Educational Corner: Step by Step Approach to Anterior Cruciate Ligament Revision Reconstruction

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Received: 07 April 2025; **Revised:** 12 June 2025; **Accepted:** 15 July 2025

Abstract

In anterior cruciate ligament reconstruction (ACLR) revision, orthopedic surgeons are faced with many obstacles in decision-making and finding the best approach. Here we discuss these challenges and review a staged approach for better understanding and practical implications in ACL revision.

Keywords: Anterior Cruciate Ligament; Sports; Orthopedic Surgeons

Citation: Tabatabaei Irani P, Ayati Firoozabadi M, Bayati M, Jahan Bakhsh SH, Razzaghi A, Toofan H, et al. **Educational Corner: Step by Step Approach to Anterior Cruciate Ligament Revision Reconstruction.** *J Orthop Spine Trauma* 2025; 11(3): 116-23.

Background

The anterior cruciate ligament (ACL) is frequently injured, particularly during sports activities. In the USA, it is estimated that more than 200,000 ACL reconstructions are performed each year (1). According to the Danish registry, the revision rate for ACL reconstruction (ACLR) in adults is reported to be 4.1% at five years, while community registries in the United States and Norway report revision rates ranging from 0.9% to 1.5% (2, 3). A meta-analysis of revision ACLRs in children and adolescents indicated a revision rate of 4.8% (4). Additionally, a recent large meta-analysis found that the failure rate for autograft ACLRs was approximately 2.8%(5), while van Eck reported a failure rate of 13% for allograft ACLRs (6).

As the number of primary ACLRs increases, so does the incidence of revisions due to failure of the initial surgery. Various definitions exist regarding what constitutes a failure following ACL reconstruction. Different objective and subjective criteria are considered, such as increased pain, reduced range of motion, episodes of instability, decreased athletic activity, a positive Lachman or pivot shift test, or a side-to-side difference greater than 5 mm on arthrometric testing (7). Noyes and Barber-Westin defined a non-functional ACL graft as one that shows a 6 mm or higher increase in anteroposterior laxity on KT-2000 arthrometer testing or a positive pivot-shift test (8).

ACLR is performed to achieve knee stability, prevent secondary injuries, and enable patients to return to their pre-injury activity levels. Studies have shown good to excellent outcomes, making ACLR the treatment of choice for patients with functional instability. While 75% to 95% of patients report good to excellent results in terms of stability and pain relief, about 0.7% to 10% experience recurrent instability due to graft failure (9).

To determine the cause of failure, the surgeon must gather a detailed history, conduct a physical examination, and perform radiographic evaluations. Additionally, operative reports from the primary reconstruction, which include information on graft type, fixation methods, and any other ligament injuries, are crucial when considering revision surgery (10). Therefore, here we decided to review a step-by-step approach to ACLR revision in order to gain a better understanding of this procedure and its challenges.

Methods

This study was a narrative review and educational corner conducted through a literature review on Embase, PubMed, and Scopus upon papers addressing ACL revision and ACL graft failures by merging important key elements in surgical planning and decision-making in the revision of ACLR failures.

"Anterior Cruciate Ligament Reconstruction Failures: What's Going Wrong?"

The causes of ACLR failure are generally categorized into 3 classes: surgical technique, failure of graft incorporation (or "biological failure"), and traumatic failure. Technical errors during surgery are the leading cause of unsuccessful ACLR. A study by Jaecker et al. involving 167 patients with failed ACLRs found that technical mistakes accounted for 64.5% of cases, with trauma contributing to 29.1% and biological factors representing 6.4% (11). Common errors during the reconstruction process include improper tunnel placement, inadequate notchplasty, suboptimal graft tensioning, and failures in graft fixation.

