Anterior Closing Wedge Tibial Osteotomy for Failed Anterior Cruciate Ligament Reconstruction

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Abstract

The success rate for achieving knee stability in primary anterior cruciate ligament (ACL) reconstruction is high; however, the results of revision reconstruction are less satisfactory. Sagittal plane malalignment is an uncommon predisposing factor for failure because excessive posterior tibial slope increases stress on the ACL graft. In carefully selected patients, tibial slope correction is an essential adjunctive procedure to achieve a stable knee. We present a case report outlining the surgical technique for correction of sagittal plane imbalance by a slope-decreasing anterior closing wedge tibial osteotomy combined with a second-stage revision ACL reconstruction. At 2 years following surgery, our patient had a stable knee and returned to low-impact athletic activity without symptoms. Further investigation is needed to refine the indications for this procedure in the setting of failed ACL reconstruction.

Keywords
- deflexion
- sagittal plane ACL
- ACL revision
- anterior closing wedge osteotomy
- increased slope

Failed reconstruction of the anterior cruciate ligament (ACL) in a young, active patient represents a difficult clinical problem. Numerous factors contribute to failure, including repeat trauma, technical errors, biologic influences, or a combination of causes. Technical errors commonly include femoral and tibial tunnel malposition, inadequate graft fixation, failure to address associated posteromedial or posterolateral corner injuries, and failure to correct coronal plane malalignment.[1–7] Less commonly, sagittal plane malalignment can be a risk factor for ACL reconstruction failure.[8] For an ACL deficient knee, each 10 degree increase in posterior tibial slope leads to a 6 mm increase in anterior tibial translation.[9] Animal studies have also demonstrated that reduction of the tibial slope in the canine model leads to decreased anterior tibial translation.[10] As a result, increased posterior slope poses a risk factor for failure of ACL reconstruction, or in the absence of a competent ACL, progressive posttraumatic arthritis.[1,8] The purpose of this work is to describe the indications, technique, and short-term results of a slope decreasing, anterior closing wedge tibial osteotomy to address sagittal plane malalignment in revision ACL reconstruction.

Case Report

A 22-year-old male patient presented after the failure of three previous ACL reconstructions performed elsewhere by sports medicine trained surgeons. Previous reconstructions utilized hamstring autograft, patellar tendon autograft, and allograft tissue. In every case, the graft failed within the first 6 months after surgery without a traumatic event.

On presentation, the patient ambulated with a nonantalgic gait and normal frontal plane limb alignment. Knee range of motion measured from −5 degrees of extension to 140 degrees of flexion compared with 2 degrees of hyperextension to 140 degrees of flexion on the contralateral leg. The Lachman test was positive without an appreciable end point and the pivot shift test was rated as 2+. On posterior drawer and sag tests, there were no signs of associated ligament injury. The knee was stable to varus and valgus testing at 0 and 30 degrees of flexion.

Knee radiographs, magnetic resonance imaging, and computed tomography were reviewed. The femoral socket and tibial tunnel appeared in appropriate positions. The ACL graft was completely disrupted. Interference screws were present on both the tibia and femur along with a backup screw on the

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tibia. The tibial slope measured 20 degrees on a full-length lateral tibial X-ray compared with 8 degrees on the contralateral tibia; there was no history of trauma to explain this difference. The tibial tunnel was ectatic with a maximum diameter of 18 mm. There was a complex tear of the medial meniscus and a longitudinal tear of the lateral meniscus. Tricompartmental mild chondromalacia was evident, but no focal articular defects were present. The full length standing radiograph revealed a normal mechanical axis (►**Fig. 1**). Single leg stance views (►**Fig. 2**) demonstrated approximately 15 mm of anterior tibial translation.

Materials and Methods

Surgical Technique

A two-stage surgical procedure was performed in our patient, but revision ACL reconstruction and osteotomy can be performed in a single stage if there is no significant tunnel widening. The first stage included a diagnostic arthroscopy, lateral meniscus repair with all-inside sutures, removal of hardware, bone grafting of the femoral and tibial tunnels, and a posterior slope-decreasing, anterior closing wedge tibial osteotomy. The second stage consisted of a medial meniscus

