary.

INTRODUCTION

The multiple ligament-injured knee is often associated with additional intra- and extra-articular injuries. Surgical repair and reconstruction of the involved ligaments are frequently discussed in the literature; however, osteotomy to correct limb malalignment may be just as important to obtaining a good outcome.

Veltri and Warren[1] outlined the role of osteotomy in the unstable, malaligned knee in the coronal plane with or without a varus thrust gait. They showed that any

[a] Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021, USA; [b] Institute for Medical Science in Sports, Osaka Health Science University, 1-9-27 Tenma, Kita-ku, Osaka City, Osaka 530-0043, Japan; [c] Mayo Clinic, 201 West Center Street, Rochester, MN 55902, USA
* Corresponding author.
E-mail address: marxr@hss.edu

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reconstructive procedure is prone to failure if the limb is not realigned because of chronic repetitive overload on the reconstructed tissue secondary to the malalignment.

This article will discuss the role of osteotomy in the treatment of the multiple ligament-injured knee.

CORONAL MALALIGNMENT

The Varus Knee

Varus malalignment represents several clinical conditions with distinct characteristics. Primary or single varus refers to the osseous (tibiofemoral) varus alignment with or without medial compartment narrowing secondary to damaged medial meniscus and/or articular cartilage. The transfer of the weight-bearing line into the medial compartment results in higher compressive loads, increased tensile forces, and excessive laxity of the lateral capsuloligamentous structures, all of which represent a double varus knee. The development of a double varus knee leads to further degeneration of the articular cartilage. Additional compromise of the posterolateral structures can occur over time, resulting in a varus/recurvatum or triple varus knee.[2] Varus thrust, often seen in double or triple varus conditions, refers to a dynamic alignment abnormality. The thrust is identified by an abrupt worsening of varus during the weight-bearing phase of gait, which corrects during the nonweight=bearing (swing) phase.[3,4]

Varus malalignment, with or without thrust, has been implicated as a potential cause for increased anterior cruciate ligament (ACL) strain and a potential risk factor for ACL reconstruction failure.[4–6] Additionally, cadaveric studies have shown that the application of a varus torque to the extended knee results higher tension forces within the ACL. Noyes and colleagues[7] recommended osteotomy in addition to ligament reconstructive procedures in knees with complex double and triple varus injury patterns and showed good outcomes after combined or staged procedures.

Acute injury to the posterolateral complex in combination with ACL injury and preexisting varus alignment simulates a triple varus knee. The addition of a posterior cruciate ligament (PCL) injury can augment the hyperextension deformity, and combined ACL, PCL, and posterolateral corner injuries can further magnify hyperextension, varus and external rotational deformities.[8] Addressing only the soft tissues when treating these complex injuries will result high rates of failures.[9] A recent systematic review by Tischer and colleagues[10] provided clinical evidence to support osseous malalignment as a contributing factor to failure of knee ligament surgery. These authors recommended limb realignment surgery in selected cases to improve function and stability, especially with posterolateral corner insufficiency.

Phisitkul and colleagues[11] suggested that osteotomy is indicated in patients with varus thrust gait and posterolateral laxity. They recommended an opening wedge, valgus-producing, proximal tibial osteotomy to produce a multi-planar correction with better intraoperative adjustment and avoidance of the proximal tibiofibular joint and peroneal nerve. Disadvantages of this technique include possible need for bone graft and difficulty in correcting severe deformities. The lateral closing wedge valgus-producing proximal tibial osteotomy remains an option and provides a stable construct with good bone apposition. However, a closing wedge can decrease posterior tibial slope, which may negatively affect a PCL-deficient knee. In addition, tibial shortening decreases the distance between the tibial plateau and tibial tuberosity, increases lateral collateral ligament laxity, and may have an unfavorable impact on future conversion to total knee arthroplasty.[8]

Alignment correction, regardless of technique, transfers the weight-bearing line (center of the femoral head to center of the talus) to the 62.5% position on the tibial plateau when measured from medial to lateral.[8]

In scenarios in which instability is combined with clear degenerative changes in the overloaded compartment, realignment procedures are indicated for additional reasons, as they can redistribute the joint forces and decrease symptoms related to osteoarthritis.[6] A medial opening wedge proximal tibial osteotomy in the varus knee will produce lower medial compartment pressures only after subsequent release of the distal medial collateral ligament (MCL).[12]

The Valgus Knee

A severe valgus-aligned limb with excessive tensile forces on the medial side of the knee can produce a triple valgus variant. This combination of severe osseous valgus malalignment, medial soft tissue laxity, and medial joint space opening leads to eventual additional rotatory instability with further compromise of the posteromedial structures.

