Sagittal Plane Correction in Revision ACL Reconstruction

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Introduction

Tibial osteotomy has been an accepted surgical technique for the treatment of knee osteoarthritis (OA) for over 50 years [1]. However, its utility in the setting of knee ligament insufficiency has only come to prominence in recent years. As soft tissue reconstructive techniques have evolved, the impact of bony morphology on knee stability has received increased attention. The importance of coronal alignment in anterior cruciate ligament (ACL)-deficient knees was addressed in detail in the previous chapter. This chapter will focus on the role of sagittal alignment and how osteotomy can be utilized to improve biomechanics and thereby optimize outcomes in revision ACL reconstruction.

Background

In the sagittal plane, posterior tibial slope (PTS) is best defined as the angle between a line perpendicular to the mid-diaphysis of the tibia and the posterior inclination of the tibial plateau. The normal values for the medial and lateral tibial plateau are 9–11° and 6–8°, respectively [2]. A number of biomechanical studies have demonstrated that increased PTS leads to increased anterior tibial translation and subsequently increased strain on the native ACL. Dejour and Bonnin [3] determined that every 10° increase in PTS resulted in a 6 mm increase in anterior tibial translation. McLean et al. [4] demonstrated that elevated PTS was significantly correlated with increased anterior tibial translation and acceleration, as well as peak anteromedial ACL bundle strain.

Clinical studies have corroborated these findings by revealing an increased risk of ACL injury among patients with elevated PTS. In a matched cohort study of 100 patients undergoing ACL reconstruction compared to 100 patients presenting with patellofemoral pain, Brandon et al. [5] demonstrated a statistically significant increase in PTS for the ACL-injured patients. A 15-year prospective longitudinal study of 200 patients following ACL reconstruction concluded that those who sustained further ACL injury (either ACL graft rupture or contralateral injury) had a mean PTS of 9.9° compared to 8.5° for those without further injury. The odds of sustaining a new injury increased fivefold when PTS ≥12° [6]. In adolescent ACL reconstruction patients, the hazard of increased PTS is even more profound with a 20-year ACL graft survival rate of only 22% in patients with PTS ≥12° [7].

Osteotomy aimed at decreasing PTS can effectively reduce the strain on the ACL graft and thereby decrease the risk of re-injury. In a

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cadaveric study, Imhoff et al. [8] determined that tibial osteotomy significantly decreased anterior tibial translation in the ACL-deficient knee, as well as significantly decreased the force through the ACL graft in the reconstructed knee. Zaffagnini et al. [9] prospectively assessed a cohort of 32 patients following revision ACL reconstruction and concurrent lateral closing wedge osteotomy. At a mean follow-up of 6.5 years, the authors showed significant improvements in patient-reported outcomes with an overall failure rate of only 6%. Even in the re-revision scenario, combining ACL reconstruction with slope-reducing osteotomy has been proven to improve graft laxity and patient-reported outcomes [10, 11].

Indications

The decision to perform an osteotomy in the setting of revision ACL reconstruction depends on a range of factors including coronal and sagittal plane alignment, integrity of other ligamentous structures, associated meniscal and chondral pathology, as well as patient characteristics including age, comorbidities, and functional status. All of these factors must be considered when creating a preoperative plan.

The three most common types of osteotomies used to decrease tibial slope and, if necessary, correct coronal plane alignment are presented in Table 14.2. Careful patient evaluation and consideration of all contributing factors must be performed prior to determining which surgical approach is most appropriate.

In addition to the three osteotomies listed in Table 14.1, a medial closing wedge osteotomy can be utilized in a patient with failed ACL reconstruction, valgus alignment, *and* increased PTS. Although the distal femur is typically the site of correction in a valgus knee, if sagittal plane alignment needs to be addressed, then a tibial-based osteotomy may be necessary.

In selecting the most appropriate approach, it is also critical to consider the geometry of the

Table 14.1 General indications and contraindications for performing a tibial osteotomy in the revision ACL setting

Indications	Contraindications
Correcting coronal alignment	Concurrent posterior cruciate ligament (PCL) deficiency
Decreasing PTS	Significant knee hyperextension (>10°)
Unloading the medial or lateral compartment (due to meniscal or chondral pathology or concurrent reconstructive procedure)	Grade 4 chondral injury in an isolated compartment
Decreasing stress on ligamentous structures (in the setting of bony malalignment)	Tricompartmental osteoarthritis
	Inflammatory arthritis
	Range of motion restrictions (>5° flexion contracture and/or < 120° of flexion)
	Older (>65 years) and lower demand patients
	Elevated body mass index (BMI >35)

proximal tibia and how different types of osteotomies will affect sagittal plane alignment. Based upon three-dimensional computed tomography modelling, Noyes et al. [12] described the proximal tibia as a triangle where the posterior cortex forms a 90° angle with the lateral cortex and a 45° angle with the medial cortex (Fig. 14.1). Due to this relationship, the "gap" angle of an anteromedial opening wedge osteotomy will influence not only coronal alignment but also tibial slope. These authors determined that in order to maintain tibial slope, the height of the anterior osteotomy gap must be half that of the posterior gap. Further, each 1 mm of gap error leads to a 2° increase in PTS. This relationship makes it challenging to maintain – and particularly difficult to *decrease* – PTS when performing a medial opening wedge osteotomy. In contrast, a lateral closing wedge osteotomy has been shown to be more likely to decrease PTS [13, 14]. Additional factors to consider when selecting between a medial and lateral osteotomy are outlined in Table 14.3.