The most frequent surgical error was femoral tunnel malposition, observed in 83.1% of technical failures. Additionally, non-anatomical placement of the tibial tunnel occurred in 45.1% of technical failures (11). Incorrect placement can lead to overstretching and eventual graft failure. A frequent mistake in femoral side is placing the graft too far anteriorly, which can create excessive tension during knee flexion, negatively impacting the graft fixation site and leading to overstretching. Conversely,

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tunnels positioned too posteriorly risk posterior wall blowout and may cause excessive tension during extension, potentially resulting in slight laxity during flexion, although the consequences of this are debated. Vertically aligned tunnels may provide good anterior stability, as indicated by a normal Lachman test, but they could compromise rotational stability (7). In addition, significant correlations were observed between non-traumatic technical failures and factors such as femoral tunnel misalignment, the transtibial drilling technique used for femoral tunnels, and the use of femoral transfixion devices. Additionally, Chen et al. noted that non-traumatic causes made up 47% of cases in re-revision ACL surgeries (12).

Illingworth et al. proposed femoral tunnel angle (FTA) in posterior to anterior (PA) flexion weight-bearing radiographs and the inclination angle (IA) on sagittal magnetic resonance imaging (MRI) for differentiation between anatomic and non-anatomic femoral tunnel positions. FTA was defined as the angle between the femoral shaft axis and femoral tunnel axis, and IA was defined as the angle between the line parallel to the most anterior fiber of ACL and the tangential line to the tibia plateau, which was drawn perpendicular to the tibia shaft axis. FTA < 32.7° and AI > 55° were considered non-anatomical and anterior placement of femoral tunnel which may cause an increase in ACLR failure (13) (Figure 1 a, c).

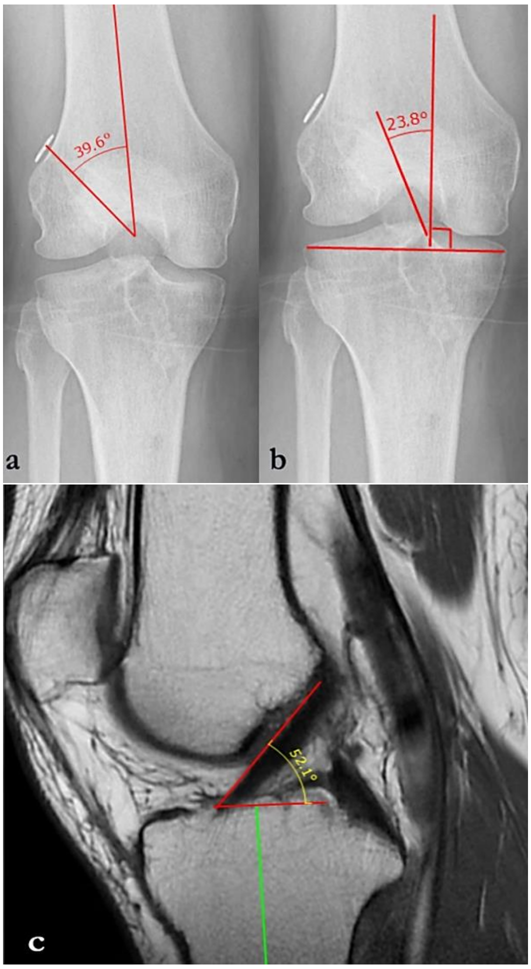

Figure 1. a. Femoral tunnel angle of 39.6°; b. Graft inclination angle of 23.8° in anteroposterior radiograph of the right knee; c. Inclination angle of 52.1° in sagittal magnetic resonance imaging (MRI)

FTA and graft inclination angle (GIA) in PA flexion weight bearing radiographs are used for graft obliquity assessment. GIA is defined as the angle between the line perpendicular to the tibia plateau and the line connecting the medial border of the tibia and femoral tunnel. A GIA of 19° can be associated with better functional outcome and stability. In contrast, a GIA < 19° is considered as vertical femoral tunnel and increases the failure rate (14) (Figure 1 b).

The femoral tunnel must be located 50-70 percent lateral to medial border of medial condyle or 43% from the lateral condyle in anterior-posterior (AP) radiographs and in the deepest quadrant along Blumensaat's line in lateral radiographs. Better clinical outcome is expected when femoral tunnel is located in 60% and more along Blumensaat's line (14) (Figure 2 A).

The placement of tibial tunnels is also crucial. Anteriorly located tibial tunnels might result in impingement and limited extension, whereas posterior placement can lead to flexion laxity and interfere with the posterior cruciate ligament. Vertical alignment negatively affects rotational stability. MRI can detect graft impingement 3 months postoperatively, showing variations in signal intensity between impinged and non-impinged grafts (15).