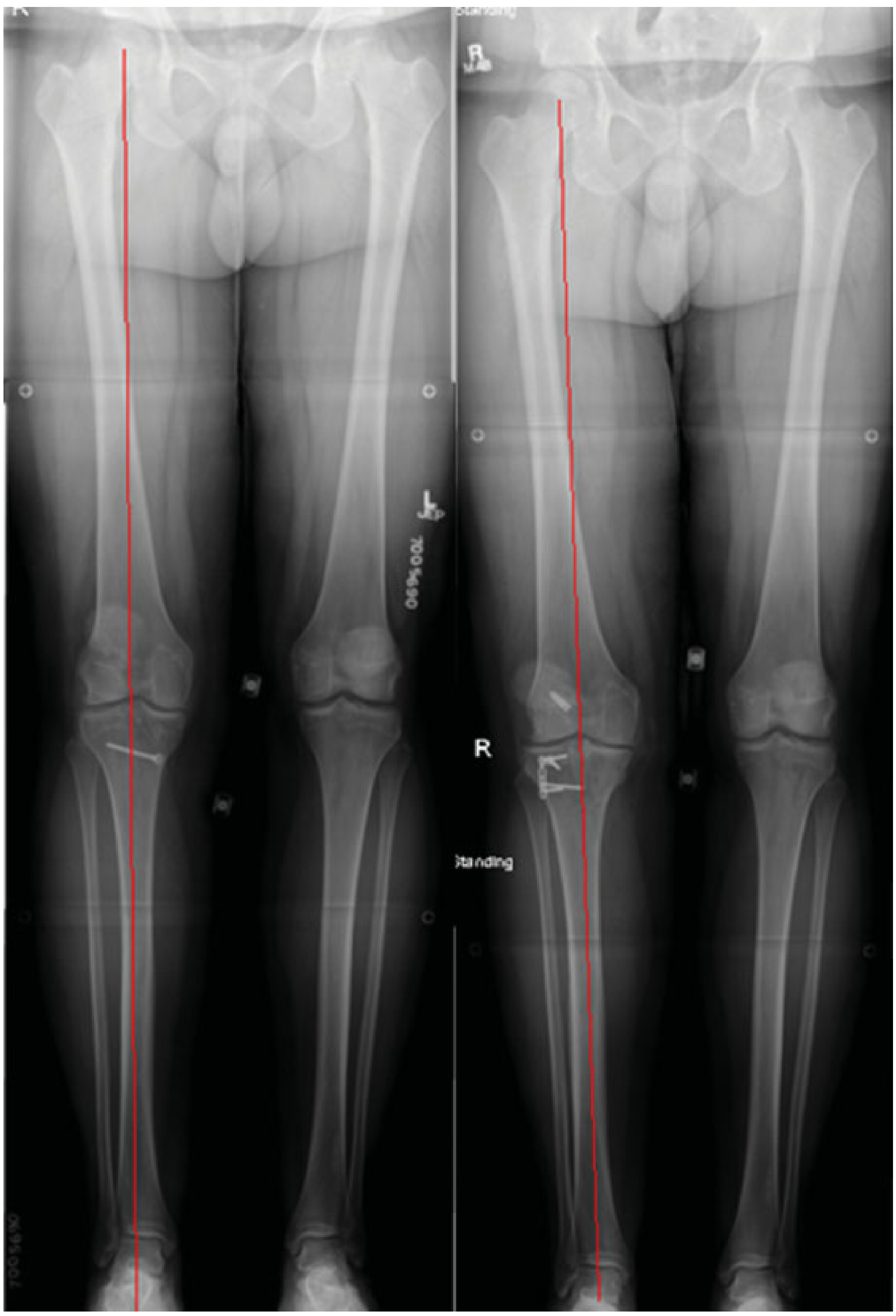

Fig. 1 Long leg standing films. To the left is the preoperative radiographs showing neutral biomechanical axis. To the right is the postoperative radiograph showing an unchanged coronal plane mechanical alignment after the osteotomy.

Fig. 2 Single leg stance view showing preoperative slope and anterior translation of the tibia under the femur of 15 mm.

transplantation and revision ACL reconstruction using a contralateral patellar tendon autograft.

The slope-decreasing anterior closing wedge tibial osteotomy was accomplished through an anteromedial incision extending from the joint line distally to the tubercle incorporating the previous surgical scar. The medial tibia was subperiosteally exposed similar to any proximal tibial osteotomy, extending anteriorly beneath the patellar tendon to the posteromedial aspect of the metaphysis. The superficial medial collateral ligament (MCL) was elevated, and then repaired after the osteotomy. The anterolateral aspect of the tibia, lateral to the patellar tendon was also exposed by elevating the anterior compartment musculature. On the basis of the preoperative templating, a 10 mm anterior closing wedge osteotomy was calculated to reduce the slope from 20 to 8 degrees (►**Fig. 3**). Under fluoroscopic guidance, two guide pins were placed on either side of the patellar tendon from anterior to posterior at the distal level of the posterior cruciate ligament (PCL) insertion (►**Fig. 4**). Two additional guide pins were placed under fluoroscopic guidance 10 mm distally to converge with the proximal pins at the posterior cortex. Using copious irrigation, an oscillating saw was then used to create the osteotomy along the guide pins with care to protect the patellar tendon and collateral ligaments. The osteotomy was carefully completed using an osteotome to perforate the posterior cortex with knee placed at 90 degrees of flexion. The osteotomy was closed anteriorly, and then fixed in compression using medial and lateral 2.7 mm locking plates. The MCL, sartorius and lateral fascia were then repaired. In this case, we used the autogeneic bone from the osteotomy to fill the ectatic femoral and tibial tunnels.