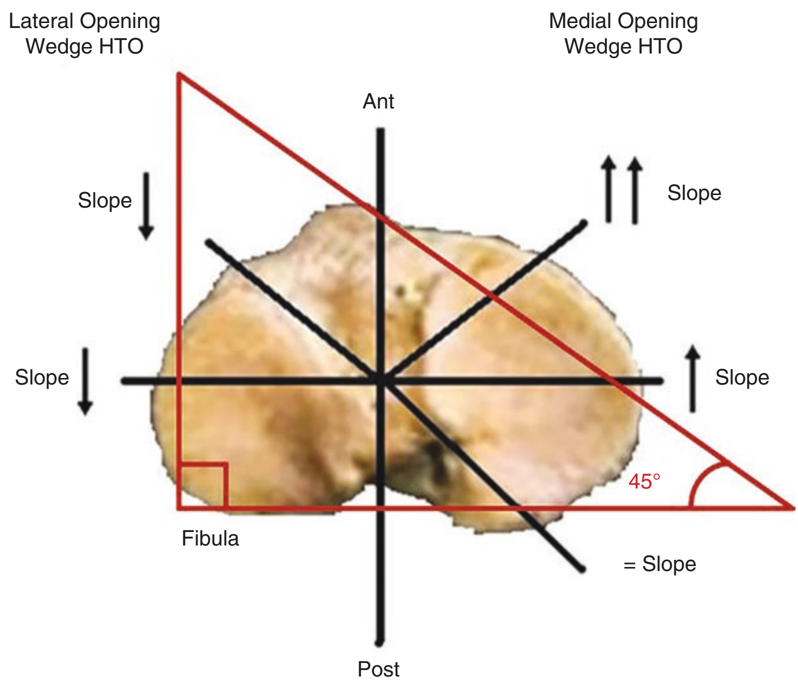

Fig. 14.1 The proximal tibia can be represented as a triangle with the medial and lateral cortices forming 45° and 90° angles with the posterior cortex, respectively. An anteromedial osteotomy is thus more likely to increase slope, while a lateral osteotomy will decrease it. (Modified from Noyes et al. [13])

Table 14.2 The three most common types of tibial osteotomies used to decrease tibial slope and correct coronal plane alignment as necessary

Type of osteotomy	Goal	Indications
Anterior closing wedge	Decrease PTS	Failed ACL reconstruction with PTS >12° and/or high-grade anterior instability
Medial opening wedge	Decrease PTS + correct varus alignment	Failed ACL reconstruction with PTS >12° and/or high-grade anterior instability *and* Early to moderate medial compartment degenerative changes Medial meniscus deficiency Concurrent osteochondral or meniscal transplant Lateral ligament insufficiency *with bony varus*
Lateral closing wedge	Decrease PTS + correct varus alignment	Same indications as for medial opening wedge

Table 14.3 Factors to consider when selecting between a medial opening and lateral closing wedge tibial osteotomy

Medial opening wedge osteotomy	Lateral closing wedge osteotomy
Difficult to decrease PTS	*Decreases PTS*
Ability to "fine-tune" correction intraoperatively	Immediate weightbearing possible
Need for bone graft	Decreased tension on lateral ligaments
Risk of non-union (i.e., smokers, large correction)	Risk of de-stabilizing the proximal tibia-fibula joint
Risk of patella baja	Risk of patella alta
Increases leg length	Decreases leg length

Preoperative Planning

Standard preoperative patient evaluation including a detailed history and thorough physical examination are essential when planning a revision ACL reconstruction. Specific to osteotomy, it is important to determine whether sagittal plane instability is the sole complaint or if there are other contributing factors such as pain or coronal plane instability. Physical examination begins with an inspection of alignment to assess for coronal and sagittal plane abnormalities such as varus and hyperextension. The patient's gait should be carefully evaluated for varus or hyperextension thrust. Leg length discrepancies should be measured as this may influence the type of osteotomy selected. Any asymmetries in range of motion (ROM) should also be documented, paying particular attention to restrictions of flexion and extension, as well as notable hyperextension deformities. A complete ligamentous examination should include a quantitative assessment of the ACL, PCL, medial ligament complex, and posterolateral ligament complex. Pseudolaxity due to meniscal and/or cartilage deficiency must be distinguished from true ligamentous laxity.