Tibial tunnel must be located medial to midline position in 47-50 percent lateral to medial border of medial plateau in AP radiographs and located 48% posterior to anterior tibial plateau in lateral view in a way that is positioned posterior to Blumensaat's line in lateral radiographs with full extended knee (14). Notably, the posterolateral and anteromedial bundles of the ACL insert on tibia plateau at about 44% and 30% of the anteroposterior axis on lateral x-ray (14) (Figure 2 A, B).

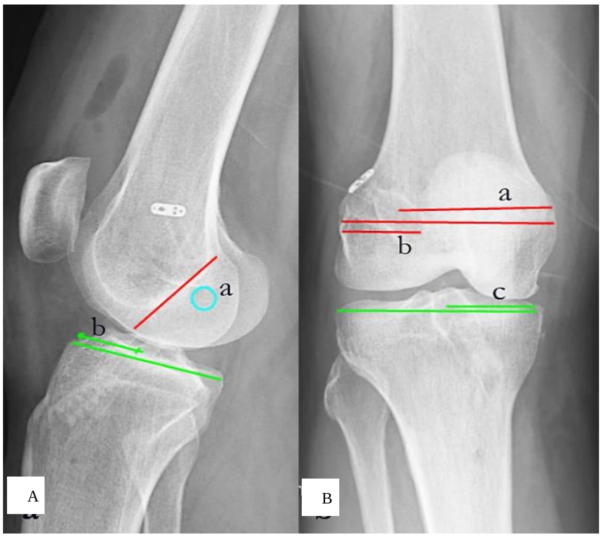

Figure 2. A. Lateral radiograph of the knee- a: femoral tunnel relation to Blumensaat's line (red line), b: distance from the anterior border of the tibial plateau to tibial tunnel center; B. Anteroposterior radiograph of the right knee- a: distance from medial border of the medial condyle to center of femoral tunnel, b: distance from lateral condyle to femoral tunnel center, c: distance from medial border of the medial plateau to tibial tunnel center

Another crucial factor in surgery linked to graft failure is the appropriate tensioning of the graft. The ideal tension remains uncertain. Excessive tension can result in loss of motion, overstretching of the graft, poor revascularization, and eventual degeneration. During the early postoperative phase, the fixation sites of the graft are more susceptible to load failure than the graft itself. Various elements, such as bone density, tunnel integrity and size, graft type, and the fixation method, significantly influence the strength of the reconstruction (9).

Recurrent trauma is noted as the second most common reason for ACL graft re-rupture (12, 17). Traumatic failures are generally categorized into early (before graft incorporation) or late (after 6 months post-rehabilitation). Early failure may happen if the graft is injured before it biologically incorporates and due to overly aggressive rehabilitation. An important predisposing factor has been premature return to sports and engaging in high-impact activities.

Biological failure remains a significant challenge following ACLR using either autografts or allografts. This phenomenon should be considered in cases where a patient experiences knee instability post-reconstruction, yet reports no history of new trauma and no identifiable technical errors. Potential causes of biological failure may include disturbances in revascularization, inhibited cellular proliferation, or complications during the ligamentization process. Any of these factors can ultimately lead to graft necrosis or failure to incorporate properly (9).

Although the infection rate following ACLR is relatively low, it is a critical cause of graft failure. Additionally, immunological factors and stress shielding have been linked to the biological failure of the reconstructed ACL (18).

The complex pathological processes underlying biological failure are not yet fully understood, necessitating further human studies on the topic. The biological incorporation of the graft is influenced by both the biochemical and mechanical environment, both of which fall under the surgeon's responsibility. This makes the precise identification of biological failure and its root causes particularly challenging.

Associated Knee Pathology

Capsular and ligamentous injuries often accompany ACL injuries. If left untreated, these can overload the graft and contribute to failure. One study indicated that 86% of patients undergoing revision ACLR had accompanying knee injuries requiring surgical treatment. Furthermore, between 10% and 15% of chronic ACL-deficient knees demonstrate posterolateral instability, which is frequently overlooked in pre-operative assessments (9).

