Technical Note

Single-Stage Anterior Cruciate Ligament Revision Reconstruction Using an Allograft Bone Dowel for a Malpositioned and Widened Femoral Tunnel

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Abstract: Tunnel widening, osteolysis, and/or malposition can be a cause of anterior cruciate ligament (ACL) reconstruction failure and a challenging problem to treat when performing revision ACL reconstruction (RACLR). Traditionally, problematic tunnels that interfere with bony stability and incorporation of the new graft at the time of revision have been treated with staged procedures—bone grafting first, followed by a return several months later for the revision reconstruction after bony incorporation has occurred. Multiple staged procedures increase the level of risk the patient may encounter and increase cost and resource utilization. In addition, they prolong the recovery period for the patient. In recent years, several studies have evaluated the clinical outcomes of performing bone grafting of tunnels and concomitant RACLR in a single-stage setting in an effort to mitigate these issues. We describe a technique by which a malpositioned and widened femoral tunnel from a primary ACL failure is treated with bone grafting using an allograft dowel, as well as immediate RACLR using a bone—patellar tendon—bone allograft.

Tunnel widening, osteolysis, or malposition can be a challenging problem in the setting of revision anterior cruciate ligament (ACL) reconstruction (RACLR). Previous studies have suggested that primary bone grafting of the tibial or femoral tunnel should be used when widening is greater than 100% of the original tunnel or measures approximately 16 to 20 mm in any dimension on preoperative imaging.[1] Other studies have described massive osteolysis as greater than 14 mm of tunnel widening or tunnel convergence that would compromise future graft fixation.[2] It has been recommended that staged reconstruction be considered in these scenarios, starting with bone grafting in the primary stage, with subsequent RACLR after bone healing.[1,3] Multiple procedures inherently introduce more potential risks to the patient. In an effort to mitigate risk, and when new divergent tunnels cannot be made, several authors have reported bone grafting with allograft and revision reconstruction performed in a single stage—all showing acceptable results and low failure rates.[4-10] This article describes a technique for allograft bone grafting in the setting of a malpositioned and widened femoral tunnel, with concurrent RACLR using a bone—patellar tendon—bone allograft.

Surgical Technique

A narrated demonstration of the surgical technique may be reviewed in Video 1. The patient is positioned in the supine position with a lateral post. A standard anterolateral viewing arthroscopy portal is established. An anteromedial portal is established with needle

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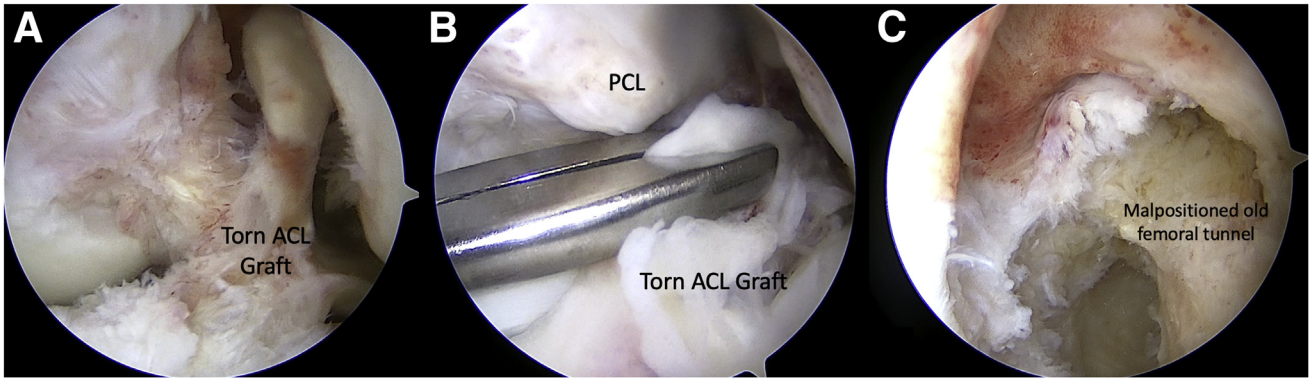