Radiographic (XR) evaluation begins with standard weightbearing anteroposterior (AP) and lateral views. A 45° flexion AP XR can be used to better assess the extent of degenerative change within the tibiofemoral joint. A skyline patellar view should also be included to determine if patellofemoral OA is present. A full-length standing XR is essential in order to evaluate for leg length discrepancy and accurately measure coronal alignment. A full-length lateral XR can also be considered to determine if any distal or proximal sagittal plane abnormalities exist. Computed tomography (CT) should be standard in all revision ACL cases to accurately assess tunnel position and the extent of tunnel enlargement. Magnetic resonance imaging (MRI) is helpful to identify other pathology, including chondral or meniscal injury, and to confirm the status of other ligamentous structures.

A number of methods have been described to measure the PTS. The authors' preferred technique is the circle method described by Hudek et al. [15]. This involves drawing two circles from the anterior to posterior cortex of the proximal tibia and connecting their midpoints to define the anatomic axis. The PTS is then calculated as the angle between a line perpendicular to the anatomic axis and the tibial plateau (Fig. 14.2). This technique can be employed with either a plain XR or cross-sectional imaging. It is important to obtain a true lateral XR to eliminate any joint obliquity. Cross-sectional imaging can permit the independent measurement of the lateral and medial tibial plateaus; however, there may not be sufficient proximal tibia included in the slices to fit the two measurement circles. A study comparing the circle method to three other methods of PTS measurement indicated that the circle method had the lowest inter- and intra-observer variability and was not dependent on the length of proximal tibia measured [16].

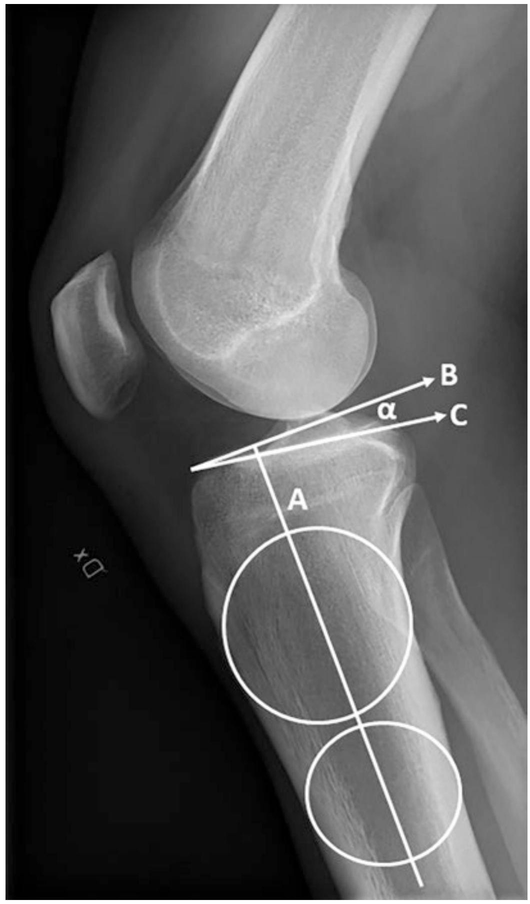

Fig. 14.2 The circle method for calculating posterior tibial slope (PTS). Two circles are drawn between the anterior and posterior cortex of the proximal tibia. The superior circle is in line with the tibial tubercle. The anatomic axis of the tibia is determined by connecting the midpoints of each circle (*A*). The PTS (α) is calculated as the angle between a line perpendicular to the anatomic axis (*B*) and the tibial plateau (*C*)

Another consideration of note in planning an osteotomy and revision ACL reconstruction is whether to proceed as a single or staged procedure. The first stage typically consists of osteotomy along with bone grafting of the ACL tunnels, if necessary. The second stage takes place once healing and bony consolidation have occurred and includes revision ACL reconstruction. The advantages of a staged approach include the following:

- The ability to address tunnel enlargement and/or malposition with bone grafting.
- Technically less challenging.
- Rehabilitation of the ACL reconstruction is not compromised.
- Decreased risk of arthrofibrosis.
- Some patients may not require later ligament reconstruction (i.e., a lower-demand patient with low-grade AP laxity and symptoms of OA).

The main benefits of a single-stage approach are a quicker return to function and decreased risk of anesthetic complications. These benefits must be balanced by the increased technical challenge of a combined procedure as well as the associated potential increase in surgical complications including thromboembolism, infection, and arthrofibrosis.