Smoking

Smoking is a significant risk factor for complications after surgery. A trial on ACLR revealed that smokers had worse mean International Knee Documentation Committee (IKDC) scores, more pain, greater knee laxity, and were less likely to return to their previous level of sport compared to non-smokers (19). Although the trial did not specify how many in each group needed revision surgery, it is reasonable to hypothesize that smoking may predict poorer outcomes and a higher likelihood of revision. Further research is necessary to establish this link definitively.

History and Physical Examination

A comprehensive medical history and review of previous surgical procedures are critical to determine the mechanism of injury, identify any associated ligament or meniscal injuries, and determine the type of graft previously used.

The examination of the knee should begin with gait and stance evaluation, looking for signs of varus or hyperextension thrust, as well as any varus deformities that may place increased strain on the graft. The initial observation should also include measuring the circumference of the quadriceps to check for any evidence of muscle atrophy. Additionally, palpating for neuroma formation around previous surgical incisions is important, as these can often be a source of pain. Previous scars can indicate the graft type used and any complications, such as infections, that occurred during the healing process.

A thorough evaluation of the soft tissues in the entire lower limb is necessary. This includes assessing the status of the skin, scars, muscle movement, muscle strength, and neurovascular integrity. The patient's gait-whether it is antalgic, stiff-kneed, or demonstrating a varus thrust pattern-can reveal important diagnostic clues.

Both passive and active motion of the knee should be assessed to determine any limitations in flexion and extension. An extension loss might suggest a cyclops lesion or graft impingement, while a loss of flexion is more likely to indicate arthrofibrosis. If the patient shows hyperextension, a careful examination for soft tissue insufficiency or bony abnormalities is warranted. Signs of knee effusion and tenderness along the joint line may indicate synovial inflammation, a meniscal tear, or chondral injury. A detailed clinical assessment of the ACL and collateral ligaments, including any signs of rotatory laxity, is crucial (20).

If there is a loss of motion, aggressive preoperative physical therapy or a staged procedure involving the lysis of adhesions may be necessary before ACL revision surgery. Moreover, stability examination of both the affected and contralateral lower extremity should be performed. This examination must include tests such as Lachman, anterior and posterior drawer tests, pivot-shift, varus and valgus stress tests, and the dial test at 30° and 90° of flexion. Careful assessment of tibial motion during the dial examination is important to distinguish between posterolateral and posteromedial insufficiencies.

Every clinical examination should include an assessment and comparison with the contralateral knee. Identifying asymmetries in stability, motion, and strength relative to the contralateral limb can be invaluable in recognizing subtle differences.

Planning a Revision Anterior Cruciate Ligament Reconstruction

A failed ACLR does not always necessitate revision surgery. Patients with bi- or tri-compartmental arthritis, regional pain syndromes, absent recurrent instability, those leading a sedentary lifestyle, or individuals reluctant to engage in post-operative rehabilitation may not be ideal candidates for revision ACLR. Instead, this particular group of patients could benefit from non-surgical alternatives, including physical therapy and modifications to their activity levels.

In general, revision ACLR is indicated in any patient with subjective instability and age ≤50 years regardless of activity level, meniscal condition, and grade of knee osteoarthritis (OA). However, for patients with severe OA (Kallgren Lawrence ≥3) and irreparable menisci in a low-level activity setting, conservative treatment is considered. in contrast, for age > 50 years with high-level activity and well-conditioned menisci and mild OA (KL < 3), revision ACLR can be indicated (21).

Thorough preoperative planning is essential for successful revision surgery (Figure 3).

This process starts by identifying the reasons behind the failure of the initial surgery. Revision surgeries tend to be more intricate, and research indicates that their outcomes are typically less favorable compared to primary procedures, making a comprehensive preoperative assessment necessary for success.