Fig 1. View of left knee from anterolateral portal with patient in supine position with lateral post. The torn anterior cruciate ligament (ACL) graft is shown (A, B), in addition to the old, malpositioned femoral tunnel (C). (PCL, posterior cruciate ligament.)

localization in a far medial position, low on the joint line, ensuring that an adequate trajectory can be obtained toward the old, malpositioned or widened femoral tunnel when hyperflexing the knee. The remnant ACL graft is removed from the tibial and femoral apertures, and the notch is debrided of any synovitis or arthrofibrotic tissue so that the old tunnels can be adequately visualized (Fig 1). Further bony debridement in the notch can be performed at the surgeon's discretion. Additional arthroscopic procedures addressing chondral or meniscal pathologies can be performed as necessary at this time. Additionally, any hardware or screws that will be in the way of the bone grafting or new tunnel to be drilled are removed.

A Beath pin is passed from the anteromedial portal into the notch. An assistant is positioned near the lateral post and hyperflexes the knee while the pin is advanced by hand into the original tunnel. Once seated, it is advanced in the trajectory of the tunnel and out the lateral aspect of the femur and skin. It is critical that the knee remain hyperflexed so as not to bend or break the pin. Sequential low-profile reamers are used over the pin to remove any remnant soft tissue or suture until there is healthy cancellous bone on all sides of the tunnel (Fig 2). This same technique can be used for any defects due to hardware removal. We prefer to ream to a diameter that is line to line or 0.5 mm smaller than the allograft bone dowel to be used and at a depth that is line to line with the dowel. By use of a prefabricated allograft bone dowel (Cannulated Revision Bone Dowel; Arthrex, Naples, FL) and impaction kit (Bone Dowel Revision Kit; Arthrex), the dowel on the Beath pin is slid into the joint. It is tamped into place until it is flush with the notch, and the Beath pin is removed (Fig 3). In the event that the primary reconstruction was performed by a transtibial technique, a pin can be passed in a transtibial manner into the widened and/or malpositioned femoral tunnel and then drilled through both to fresh cancellous bone. The femoral dowel is then passed and impacted over the pin as described earlier. In this case, the tibial tunnel should be drilled 0.5 mm larger to pass the femoral dowel. Additionally, placement of a tibial dowel may need to be considered, and similar bone grafting concepts can be applied in the setting of tibial tunnel osteolysis, widening, or malpositioning.[4]

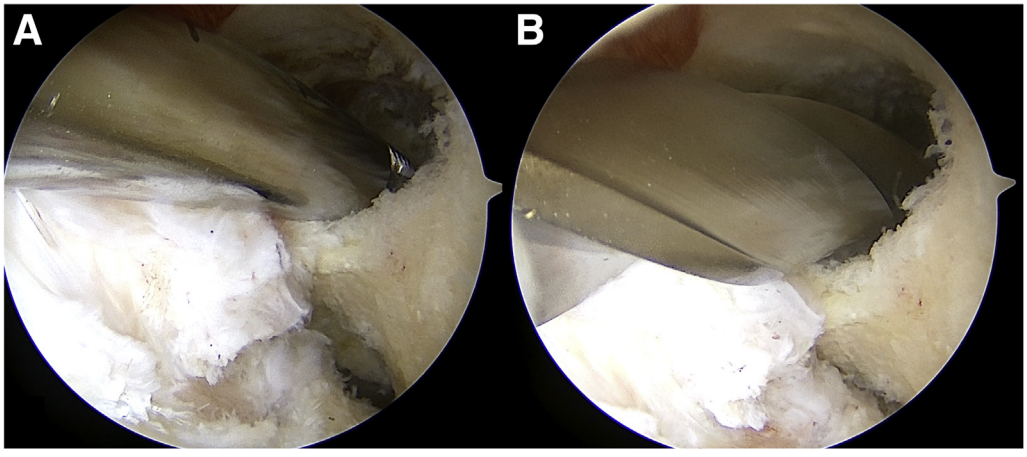

Fig 2. View from anterolateral portal with patient in supine position with left knee hyperflexed. An arthroscopic shaver (A) and sequential low-profile reamers (B) are used in the debridement and drilling of the old, malpositioned femoral tunnel.