Cases

Case #1

A 29-year-old male presents with bilateral knee instability. He initially injured his left knee in 2015 while sliding into base during a baseball game. He underwent ACL reconstruction with hamstring autograft. No meniscal pathology was identified during the initial surgery. He suffered an atraumatic failure of his ACL within the first postoperative year and subsequently underwent revision reconstruction with soft tissue allograft. Unfortunately, this reconstruction also failed atraumatically, and he was advised to manage his symptoms conservatively with lifestyle modification and a stabilizing knee brace. Shortly thereafter, the patient tore his right ACL during a baseball game. He is employed in sales and hopes to return to baseball and volleyball at a recreational level.

On physical examination, he is 5 foot 11 inches and 250 pounds (he has gained 30 pounds since his initial injury), with a BMI of 34. He has neutral alignment and a normal gait with no thrust. ROM assessment reveals 5° of hyperextension and 140° of flexion, bilaterally. Ligamentous examination reveals a grade 3 Lachman and grade 3 pivot shift on the left and a grade 2 Lachman and grade 2 pivot shift on the right. No other ligamentous instability is evident with varus, valgus, posterior drawer, or Dial testing.

XR reveals interference screw fixation on both the femoral and tibial side from a previous left ACL reconstruction. There is no evidence of osteoarthritis or patella alta. The PTS is measured as 15° in both knees (Fig. 14.3). Full-length standing XR indicates neutral coronal alignment. Computed tomography confirms appropriate tunnel placement with no evidence of enlargement. An MRI is/was not performed.

This case highlights the importance of measuring PTS as part of the standard work-up in all ACL-deficient patients. This particular patient has an elevated PTS bilaterally. This bony morphology was not addressed at the initial and first revision surgeries and thus contributed to ACL graft failure. Accordingly, a slope-reducing osteotomy must be a component of the surgical plan for this revision ACL reconstruction scenario. This patient has neutral alignment in the coronal plane and no evidence of meniscal or chondral pathology; therefore, only sagittal plane correction is necessary.

Given that tunnel size and position were deemed appropriate, a revision ACL reconstruction was planned concurrent with the osteotomy. A patellar tendon autograft was selected for this patient. This is the authors' preferred graft in a revision scenario as it allows for early bone-to-bone healing and can fill large (up to 10 mm) tunnels. Additionally, the tibial bone plug can cross the osteotomy site, thus providing increased stability. In tunnels larger than 10 mm or if patellar tendon is not available, quadriceps tendon autograft (with or without a bone plug) may be utilized.

