

Technical Note

Management of Bony Deficiency in Revision Anterior Cruciate Ligament Reconstruction Using Allograft Bone Dowels: Surgical Technique

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Abstract: Revision anterior cruciate ligament (ACL) reconstruction surgery has become increasingly common over the past decade and its popularity is likely to rise further as the number of primary ACL reconstructions increases each year. More than 75% of all cases of failed ACL reconstruction are the result of technical error and, of these, more than 70% are attributed specifically to malpositioned tunnels. Management of tunnel malposition in revision surgery often requires innovative approaches for dealing with the resultant bony defects. In addition, tunnel osteolysis may create bone loss that interferes with desired tunnel placement. A number of options have been described for handling these bony deficiencies, many of which are technically difficult and time consuming. We describe a novel technique to address bony defects during revision ACL reconstruction using freeze-dried allograft bone dowels. These allografts are readily available and can be used easily to fill deficiencies resulting from previous tunnels or osteolysis. The grafts provide sufficient structural support for redrilling of new tunnels through or next to the bony plug, allowing uncompromised tunnel placement. **Key Words:** Anterior cruciate ligament—Reoperation—Treatment failure—Allograft—Athletic injuries—Knee injuries.

The number of primary anterior cruciate ligament (ACL) reconstructions performed in the United States is growing rapidly. More than 100,000 procedures are currently performed annually, up from 63,000 and 75,000 procedures in 1991 and 1995, respectively.^{1,2} Accordingly, ACL revision surgery has also become increasingly common over the past decade and is likely to rise further as the number of

primary reconstructions increases each year. Although long-term functional stability and symptom relief after primary ACL reconstruction approach 90% in some studies, overall clinical failure rates of 10% to 25% have been documented.³⁻⁸ It is currently estimated that between 3,000 and 10,000 patients are candidates for revision ACL surgery annually.⁹

Objective failure of ACL reconstruction has been defined as an increase in anterior tibial translation during KT-1000/2000 testing of greater than 5.5 mm compared with the contralateral knee or a pivot-shift test demonstrating gross subluxation.¹⁰ Recurrence of subjective instability during activities of daily living or with desired athletic activities may also be viewed as an indication for revision reconstruction.^{1,11} Four general causes of failure exist: errors in surgical technique, graft failure, trauma, and failure to address coexisting laxity in secondary restraints (e.g., the posterolateral corner). By far, the most common cause is error in surgical technique, with 77% to 95% of all

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cases of ACL failure attributed to technical error.⁷ This category includes inadequate notchplasty; poor graft selection, harvest, tensioning, or fixation; and, especially, incorrect tunnel placement.^{3,4,12} More than 70% of technical failures, and thus more than 50% of all ACL failures, are attributed to malpositioned tunnels.^{11,12}

Inappropriate positioning of either the tibial or femoral tunnel results in excessive length changes in the graft as the knee moves through a range of motion, resulting in either limited range of motion or excessive graft laxity.^{3,11} Anterior placement of the femoral tunnel (the most common single technical error) will result in limited flexion, whereas posterior placement may cause loss of extension. Tibial tunnel placement may be somewhat more forgiving, but anterior placement leads to impingement in extension and excessive tension in flexion, whereas posterior placement may cause laxity in flexion.¹² Accordingly, correct tunnel placement—of utmost importance in primary ACL reconstruction—is even more crucial in revision cases. This requires placement of revision tunnels at the appropriate anatomic tibial and femoral sites, regardless of considerations of previous tunnel placement.¹³ Management of previous tunnel malposition is technically demanding and often requires innovative approaches for dealing with bony defects resulting from incorrectly positioned prior tunnels. In addition, osteolysis or tunnel widening is also encountered frequently in revision surgery and may also interfere with desired tunnel placement. Finally, hardware removal, if necessary, will further contribute to loss of bone stock.

A number of options have been described for managing these bony deficiencies. If the original tunnel is correctly positioned and only slightly larger (3 to 5 mm) than the new graft, stacking 2 interference screws may be sufficient to fill the tunnel and secure the graft.¹³ In some cases of gross tunnel malposition, a new tunnel may simply be drilled without violating the original tunnel or removing any tunnel hardware. Alternatively, tunnels can be oriented in a divergent pathway that maintains the appropriate articular surface attachment. In many cases, however, new tunnels cannot be drilled without overlapping or breaking into a previous tunnel. Graduated tunnel dilators may allow controlled expansion of a previous tunnel, compacting rather than removing additional bone.¹² In such instances, options include use of an allograft tendon with an enlarged bony portion, use of an oversized interference screw, or use of stacked interference screws.¹⁰ Unfortunately, very large defects often

require staged procedures, with graft removal, tunnel curettage, and bone grafting comprising the first stage, followed by revision ACL reconstruction after incorporation, from 6 weeks to 6 months later.^{9,11-14} Staged bone grafts have been recommended for defects as small as 10 to 15 mm in diameter.^{4,11}

These techniques are often time consuming and technically demanding. In this article, we describe a novel technique to address bony defects during revision ACL reconstruction using freeze-dried allograft bone dowels. These allografts are readily available and can be easily used to fill deficiencies resulting from previous tunnels or osteolysis. The grafts provide sufficient structural support to allow redrilling of new tunnels through or next to the bone plug. To our knowledge, no reports exist describing the use of allograft bone plugs at the time of revision ACL reconstruction. We believe that the use of these allografts, in appropriately selected cases, is an effective and efficient method to address bony defects encountered in revision ACL procedures.