Phisitkul and colleagues[11] previously defined excessive valgus deformity as a weight-bearing line that falls lateral to the lateral tibial spine on a single- or double-leg weight-bearing radiograph.

The preferred way to treat these complex valgus deformities with symptoms of instability, pain, and possible medial thrust is a distal femoral lateral opening wedge or medial closing wedge osteotomy. Soft tissue procedures performed in isolation are not the proper treatment option in these circumstances.[8,13,14] Biomechanically, it has been shown that lateral opening wedge distal femoral osteotomy decreased medial knee opening when medial structures were sectioned.[14]

The lateral opening wedge osteotomy (**Figs. 1** and **2**) is becoming more popular, mainly because of the simple surgical exposure, single bone cut, and possibly more accurate correction. However, medial closing wedge osteotomy is preferred for larger corrections (>17.5°), earlier weight bearing, and if the patient has predisposing factors for delayed healing.[15]

In cases in which the osseous malaligned multiple injured knee presents with additional intra-articulator pathologies that require treatment, such as cartilage restoration or meniscal transplantation, a realignment procedure should be considered, not only for stability purposes, but also for redistribution of joint forces to protect these tissues.[16,17]

SAGITTAL MALALIGNMENT

Posterior Tibial Slope

Malalignment in the sagittal plane influences knee stability in the setting of ligamentous injury, especially with cruciate ligament rupture.[8,11,18,19] Normal posterior tibial slope values are between 9° to 11° medially and 6° to 8° laterally with a large amount of variation. Posterior tibial slope greater than 13° has been considered excessive.[20] Increased posterior tibial slope allows increased anterior tibial translation owing to the tendency of the femur to slide posteriorly. Increased anterior tibial slope allows increased posterior tibial translation owing to the tendency of the femur to slide anteriorly. In an ACL-deficient knee, anterior tibial translation is magnified by increased posterior slope and reduced with decreased posterior slope. In a PCL-deficient knee, posterior tibial translation is magnified by increased anterior slope and reduced with decreased anterior slope.

The medial opening wedge, valgus-producing, proximal tibial osteotomy can produce combined biplanar, coronal, and sagittal realignment, depending on the location