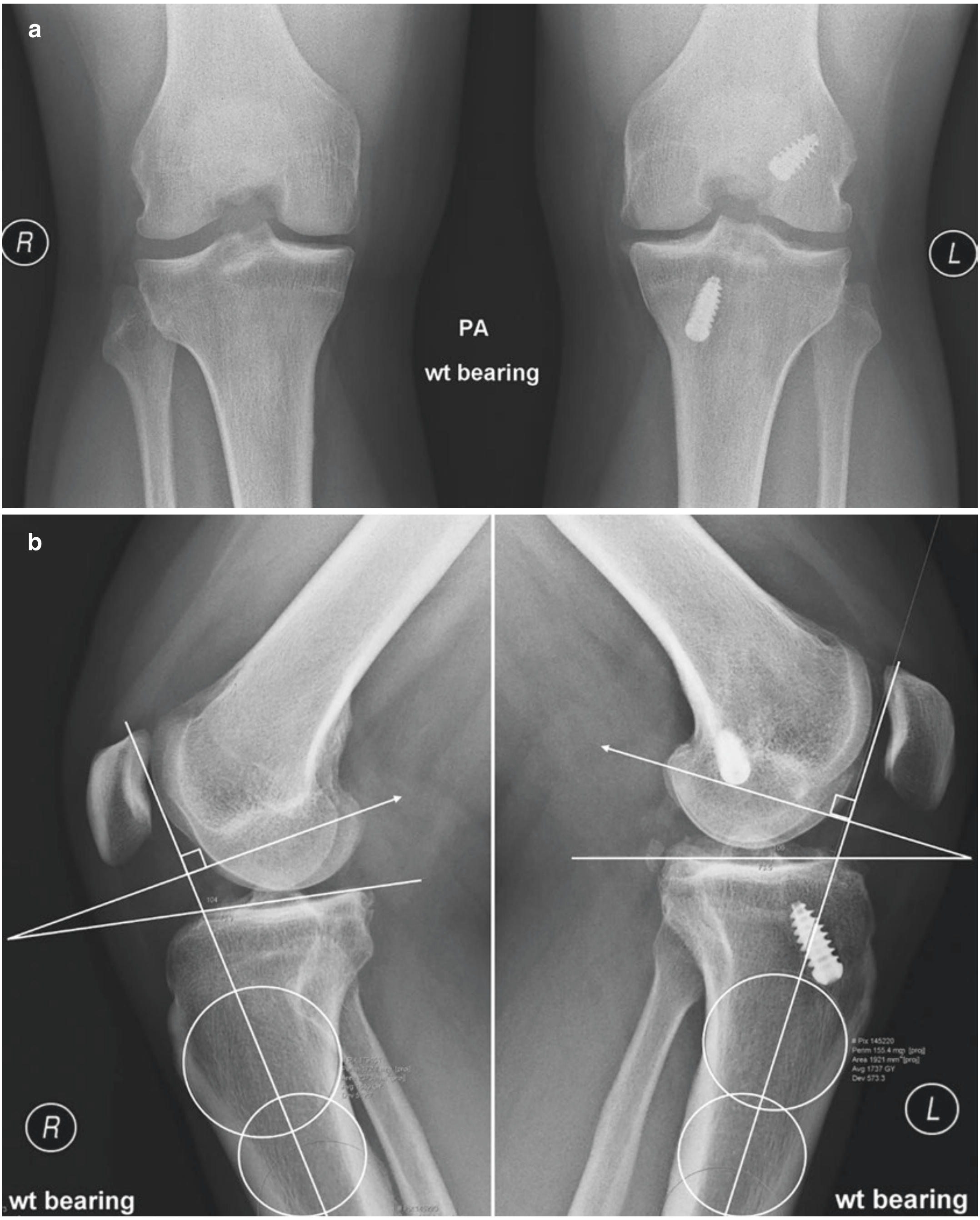

Fig. 14.3 (**a**) Preoperative, weightbearing AP XR, bilateral knees. Left knee shows a previous ACL reconstruction with interference screw fixation. (**b**) Preoperative, weightbearing lateral XR, bilateral knees. PTS is measured bilaterally as 15°

An anterior closing wedge osteotomy combined with revision ACL reconstruction was selected for this patient in order to address his elevated PTS without altering his coronal plane alignment. A tibial tubercle osteotomy was performed due to the large degree of correction necessary (8°) and so as to not alter the position of the patella. The ACL was reconstructed with patellar tendon allograft. This was performed as a single-stage procedure. The technical details are outlined below.

Four months postoperative from the above-mentioned left knee, a primary ACL reconstruction with patellar tendon autograft and concurrent anterior closing wedge osteotomy was performed on the contralateral (right) knee (Fig. 14.4). Although the use of osteotomy in the primary ACL reconstruction setting is controversial, the rationale in this case was the elevated PTS of 15°, as well as the patient's history of ACL graft failure on the contralateral (left) knee.

Case #2

A 48-year-old female presents with left knee pain and instability. She initially injured her left knee in 1991 in a twisting fall while skiing. She underwent ACL reconstruction with patellar tendon autograft and partial medial meniscectomy. She had two additional arthroscopic surgeries for recurrent meniscal tears. Two years ago, she reinjured her knee while playing soccer and sustained a rupture of her ACL graft. She is employed as a pharmaceutical representative and hopes to return to skiing and soccer at a recreational level.

On physical examination, the patient is 5 foot 9 inches and 185 pounds with a BMI of 28. She has neutral alignment and evidence of a slight

Fig. 14.4 Postoperative AP and lateral XR of the left knee. An anterior closing wedge HTO was performed and secured with two staples. The PTS was decreased to 6°. A concurrent ACL reconstruction with patellar tendon autograft was performed

varus thrust on gait assessment. Range of motion is 2–135° on the left and 0–140° on the right. Ligamentous examination of the left knee reveals a grade 2 Lachman and grade 1 pivot shift. There is some pseudolaxity to varus stress but no ligamentous instability to valgus, posterior drawer, or Dial testing.

X-rays reveal interference screw fixation on both the femoral and tibial side from a previous ACL reconstruction. Moderate OA is noted in the medial compartment, and PTS is measured as 12°. Full-length standing XR shows mild (<5°) varus alignment (Fig. 14.5). An MRI confirms complete rupture of the ACL graft, subtotal medial meniscectomy, and moderate chondral loss in the medial compartment. Articular surfaces in the lateral and patellofemoral compartments are preserved. Tunnel position is appropriate with no evidence of enlargement. A CT was not performed.

This case illustrates the not uncommon scenario of a patient with a failed ACL reconstruction and early medial compartment OA. Considering the increased PTS of 12° and mild varus deformity, this patient would benefit from a realignment osteotomy in both the sagittal and coronal planes. Accordingly, a lateral closing wedge osteotomy was selected due to its ability to decrease PTS and correct varus alignment. A revision ACL reconstruction was performed concurrently as there were no concerns regarding tunnel size or position. A patellar tendon allograft was used due to the patient's age (Fig. 14.6).