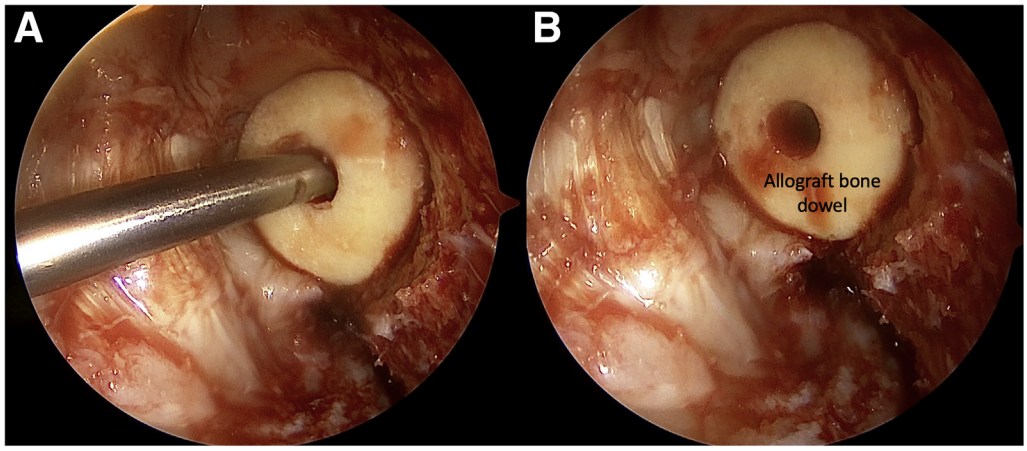

Fig 3. View of left knee from anterolateral portal with patient in supine position with lateral post. (A) By use of a prefabricated allograft bone dowel and impaction kit (Arthrex), the dowel on the Beath pin is slid into the joint. (B) It is tamped into place until it is flush with the notch, and the Beath pin is removed.

A 45° microfracture awl is used to mark the desired start point for the revision femoral tunnel so that the surgeon can perform an adequate assessment of the bony bridge or overlap between the bone dowel and the new tunnel (Fig 4). Alternatively, an anteromedial portal guide can be used with the knee hyperflexed and a pin hole created in the desired start point.

The knee is again hyperflexed with the anteromedial pin guide inserted. A Beath pin is drilled into the lateral femoral condyle in the previously established start point. At this juncture, the femoral preparation can proceed as in the case of a primary ACL reconstruction. The knee is hyperflexed and the femoral tunnel is reamed over the Beath pin to the desired depth and in the desired diameter. A passing stitch is shuttled through the tunnel using the Beath pin and snapped while the tibial tunnel is prepared in the surgeon's preferred fashion (Fig 5).

A bone–patellar tendon–bone allograft is prepared on the back table in the surgeon's desired fashion. The bone blocks are made to match the diameters of the newly drilled femoral and tibial tunnels. Note is made of the overall graft length.

The remainder of the RACLR is now carried out as it would be in the primary setting. The graft is shuttled through the tibial tunnel and docked in the femoral tunnel. A nitinol wire is inserted from the anteromedial portal into the anterior aspect of the femoral tunnel with the knee flexed to 90°, and the knee is then hyperflexed. An interference screw is inserted over the nitinol wire and inserted until it is flush with the notch while pulling tension on the graft out the lateral femoral condyle. We prefer to use a metal interference screw (Fig 6). The knee is cycled to remove any creep from the graft. The knee is brought into full extension, a posterior drawer is applied, and a nitinol wire is