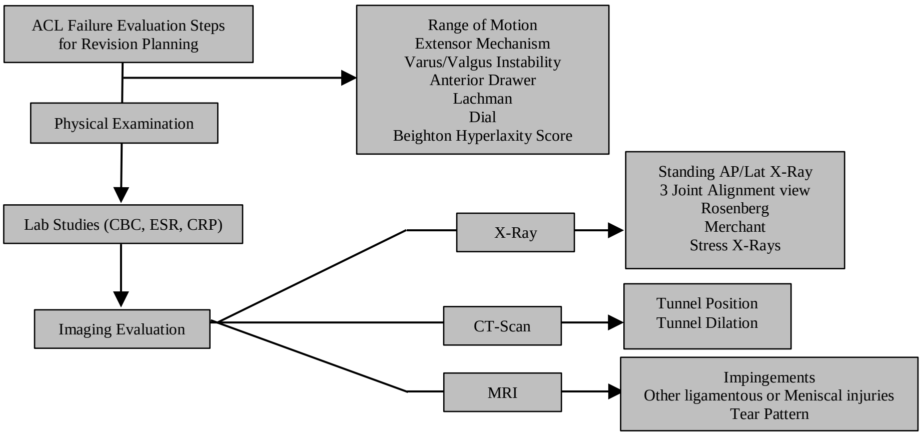

Figure 3. Anterior cruciate ligament Reconstruction failure evaluation steps for revision planning

The patient's medical history should document subjective symptoms such as pain, instability, swelling, locking, or episodes of the knee giving way, as well as stiffness. Differentiating between pain and true instability is crucial. It is also critical to inquire whether the initial ACLR resolved the patient's symptoms and whether the current symptoms mirror those experienced before the first surgery. It is also important to assess activity levels and compliance with rehabilitation protocols (9).

The operative report from the primary ACLR should be thoroughly reviewed, with attention to graft type, fixation method, tunnel position, and any associated ligament or cartilage injuries. The physical exam should not focus solely on the ACL but also aim to detect concurrent pathologies, such as meniscal tears, collateral ligament insufficiencies, and capsular damage, particularly in the posterolateral structures. Gait should be evaluated for patterns such as varus thrust, which may require surgical correction. MRI can be beneficial in evaluating graft integrity and identifying related issues within the menisci, articular cartilage, or ligaments (7).

Once all patients' information has been collected, the surgical planning can begin. Each patient presents a unique combination of factors that may require customized techniques. The surgeon might opt for a staged approach, depending on the findings observed during the operation; thus, this option should be discussed with the patient before the procedure. A staged approach could be warranted if the patient presents with a flexion contracture greater than 5°, a loss of flexion exceeding 20°, a bone tunnel wider than 15 mm, or if any bone loss or osteolysis cannot be addressed during the revision surgery (22). Even with detailed preparation, unforeseen challenges may arise during surgery, and the surgeon should be prepared to modify the plan as needed, utilizing a range of surgical strategies.

Preoperative Imaging Studies

All patients undergoing evaluation should receive standard knee radiographs, which include views such as full weight-bearing anteroposterior, 45° of flexion weight-bearing, lateral, full extension lateral, notch, and merchant views. Imaging through standing anteroposterior, lateral, and Rosenberg X-ray views facilitates the detection of degenerative changes and the assessment of tunnel location and dilation. These images are instrumental in identifying both the site and the type of hardware utilized. The lateral view in full extension is particularly valuable for evaluating the sagittal alignment of the tibial tunnel, with the ideal tunnel position being parallel and slightly posterior to Blumensaat's line (23).

Furthermore, the obliquity of the graft in both the tibial and femoral tunnels is a critical factor in restoring the rotational stability of the knee following ACLR (20). Proximal tibial posterior slope should be measured on a lateral knee radiograph. If this is greater than 13°, corrective osteotomy may be required. Femoral tunnel angle and GIA in AP radiography are the two main diagnostic criteria for analysis of graft and femoral tunnel obliquity (14). In cases where there is lower limb malalignment or a lateral thrust gait, alignment view radiography is recommended, as it may indicate the need for a corrective osteotomy.

Accurate visualization of tunnel positioning is essential for the preoperative planning of revision ACLR. The categorization of tunnel position should encompass four classifications: ideal and usable, slightly misplaced but usable, slightly misplaced and unusable, or completely misplaced.

In instances where plain radiographs do not adequately portray tunnel position and integrity, a three-dimensional imaging study should be pursued. Computed tomography (CT) is preferred, as it reliably enables the characterization of tunnel position, expansion, and the integrity of the surrounding bone. In cases of significant bone loss or tunnel widening, staging the procedure with bone grafting before ACLR may be necessary.