Surgical Technique for Anterior Closing Wedge Osteotomy and ACL Reconstruction

As with any complex procedure, the order of the surgical steps is of particular importance and should be clear to the entire operating room team. The authors recommend beginning with ACL graft harvest and preparation. The incision site should be carefully planned so as to incorporate the osteotomy whenever possible. A midline incision from the distal pole of the patella to the distal aspect of the tibial tubercle allows access to the patellar tendon for graft harvest and exposes the anterior tibia for optimal visualization of the osteotomy. Alternatively, a "lazy-S" incision can be utilized to expose the proximal medial tibia for visualization of the tibial tunnel and fixation of the osteotomy (Fig. 14.7).

An arthroscopic evaluation of the knee should be performed next. The chondral cartilage should

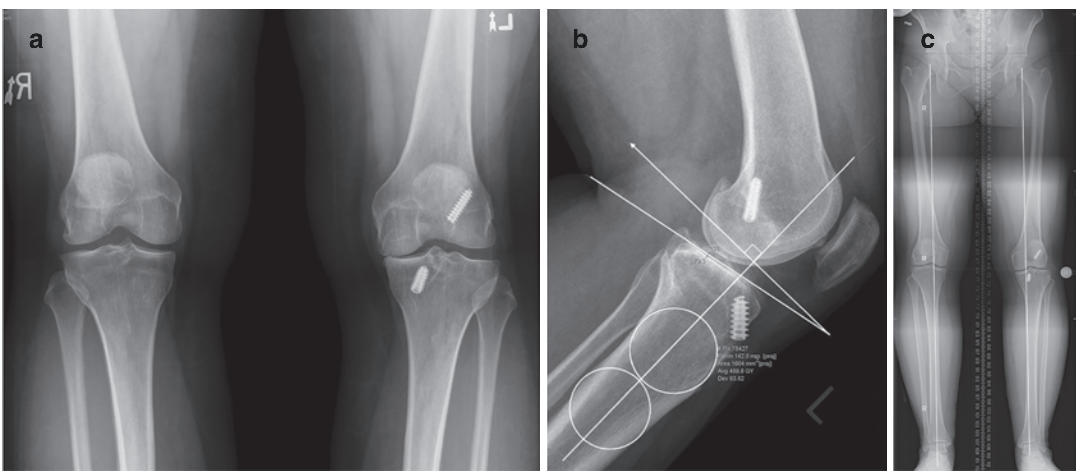

Fig. 14.5 (**a**) Preoperative, weightbearing AP XR, bilateral knees. Left knee shows a previous ACL reconstruction with interference screw fixation and medial compartment narrowing consistent with OA. (**b**) Preoperative, weightbearing lateral XR, left knee. PTS is measured as 12°. (**c**) Preoperative, full-length standing AP XR reveals slight varus alignment on the left

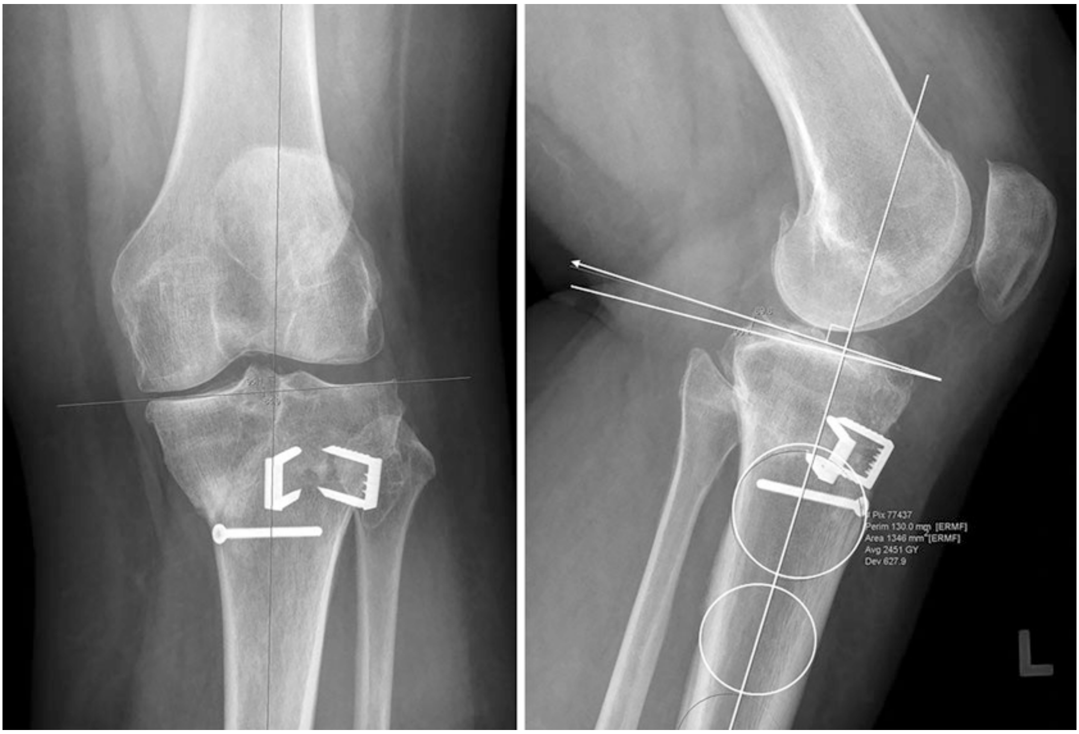

Fig. 14.6 Postoperative AP and lateral XR of the left knee. A lateral closing wedge HTO was performed and secured with two staples. The PTS was decreased to 5°. A concurrent ACL reconstruction with patellar tendon allograft was performed with secondary fixation of the tibia over a small-fragment screw