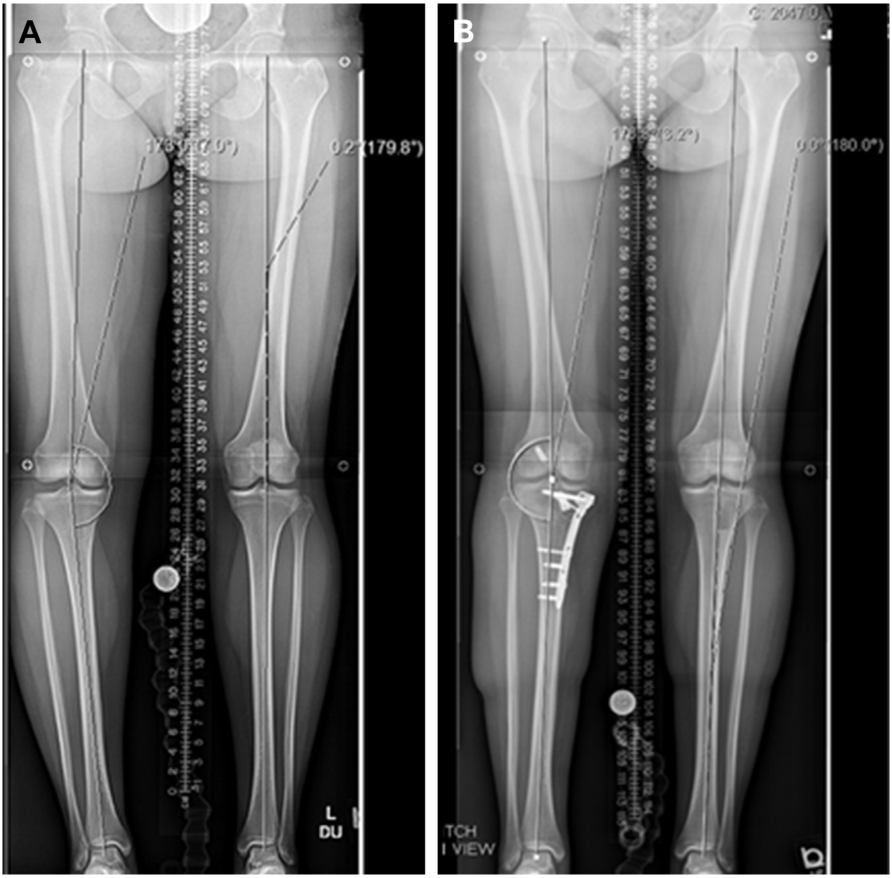

Fig. 1. 20-year-old woman presented after right ACL and lateral side injury. Physical examination revealed varus and valgus thrust gait and anterior knee instability. (*A*) AP alignment radiograph showing 7° of varus on the right knee compares to no varus on the left. (*B*) AP alignment radiograph after a proximal medial opening wedge osteotomy and ACL reconstruction. Varus thrust gait was eliminated after surgery.

of the intact cortical hinge and the degree of anterior or posterior opening. A more posterolateral hinge will result in a larger change and increase in posterior tibial slope, whereas lateral cortical hinge will result in mainly coronal realignment and minimal sagittal slope change.[8,21] Increased posterior tibial opening will decrease posterior tibial slope, and increased anterior opening will increase slope.

Other osteotomies directed at changing sagittal alignment are anterior closing wedge proximal tibial osteotomy to reduce the posterior tibial slope in the setting of ACL deficiency (**Fig. 3**) and anterior opening wedge proximal tibial osteotomy to increase the posterior tibial slope in the setting of genu recurvatum and PCL deficiency (**Fig. 4**).

Corrective osteotomies of the tibial slope, either in isolation or combined with coronal realignment, are another important tool in the multiple ligament-injured knee surgeon's tool box.

REVISION MULTIPLE LIGAMENT KNEE RECONSTRUCTION

Woodmass and colleagues[22] reported their outcomes after revisions of failed multiple ligament reconstruction surgery and showed that almost 50% of failures had an

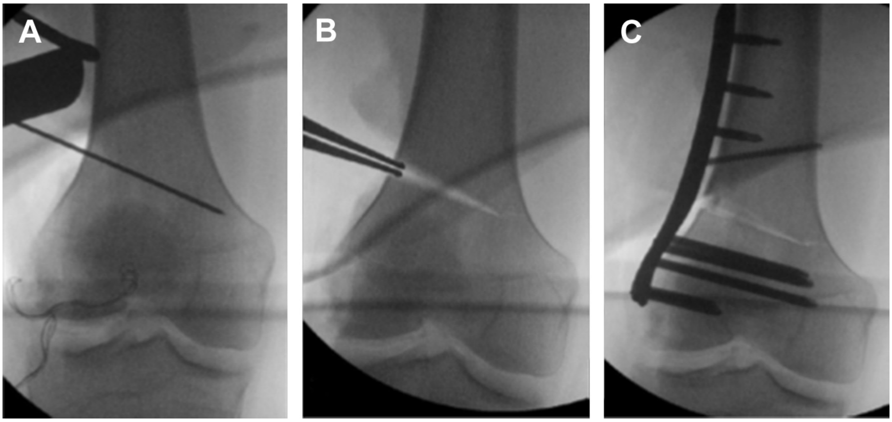

Fig. 2. Intraoperative fluoroscopy images of lateral opening wedge varus producing osteotomy. (*A*) Guide pin drilled through lateral distal femur. (*B*) Opening lateral wedge without compromising medial femoral cortex. (*C*) Bone grafting the open wedge and fixation.

unaddressed concomitant pathology. Osteotomy was required in 4 patients (17.4%) to treat coronal malalignment (defined as >5°), and realignment osteotomy was performed in a staged fashion. Overall, good clinical results and moderate functional results were observed at a mean follow-up 7.5 years. Based on their results, they proposed a treatment algorithm for the management of the failed multiple ligament reconstruction patient. The algorithm recommends a staged realignment procedure if coronal malalignment greater than 5° is present.