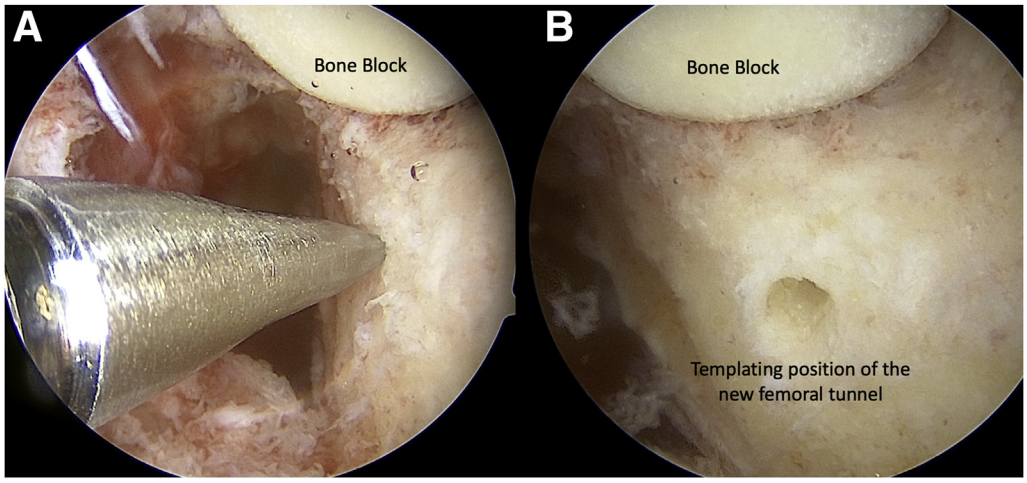

Fig 4. View of left knee from anterolateral portal (A) and anteromedial portal (B) with patient in supine position with lateral post. (A) The desired start point for the revision femoral tunnel is marked with a 45° microfracture awl. (B) This template-determined start point allows for an adequate assessment of the bony bridge or overlap between the bone dowel and the new tunnel.

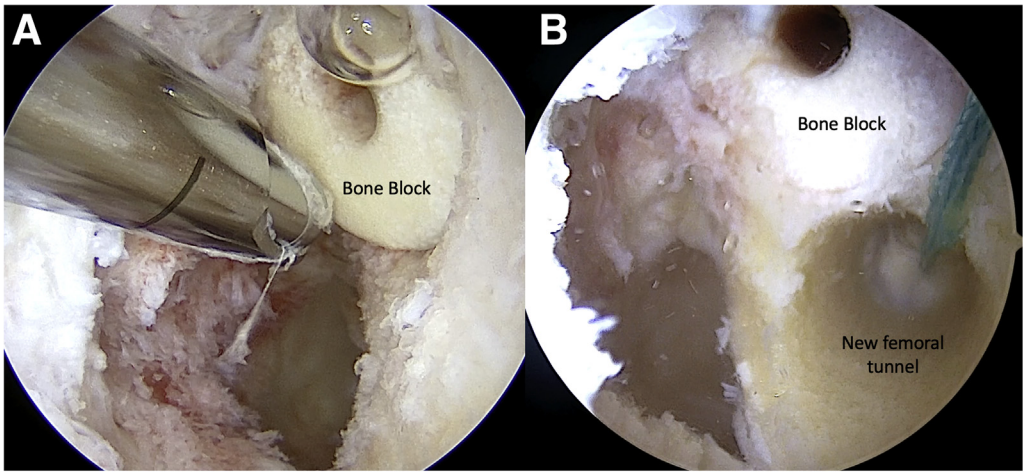

Fig 5. View from anterolateral portal with patient in supine position with left knee hyperflexed. (A) An arthroscopic shaver is used to contour the bone graft. (B) A shuttle stitch passes through the new femoral tunnel for later graft passage.