The knee was placed in a hinged brace locked in full extension to protect osteotomy and repaired MCL from varus and valgus stress. The patient was allowed full knee range of motion and partial weight-bearing using crutches. Full weight bearing in extension was permitted at 6 weeks after surgery. At 10 weeks, the brace was unlocked during ambulation. Three months after surgery, a lower extremity strengthening program was instituted in preparation for the second-stage revision ACL reconstruction. Knee radiographs at 6 months following surgery demonstrated healing of the osteotomy and the patient stated that his knee felt more stable than after his previous ACL reconstruction procedures (►**Fig. 5**).

Eight months after the initial operation the second stage was performed, and consisted of osteotomy plate removal (to allow creation of the tibial tunnel), medial meniscus allograft transplantation, and repeat revision ACL reconstruction using a contralateral knee patellar tendon autograft.

Results

Two years following surgery, the patient reported rated his pain at 0/10 on the visual analog scale and denies any episodes of knee instability.[11] He returned to biking, elliptical and his job which required standing and walking 12 hours per day. He was pleased with the postoperative result and indicated that he would undergo the procedures again. Physical examination revealed knee range of motion from full extension (0 degrees) to 140 degrees of flexion. The Lachman and pivot shift tests were negative. The knee was stable to varus and valgus stress testing at 0 and 30 degrees of flexion. At 18 months after surgery, his Knee Society Score[12] was 97.5, Lysholm Activity score[13] was 90, and International Knee Documentation Committee (IKDC) Subjective Knee score[14] was 73.6, with objective score of A.

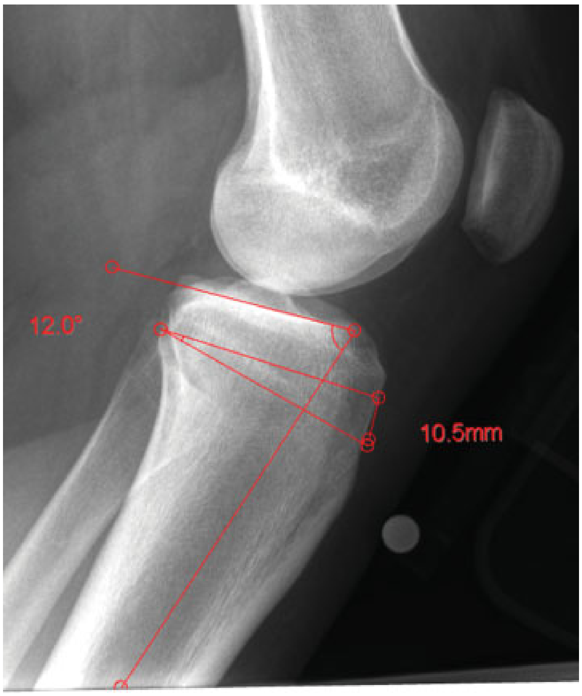

Fig. 3 Slope calculation calculated preoperatively based on the lateral X-ray with magnetic markers for calibration. After measuring the slope on the lateral X-ray, a line parallel to the tibial slope was drawn at the level of planned resection and then a 12-degree angle was drawn with the opening along the anterior cortex. The distance was then calculated for resection level between these two points.

Discussion

Although the ACL is the primary restraint to anterior tibial translation, the contribution of other anatomic structures should be considered, including the posterior horn of the medial meniscus and the slope of the tibia. Increased slope contributes to posterior translation of the femur relative to the tibia, increased tibial load, and lack of full knee extension. In a recent model, higher degrees of posterior tibial slope correlated with increased forces on the ACL during walking.[15] Excessive posterior tibial slope is associated with increased anterior tibial translation and elevated ACL stress. In this setting, a decrease in the tibial slope will reduce stresses on the ACL graft in the primary and revision setting. Neyret et al suggest addressing tibial slope when the primary ACL reconstruction fails, posterior tibial slope measures greater than 13 degrees, and anterior tibial translation measures greater than 10 mm on a single leg stance radiograph.[8] We also recommend correction of other concomitant pathology that contributes to ACL failure including posterior horn medial meniscus deficiency.