COMBINED PROCEDURES

In combined realignment and ligament reconstruction procedures, the ligament reconstruction can be performed at the same time as the osteotomy, or deferred. In

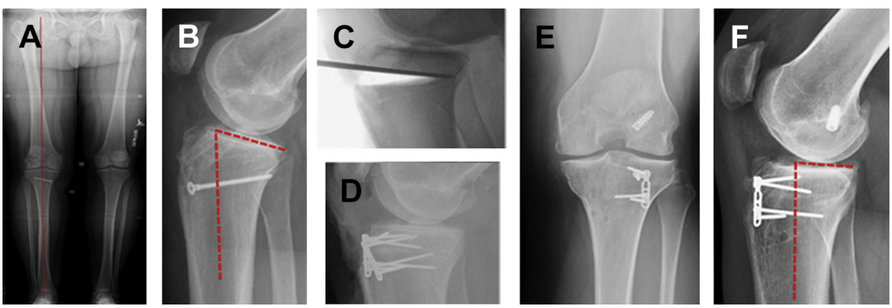

Fig. 3. A 22-year-old basketball player presented with right knee pain and recurrent giving way episodes. Surgical history consisted of 3 failed ACL reconstructions, and physical examination demonstrated high-grade Lachman and pivot shift. (*A*) AP radiograph showing normal coronal alignment. (*B*) Lateral radiograph showing increased posterior tibial slope of 25°. Additional computed tomography (CT) and MRI findings were large bony tunnels defects, medial meniscus deficiency, and lateral meniscus radial tear. A t2-stage revision was decided. The first stage included anterior proximal tibial closing wedge osteotomy, tunnel bone grafting, and lateral meniscus repair, and the second stage included ACL revision and medial meniscus transplantation. (*C*) Intraoperative fluoroscopy showing opening of anterior wedge. (*D*) Lateral radiograph after the first stage. (*E*) AP radiograph after the second stage. (*F*) Lateral radiograph after the second stage showing corrected posterior tibial slope of 7°.

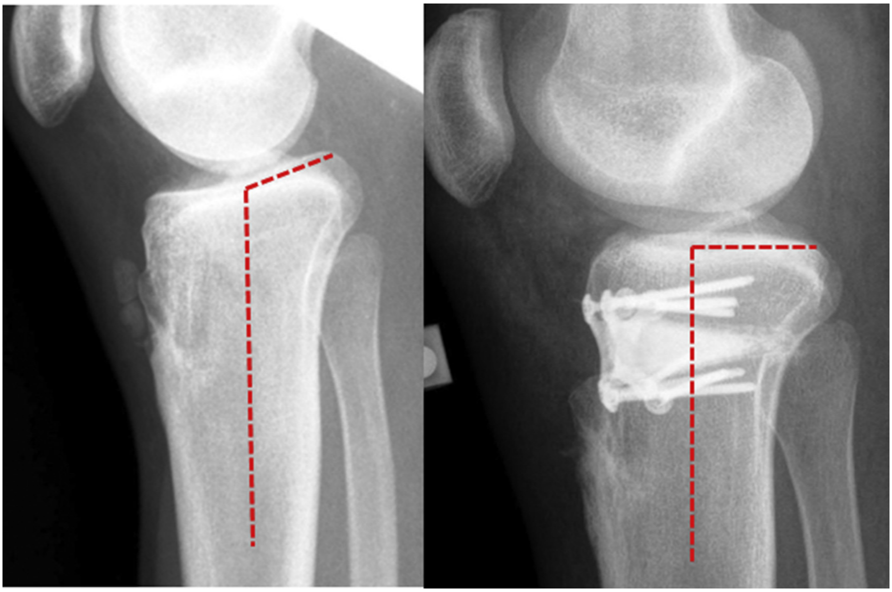

Fig. 4. Anterior opening-wedge high tibial osteotomy to increase posterior slope. On the left, preoperative lateral radiograph with negative posterior tibial slope. On the right, post-operative lateral radiograph with posterior tibial slope of 0°.

some cases ligament reconstruction is not necessary after the osteotomy, as sufficient stability, functionality, and pain reduction are achieved with the realignment procedures only.[23]

SUMMARY

Limb realignment in the coronal and sagittal planes must be carefully evaluated and treated in the setting of complex knee instability. Isolated soft tissue procedures are prone to failure if significant malalignment, deformity, and thrust are ignored. In select cases, osteotomy can lead to restored mechanical stability, optimal joint load distribution, improved survival of simultaneous soft tissue procedures, and better patient outcomes.

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