be carefully inspected, and any chondral or meniscal pathology can be addressed. The femoral tunnel of the ACL should be drilled in its anatomic location. The tibial tunnel is not drilled at this time but can be landmarked to facilitate drilling once the osteotomy is complete.

The tibial osteotomy should be performed as the next step. A tourniquet may be utilized as bleeding from the osteotomy site can obscure the surgical field. Although not always necessary in small corrections, the authors advocate for a tibial tubercle osteotomy concurrent with an anterior closing wedge osteotomy. The benefits of a tibial tubercle osteotomy are that it improves visualization of the anterior tibia, allows for greater correction of alignment if needed, and enables repositioning of the tubercle to prevent patella baja. The main disadvantage is delayed union. Note that a tibial tubercle osteotomy should not be performed with ipsilateral patellar tendon harvest. A long (6 cm) and thin (1–2 cm) tibial tubercle osteotomy is performed in a plane perpendicular to the anterior tibial cortex. The edges of the patellar tendon correspond to the medial and lateral borders of the osteotomy. Once the tubercle has been osteotomized, two Steinman pins can be placed in a converging fashion from anterior to posterior at the expected site of the anterior closing wedge osteotomy (Fig. 14.8). Fluoroscopy may be used to confirm the pin position and degree of correction. In general, removal of 1 millimeter of anterior tibial cortex corresponds to a 1 degree decrease in PTS. An oscillating saw should be used to initiate the cortical cuts, and osteotomes may be helpful to complete them as they provide more tactile and acoustic feedback and are less likely to cause neurovascular injury. The posterior cortex should not be disrupted in an anterior closing wedge osteotomy.

The osteotomized wedge of bone is removed, and curettes are used to extract cancellous bone until the posterior cortex of the tibia is exposed.

Fig. 14.7 A "lazy-S" incision can be used to expose the patellar tendon for graft harvest and the proximal medial tibia for visualization of the ACL tibial tunnel and anterior osteotomy site.

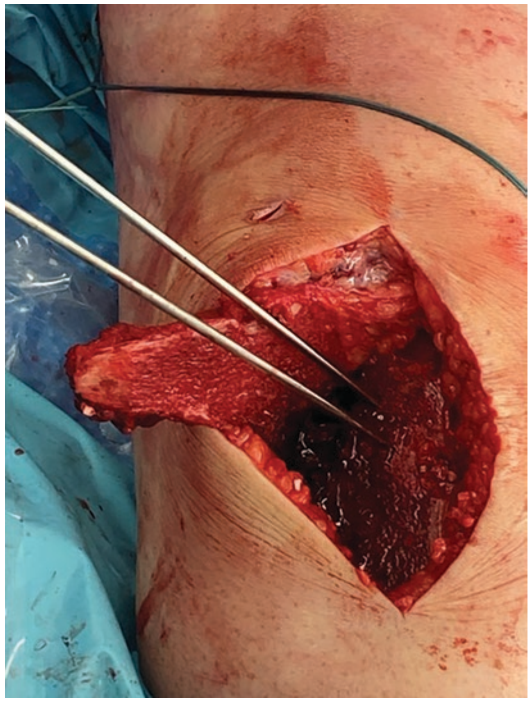

Fig. 14.8 Intraoperative photo showing a TTO exposing the anterior tibia with two converging Steinman pins indicating the planned osteotomy site and orientation

This can be used for bone graft along the osteotomy site once complete. The knee is then placed into hyperextension to close the osteotomy gap. In large corrections, the proximal tibia-fibula joint will need to be released to ensure complete closure of the osteotomy laterally. This is typically performed from the medial aspect of the joint so as to not injure the common peroneal nerve. Complete closure of the osteotomy and the degree of correction are confirmed clinically and fluoroscopically. The osteotomy is fixated with two crossing 3.5 mm screws directed from anteromedial/lateral to posterolateral/medial or two large staples. Fixation of the tibial tubercle is performed with two 3.5 mm screws in an anterior to posterior fashion ensuring bicortical fixation and adequate compression to minimize the risk of delayed union. When placing the osteotomy hardware, consideration should be given to the position of the ACL tibial tunnel.