CT imaging should be considered the gold standard method for the analysis of femoral and tibial tunnel widening and should be measured at least in 3 points of the tunnel, including the entrance, midpoint, and exit, and perpendicular to the tunnel (24) (Figure 4).

MRI scans are beneficial in detecting graft ruptures, synovitis, graft impingement, meniscus tears, cartilage lesions, associated ligament tears, and the presence of cysts or intra-articular collections. The Porto knee MRI sequences are particularly useful for the dynamic assessment of anteroposterior and rotational stability. However, the utility of MRI can often be diminished due to artifacts caused by existing metal hardware within the knee. Illingworth et al. illustrated that the femoral tunnel angle in radiography and inclination angle in sagittal MRI could help to differentiate between anatomic and nonanatomic femoral tunnel position (13).

Figure 4. Measurement method of tibial tunnel width in coronal and axial computed tomography-scan images at three points of the tunnel

It is advisable to rule out infection before proceeding with any revision ACLR surgery. Inflammatory serum markers such as erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP), along with joint fluid aspiration, represent reliable methods with high diagnostic accuracy. Further evaluation using contrast-enhanced MRI scans may be warranted if the initial assessment indicates a positive result for infection. ACLR failure in the setting of low grade infection may create an extended tunnel, so it should be ruled out (21).

Graft Choice in Revision Anterior Cruciate Ligament

The choice of graft is a critical determinant of success in both primary and revision ACLR. There is no universally ideal graft, as each option carries unique advantages and limitations (9).

Allografts should generally be avoided when possible due to their higher rates of re-tear (2.78 times greater) and poorer patient-reported outcomes, especially in young, active, and athletic patients (25). Autografts are typically preferred unless they are unavailable or compromised due to previous surgical procedures.

The selected graft must have an adequate diameter to fit the tunnel if a one-stage procedure is planned. Bone-patellar tendon-bone (BPTB) and quadriceps tendon (QT) grafts are preferred because they facilitate bone-to-bone healing (26). While allografts reduce concerns about donor site morbidity, they may be particularly useful in multi-ligament knee reconstructive surgeries. Certain grafts, such as the Achilles tendon, provide a large cross-sectional area and can be useful for filling large but well-positioned tunnels during single-stage revision ACLR. However, there is a small risk of disease transmission with allografts, which does not exist with autografts. Additionally, allografts tend to incorporate more slowly than autografts, which can prolong the rehabilitation process. The sterilization and irradiation of allografts may also weaken their mechanical properties.

Due to these additional risks, many surgeons prefer autografts. However, options like patellar tendon or hamstring autografts may not be viable choices for revision surgery. It is essential for patients to fully understand the risks and benefits associated with both graft types before proceeding with surgery. In cases where there is significant tunnel expansion or partial tunnel malposition, a staged approach may be necessary, regardless of the graft selected (20).

Furthermore, the fixation of the graft is as important as the choice of graft in revision settings. The fixation must be secure, especially given that the quality of the bone may be compromised. If there are any doubts about the security of the graft fixation, it is advisable to perform a secondary fixation.

Single-Stage Procedure

Various techniques exist for ACL revision, depending on the position and size of previously created femoral and tibial tunnels-malposition and tunnel widening being the most common issues. The majority of revision ACLRs can be successfully conducted as a one-stage procedure, assuming that the previous femoral and tibial tunnels are deemed acceptable. Ideally, this involves completely non-anatomic but minimally dilated tunnels, allowing the identification of correct anatomic insertion sites and the creation of new tunnels with adequate bone bridges between old and new positions (7, 9).

In less-than-ideal scenarios, where the existing tunnels are anatomically positioned but show minimal to no dilatation, the solution involves enlarging these tunnels to fit a larger graft while maintaining the integrity of the surrounding bone walls. An alternative technique is outside-in drilling of the femur, which uses an adjusted trajectory to ensure that healthy bone remains in the tunnel walls while preserving the anatomical insertion site (9, 21).

Malpositioned femoral tunnels, particularly those made vertically via the transtibial technique, can be revised by drilling a new anatomic femoral socket with minimal risk of tunnel convergence. In partially overlapping tunnels, case-by-case judgment is required. Posteriorly placed and widened tibial tunnels often require a staged procedure to prevent significant malalignment. Conversely, anterior tibial tunnels that are relatively anatomic, even if enlarged, can be managed with larger grafts in a single-stage approach (23).