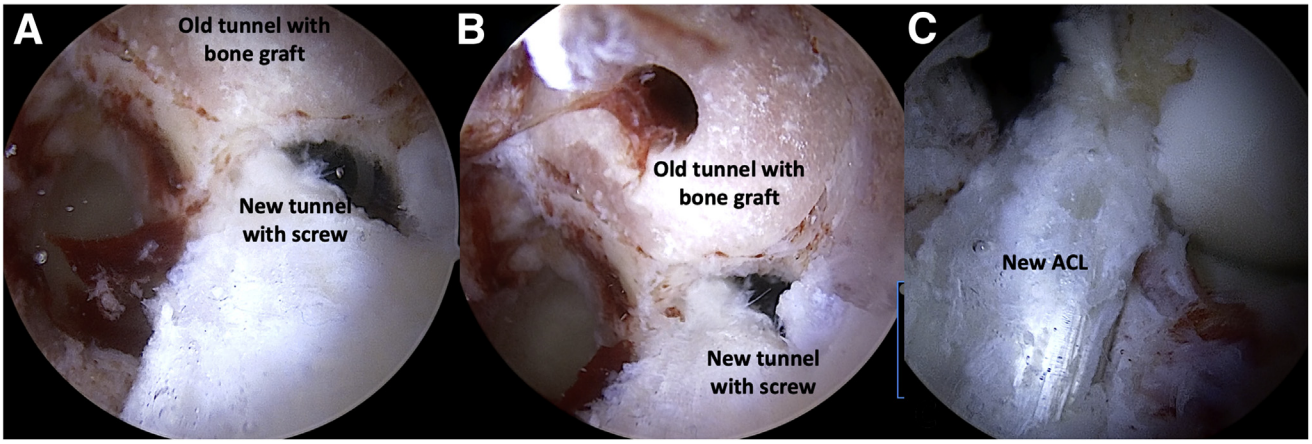

Fig 6. View of left knee from anterolateral portal with patient in supine position with lateral post. Arthroscopic images showing the old, malpositioned tunnel with allograft bone dowel (A, B) adjacent to the new femoral tunnel with the anterior cruciate ligament (ACL) graft and interference screw (C).

Table 1. Pearls and Pitfalls of Single-Stage Revision Anterior Cruciate Ligament Reconstruction Using Allograft Bone Dowel for Malpositioned and/or Widened Tunnels

Pearls
Preoperative imaging should be critically evaluated to assess tunnel positioning and widening; a CT scan should be obtained if necessary.
One should ensure that dowel sizes, reamers, and other equipment are available based on preoperative tunnel evaluation.
The patient should be counseled on the use of allograft.
A 70° arthroscope can assist with visualization and intraoperative tunnel assessment during impaction and when drilling the new tunnel.
Pitfalls
One should ensure that all old graft and soft tissue are removed from the old tunnel; otherwise, the bone dowel may not incorporate.
Inappropriate reaming or positioning of equipment could lead to divergence of drills, dowels, graft, or hardware.
Over-reaming must be avoided because allograft may be softer than native bone and may predispose to the risk of loosening of the new dowel and/or graft.
Poor visualization, positioning, or lack of adequate assistance could lead to any of the aforementioned potential pitfalls.

CT, computed tomography.

Table 2. Advantages and Disadvantages of Performing Revision Anterior Cruciate Ligament Reconstruction in Single Stage With Allograft Bone Dowels

Advantages
Avoidance of staged reconstruction—therefore, less time missed from activities, sports, and daily living
Lower risk profile owing to fewer procedures and less anesthesia
Cost-effective: requires use of allograft but otherwise decreases operating room and anesthesia costs
Disadvantages
May not be possible if widening is greater than available commercial dowel sizes
Risks associated with allograft use, including infection, rejection, or resorption, among others
Allografts are expensive

inserted posterior to the graft. An interference screw is inserted over the wire while pulling tension on the graft in line with the tunnel. Arthroscopy is again performed to assess the tension of the graft and confirm there is no notch impingement.

Discussion

Single-stage RACLR with allograft bone can mitigate the need for multiple additional procedures. Avoiding the need for a 2-stage revision can have obvious physical and financial benefits, in addition to impacting the mental and emotional well-being of the patient.[11] In this article, we present a technique in which tunnel widening, osteolysis, and/or malposition can be treated in the same setting in which the RACLR takes place. This technique focuses on the femoral tunnel; however, the same principles can be applied to the tibial tunnel. Pearls and pitfalls of the technique are provided in Table 1, and the benefits and risks are provided in Table 2.