Our case report illustrates a surgical technique for addressing sagittal plane imbalance during revision ACL reconstruction. Dejour et al[16] reported the results of 22 knees that underwent a similar osteotomy with good results using a technique described by Neyret et al.[8] Others have also described sagittal realignment osteotomies of the proximal tibia.[17] There are several differences between our technique and those previously published. First, the slope-decreasing anterior closing wedge tibial osteotomy and revision ACL were performed in staged fashion rather than in the same setting, allowing healing of the osteotomy and incorporation of bone graft placed in previous ACL reconstruction tunnel sites. This allows the surgeon to create tibial and femoral tunnels without concern for deficient bone stock, crossing the osteotomy with graft fixation hardware, or problems with tibial tunnel placement because of the osteotomy hardware. In addition, care is taken to ensure that the proximal limb of the osteotomy is placed distal enough from the joint line to allow adequate fixation of the proximal segment. The authors' choice of fixation is anteromedial and anterolateral L-shaped, 2.7 mm locking dynamic compression plates. The L plate configuration allows placement of more screws in the proximal segment despite the proximity of the osteotomy to the joint line. The 2.7 mm screws are sufficient because of the inherent stability of the osteotomy and avoid bulkier or more prominent internal fixation. Use of locking screws allows increased rigidity of the fixation construct despite the use of smaller diameter screws and the relatively low number of screws in the proximal segment, but may not be mandatory. The plates are used as a template when planning the site of the proximal osteotomy cut to ensure adequate space

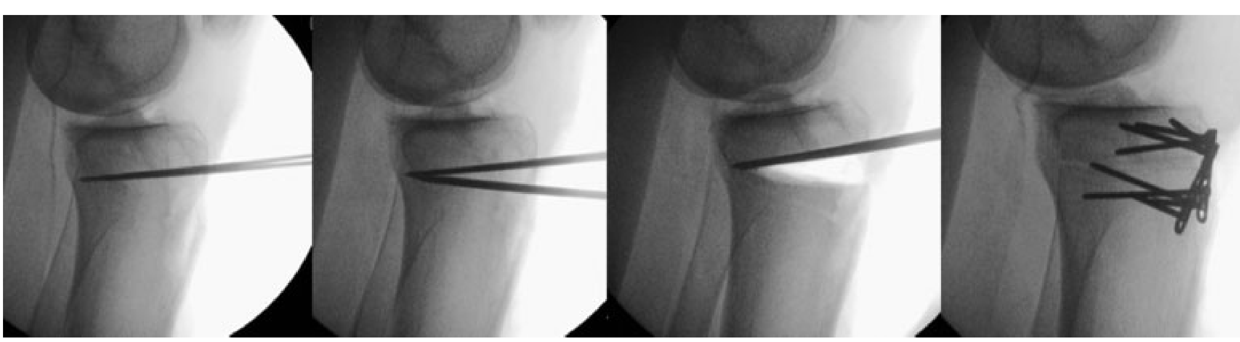

Fig. 4 Two Steinman pins (one medial and one lateral to the patellar tendon) are placed proximally parallel to the native slope of the plateau aiming toward the PCL insertion. The next Steinman pins are placed distally, at the planned distance from and convergent with the first pins for the predetermined correction. The saw is used to cut along the Steinmann pins, protecting the collateral ligaments and patellar tendon. Once the bone is cut, 95% from anterior to posterior an osteotome is used to complete the osteotomy. The plates are contoured to fit the tibia. Locking screws are placed proximally and then cortical nonlocking screws are placed distally in compression mode.

Fig. 5 Anteroposterior and lateral X-rays showing a healed osteotomy before stage 2 of the surgery.

available for the fixation screws. The anteromedial and anterolateral plates allow equal compression across the osteotomy. This technique can restore knee extension and decrease posterior tibial slope as demonstrated by this case presentation. However, caution should be used in a patient with full, terminal extension before surgery to avoid knee hyperextension after the procedure. Some authors have recommended a posterior capsular plication to prevent this result.[8]

Conclusion

Sagittal plane tibial morphology should be considered in the setting of failed ACL reconstruction to recognize excessive posterior slope. Combined slope-decreasing anterior closing wedge tibial osteotomy and revision ACL reconstruction may improve outcome in these carefully selected patients.

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