In 2024, Tabatabaei Irani et al. introduced a single-stage revision strategy involving simultaneous tunnel grafting. This technique uses adjustable buttons for fixation and allows the femoral and tibial tunnels to be drilled at existing or new sites. Bone allografts fill tunnel defects, promoting rapid incorporation and preserving bone for potential future revisions. Double suspensory fixation minimizes reliance on metaphyseal bone stock and may reduce the need for two-stage surgeries, offering a cost-effective, efficient, and recovery-friendly option (5).

Step 1. Diagnostic Arthroscopy and Socket Characterization

A thorough examination of the knee under anesthesia is essential before arthroscopy. Effective debridement is necessary for proper visualization and success in revision ACLR, particularly at both fixation points of the previous graft. Before starting the procedure, any cyclops lesion or residual graft should be completely removed, and the notch should be visualized, including the excision of any hypertrophic scar tissue.

In some cases, notchplasty may be needed for adequate visualization during anatomic socket preparation, especially in rare narrow or "A-frame" notch configurations that increase the risk of notch-graft impingement.

Step 2. Hardware Removal

All loose hardware should be removed, regardless of position. The decision to remove secure hardware depends on the position of tunnels from previous ACL surgery. If the tunnels are significantly malpositioned and new tunnels can be drilled, it is better to leave the previous hardware in place to avoid bone voids that could compromise revision fixation. If tunnels are only partially malpositioned or correctly positioned, removal may be necessary. Bioabsorbable screws can often be over drilled, while nonbioabsorbable screws usually need removal. The tibial tunnel is often problematic, as screws can interfere with revision, while the femoral tunnel may allow for a new anatomically positioned tunnel. Suspensory fixation devices can often remain in place (20).

Step 3. Tunnel Preparation

Femoral Tunnel Preparation: The medial aspect of the lateral femoral condyle can be accessed through the AM portal or a 2-incision technique. The new femoral tunnel's center can be located at the preserved native ligament footprint. If the footprint is obliterated from prior surgery, the intercondylar and bifurcate ridges can assist in localization. Using a medial portal technique, the knee should be hyper-flexed to 120° before drilling the guide wire for adequate clearance and graft obliquity. "Half-moon" low profile or flexible reamers can help avoid injury to the medial femoral condyle (20).

Alternatively, outside-in drilling through an accessory lateral incision allows for tunnels to be drilled in a more oblique orientation, enhancing versatility. The over-the-top technique serves as a salvage option when the previous femoral tunnel's posterior wall is compromised. It involves creating a small opening in the intermuscular septum and bluntly dissecting to the posterolateral intercondylar notch, which should be decorticated for graft fixation. The graft is then passed through the septal hiatus and fixed proximally using a soft tissue staple or suspensory fixation (20).

Tibial Tunnel Preparation: A relatively anatomic intra-articular aperture with modest tunnel widening can be filled with a graft in a single-stage approach. A posterior tibial tunnel, often seen with a transtibial technique, may pose issues; thus, a new tunnel with a more anterior trajectory in the ACL footprint can be prepared. The ACL footprint extends anteriorly to the intermeniscal ligament, allowing for this positioning. In cases of significant tunnel expansion or posterior malposition, a staged approach may be necessary to prevent tunnel convergence or recurrent malposition (20).

Step 4. Graft Fixation

Fixation sites represent the most fragile aspect of revision ACLRs and are often associated with early failure. It is crucial to assess bone quality and graft size to tunnel diameter to ensure effective interference screw fixation. In instances of adequate bone stock, conventional interference screw techniques can be employed; however, any methods that jeopardize graft fixation should be avoided to minimize the risk of failure. Screw divergence from the tunnel should not exceed 15° (27). In cases of poor bone quality, it is advisable to enhance fixation with a suspensory device, such as a screw-post or ligament button, which offers improved stability without the issues of graft toggling.