Several studies have reported outcomes after single-stage bone grafting with RACLR. Dragoo et al.[4] in 2019 evaluated the results of a single-stage RACLR technique with bone dowel grafts in patients who had malpositioned and/or widened tibial tunnels with minimum 2-year follow-up. All 18 patients had improved knee pain and function with no revision surgical procedures and no subjective instability. Demyttenaere et al.[5] in 2018 retrospectively evaluated 8 patients with tunnel widening ranging from 87.5% to 250%. They performed a single-stage procedure in which they used 8- to 10-mm allograft bone dowels in a press-fit construct with the ACL graft and fixation device. At a minimum 1-year follow-up, the Knee Injury and Osteoarthritis Outcome Score and International Knee Documentation Committee score were improved with stable grafts via KT-1000 (MEDmetric, San Diego, CA) and pivot-shift testing. In 2013, Ra et al. reported on 17 cases with minimum 2-year follow-up in which they impacted the malpositioned femoral tunnel and screw hole with bone graft and proceeded with single-stage RACLR.[6] They reported no failures and observed stable grafts using KT-1000 assessment and improvements in Tegner scores in all patients. Werner et al.[7] in 2016 evaluated 12 patients with single-stage RACLR using allograft bone dowels for bony femoral deficiency. They showed objective and subjective outcomes comparable to those reported in the literature for other RACLR techniques. They also reported dowel incorporation with computed tomography scans in all 12 patients who were available for follow-up. In conclusion, the described technique for single-stage RACLR with bone grafting in the setting of tunnel malposition and/or widening could result in a more efficient, lower–risk profile, and more cost-effective experience for the patient with ACL reconstruction failure.

References

1. Maak TG, Voos JE, Wickiewicz TL, Warren RF. Tunnel widening in revision anterior cruciate ligament reconstruction. *J Am Acad Orthop Surg* 2010;18:695-706.
2. Laidlaw MS, Buyukdogan K, Werner BC, Miller MD. Management of bone deficiency in revision anterior cruciate ligament reconstruction. *Ann Joint* 2017;2:38.
3. Allen CR, Giffin JR, Harner CD. Revision anterior cruciate ligament reconstruction. *Orthop Clin North Am* 2003;34:79-98.
4. Dragoo JL, Kalisvaart M, Smith KM, Pappas G, Golish R. Single-stage revision anterior cruciate ligament reconstruction using bone grafting for posterior or widening tibial tunnels restores stability of the knee and improves clinical outcomes. *Knee Surg Sports Traumatol Arthrosc* 2019;27:3713-3721.
5. Demyttenaere J, Claes S, Bellemans J. One-stage revision anterior cruciate ligament reconstruction in cases with excessive tunnel osteolysis. Results of a new technique using impaction bone grafting. *Knee* 2018;25:1308-1317.
6. Ra HJ, Ha JK, Kim JG. One-stage revision anterior cruciate ligament reconstruction with impacted bone graft after failed primary reconstruction. *Orthopedics* 2013;36:860-863.
7. Werner BC, Gilmore CJ, Hamann JC, et al. Revision anterior cruciate ligament reconstruction: Results of a single-stage approach using allograft dowel bone grafting for femoral defects. *J Am Acad Orthop Surg* 2016;24:581-587.
8. Barrett GR, Brown TD. Femoral tunnel defect filled with a synthetic dowel graft for a single-staged revision anterior cruciate ligament reconstruction. *Arthroscopy* 2007;23:796.e1-796.e4.
9. Battaglia TC, Miller MD. Management of bony deficiency in revision anterior cruciate ligament reconstruction using allograft bone dowels: Surgical technique. *Arthroscopy* 2005;21:767.
10. Serbin PA, Griffin JW, Bonner KF. Single-stage revision anterior cruciate ligament reconstruction using fast-setting bone graft substitutes. *Arthrosc Tech* 2020;9:e225-e231.
11. O'Hara MW, Ghoneim MM, Hinrichs JV, Mehta MP, Wright EJ. Psychological consequences of surgery. *Psychosom Med* 1989;51:356-370.