The tibial tunnel of the ACL should be drilled next. The arthroscope is re-introduced into the knee and the tunnel landmarked in the anatomic footprint on the tibia. It is preferable that the tunnel crosses the osteotomy site to improve fixation. Finally, the ACL graft should be passed and secured in the standard fashion.

The incision should be closed in layers, using interrupted sutures or staples for the skin to facilitate drainage of the wound and decrease the risk of hematoma and compartment syndrome. Thromboembolic prophylaxis is recommended for 2 weeks postoperative. A stabilizing brace is typically not needed, and early range of motion is encouraged. Isometric strengthening exercises are initiated as tolerated. The patient can begin partial weightbearing with the use of crutches immediately postoperative, and full weightbearing is permitted at 6 weeks. Plyometric exercises begin around 4 months. Return to sport is delayed for at least 1 year and until the patient has passed appropriate clinical and functional assessments.

Discussion

Assessment of alignment in the sagittal plane is a critical step in preoperative planning for revision ACL reconstruction. In general, a slope-reducing osteotomy should be considered if PTS is measured as ≥12°. In Case #1, an inherently elevated PTS was not recognized and thereby contributed to ACL graft failure. An anterior closing wedge osteotomy is most effective at reducing PTS without affecting coronal plane alignment. When coronal plane correction is desired, as in Case #2, a lateral or medial osteotomy should be considered. The advantages and disadvantages of a medial opening or lateral closing wedge osteotomy to correct varus alignment and address tibial slope were previously reviewed. Of particular importance in the setting of ACL deficiency are the geometry of the proximal tibia and the effect of the osteotomy "gap" on tibial slope [12]. Due to this relationship, a lateral closing wedge osteotomy is much more likely to decrease PTS, while a medial opening wedge osteotomy is more likely to increase it (Fig. 14.9). In light of these findings, the authors' preferred approach to correct varus alignment and decrease PTS in an ACL-deficient knee is a lateral closing wedge osteotomy.

Fig. 14.9 Lateral XR of a patient whose PTS was inadvertently increased in performing a MOW-HTO for early medial compartment OA. They subsequently developed sagittal plane instability, and osteoarthritis continued to progress

Another important consideration in osteotomy planning is the position of the patella. In general, closing osteotomies tend to increase patellar height (alta), while opening osteotomies tend to decrease it (baja). A tibial tubercle osteotomy to shift the patella proximally or distally should be considered if there is concern about patellar malposition following a planned osteotomy. A distalizing tibial tubercle osteotomy was performed in Case #1 due to the need for a large sagittal plane correction that could have resulted in a patella alta. When needed, the tubercle will be translated distally to equal the correction from the sagittal plane osteotomy. We also find it optimal to have the tubercle positioned on both sides of the osteotomy, and, if possible, to have screw purchase on both sides of the osteotomy cut.

Leg length should also be taken into account in planning for either an opening or closing osteotomy. Many individuals have some degree of congenital leg length discrepancy, and, in general, up to 10 mm is reasonably well tolerated. However, it is important to be mindful of not over-lengthening the limb with an opening osteotomy or substantially shortening it with a closing wedge osteotomy. Importantly, limb length is affected by both coronal and sagittal plane corrections. For example, a medial opening wedge osteotomy will increase leg length both due to the osteotomy gap and by the degree of coronal realignment. Similarly, a lateral closing wedge osteotomy will decrease leg length due to the osteotomy gap and *increase* it by the degree of coronal plane correction. It is critical to consider these relationships in preoperative planning and surgical decision-making.

Finally, the complete ligamentous status of the knee must be carefully evaluated in any revision ACL scenario. Collateral ligament instability in the setting of coronal plane malalignment will benefit from osteotomy, and this should be incorporated into the surgical plan. In some cases, osteotomy can correct both the sagittal and coronal plane instability without the need for subsequent ligament reconstruction. Conversely,

Fig. 14.10 XR of a patient who underwent concurrent ACL and posterolateral corner (PLC) reconstruction combined with MOW-HTO. A medial approach was selected in this case so as not to compromise the PLC reconstruction, and careful attention was paid to maintain tibial slope as it was not elevated

an osteotomy can be combined with ligamentous reconstruction in order to restore sagittal and coronal plane stability (Fig. 14.10).

Conclusion

Failed ACL reconstruction is a frustrating situation for both the patient and surgeon. It is essential that all modifiable factors predisposing to graft failure are eliminated prior, or concurrent to, proceeding with revision reconstruction. Increased posterior slope of the proximal tibia has been well documented to contribute to ACL rupture and should thus be addressed with a slope-reducing osteotomy. The best approach is dependent on a variety of factors, and each patient should be evaluated independently. The addition of tibial osteotomy to a surgeon's toolbox can greatly enhance the management of complex knee instability cases and thereby contribute to reduced ACL graft failure and improved patient outcomes.

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