Two-Stage Revision Anterior Cruciate Ligament Reconstruction

In certain circumstances, it can be beneficial to revise ACLR in two stages to ensure optimal graft selection and positioning. Tunnel widening is a concern if either tunnel is enlarged by 100% or if the diameter exceeds 14-16 mm (26). In the first stage, any interference screws are removed, and the enlarged femoral and/or tibial tunnels are cleaned and grafted. This involves clearing the tunnels of debris and freshening their sclerotic walls to promote bleeding bone. Grafting can utilize autograft from the iliac crest, tibial tuberosity, or Gerdy's tubercle, or allograft in the form of morselized cancellous chips or dowels, with allografts reducing donor site morbidity. To verify graft incorporation, a CT scan is performed 3-4 months later. The first stage may also include necessary ligament reconstruction or meniscus repairs.

The second stage is usually performed 4-6 months afterward, and in cases of significant arthrofibrosis, a synovectomy may be done initially to restore the full range of motion (28). However, emerging techniques such as double suspensory fixation and single-stage tunnel grafting (e.g., Tabatabaei Irani et al., 2024) may eliminate the need for two-stage surgeries in select patients by simultaneously addressing tunnel defects and fixation needs (5).

Postoperative Course

There is no universally accepted rehabilitation protocol for revision ACLR, as factors like age, athletic goals, graft type, and reasons for initial failure can influence the process. Despite these variables, key principles remain: promote an early range of motion, maintain quadriceps function, and gradually advance activities while respecting healing. Initially, weight-bearing should be limited to toe-touch, progressing as tolerated with improved quad strength. Knee braces can provide stability and support for weight-bearing. Early exercises for quadriceps strength include heel slides, straight-leg raises, and ankle pumps, aiming for full range of motion by 6 weeks. At this point, patients can bear full weight and start closed-chain kinetic exercises.

More intense activities, like running and cutting, should not be performed for at least 6 months, depending on the bone condition and reasons for the initial failure. Competitive sports should resume only after assessments confirm strength, balance, and proprioception are comparable to pre-injury levels, ideally not before 9 to 12 months post-surgery.

Expected Outcomes

Revision ACLR leads to different outcomes than primary ACLR. While it may restore knee laxity, it often results in lower Lysholm scores, decreased clinician-reported function, and increased tibiofemoral arthritis. Defining graft re-rupture as the sole failure indicator underestimates actual failure rates.

A meta-analysis by Grassi et al. found that cumulative failure rates, defined by knee laxity and IKDC scores of grade C or D, exceeded 5% in 15 case series and over 20% in 5 cases. Factors like metal interference screws and not doing notchplasty correlated with better outcomes, whereas being female, having a higher BMI, lower activity scores, and shorter intervals between surgeries negatively impacted results. Additionally, being under 20 years of age and using allografts are independent risk factors for revision surgery (29).

After 2 years, allografts generally lead to worse outcomes than autografts, which have better sports participation rates and lower re-rupture rates. Return to sports (RTS) is a key success indicator. The meta-analysis by Andriolo et al. revealed that while 73% of patients reported good outcomes, only 43% returned to their previous activity level, which is much lower than primary ACLR (30). Studies indicate that RTS rates were similar between primary and revision ACLRs, but revision patients had a reduced chance of returning to their usual sport, with only 68.4% of adolescent athletes returning to pre-injury levels within 2 years (31). This emphasizes the need for realistic expectations after ACLR revision.

Conclusion

The number of primary ACLRs is increasing, leading to a rise in revision procedures. Research shows that improper tunnel placement causes 70% to 80% of initial surgery failures, primarily due to femoral tunnel misplacement. Successful revision outcomes require careful preoperative planning and thorough history-taking. Revision ACLR is challenging due to limited graft options and altered anatomy, often resulting in meniscus and cartilage damage. Ultimately, while revision ACLR can restore stability and function, patients must be appropriately counseled about the likelihood of inferior results compared to primary reconstruction. Many studies regard revision ACLR as a salvage procedure, reinforcing the importance of tailored surgical planning and transparent patient communication.

Conflict of Interest

The authors declare no conflict of interest in this study.

Acknowledgements

Special thanks to staff of the orthopedic department and orthopedic knee fellowships of Tehran University of Medical Sciences, Imam Khomeini Hospital Complex.

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