SURGICAL TECHNIQUE

Once the diagnosis of failed ACL reconstruction has been made and revision is planned, preoperative evaluation should include anteroposterior and lateral radiographs in full extension to assess tunnel size and position. The extent of osteolysis and any other bony defects should be carefully noted. If possible, comparison with previous radiographs will help quantify bony loss. Computed tomography will also help to delineate tunnel position and the extent of osteolysis, although magnetic resonance imaging is usually preferable because it will also provide valuable information about meniscal and articular surface pathology.^{4,10,12,14} Preoperative counseling should alert the patient to the potential need for allograft use, alternative ACL graft sources, or staged reconstruction with bone grafting.

Intraoperatively, the final assessment of previous tunnel position and osteolysis is made. If new tunnel placement is possible without interference from previous hardware, the hardware should be left in place. However, in those cases in which the desired position for the revision tunnel intersects with or overlaps the previous tunnels, interference screws should be removed carefully after ensuring that the screw head is free of all soft tissue and that the screwdriver is fully seated. Any soft tissue in the tunnel is also removed with an arthroscopic shaver. The diameter of the ex-



FIGURE 1. Human freeze-dried allograft bone dowel from Life-Link Tissue Bank, Tampa, Florida.

isting tunnel must then be established using sequentially sized reamers or dilators to determine the largest reamer that fits into the tunnel without excessive force. Occasionally, in instances where the tunnel is irregular in diameter or contains significant amounts of soft tissue, gentle reaming may be used to prepare the tunnel walls.

An allograft bone dowel approximately 1 mm larger in diameter is then chosen. These human corticocancellous allograft bone plugs are available from Life-Link Tissue Bank (Tampa, FL) and are offered in diameters of 12, 13, 14, or 16 mm, with variable lengths from 15 to 25 mm (Fig 1). The grafts are freeze dried and do not require refrigeration. The approximate cost is \$450.00 per graft. Each is sterilized with a combination of bacitracin and gentamycin soaks, as well as through a patented mechanical and biological detergent process (Allowash; LifeNet, Virginia Beach, VA) to remove bone marrow and lipid components from the processed bone. This process is purported to have no biomechanical, conductive, or inductive effects on the tissue and to be nonimmunogenic and nontoxic to the host.

The graft should be briefly rehydrated in sterile saline solution before being press-fit or impacted into the bony defect. For insertion into a tibial tunnel, the graft is inserted from the outside in using a tamp and mallet to advance the dowel to just below the articular surface. For the far more common use on the femoral side, the graft is introduced into the knee through the

medial arthroscopic portal and impacted into the defect. This may require slight enlargement of the portal. Each plug has a central axial hole; to assist alignment with and insertion into the existing tunnel, a guidewire may be placed through the portal and into the tunnel and the plug inserted directly over the wire (Fig 2).

The notchplasty should then be completed in a standard fashion, taking care that the graft lies flush or slightly recessed from the notch roof and that the over-the-top position is well visualized. Drilling of new anatomic tunnels may then proceed as normal without regard to previous tunnel position (Fig 3). The corticocancellous nature of the allograft and the press-fit technique provide excellent purchase and stability, and we have not encountered loosening or fragmentation of the graft, even when the new tunnel intersects or overlaps with the now-filled defect (Fig 4).

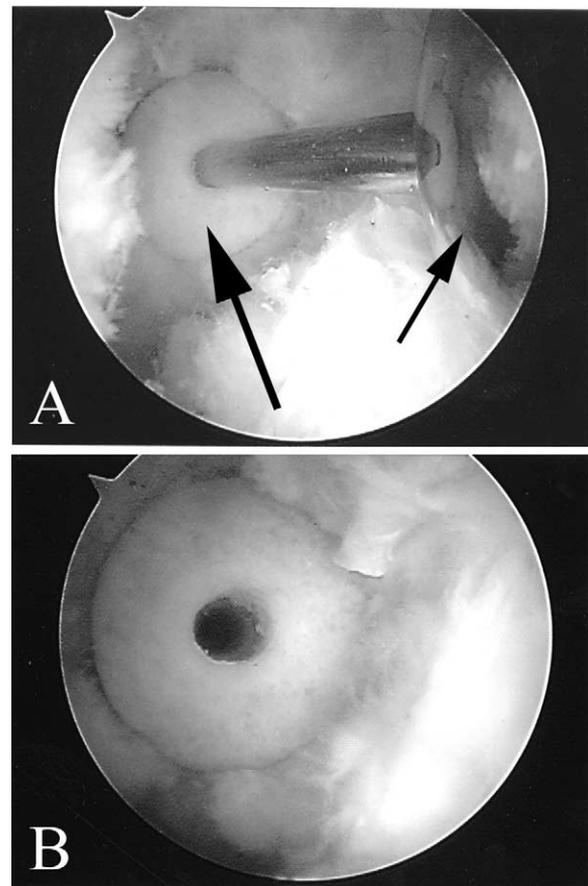


FIGURE 2. (A) Insertion of allograft bone dowel (large arrow) into the previous tunnel over a guidewire. A cannulated tunnel dilator (small arrow) is used here to advance the allograft. (B) Fully inserted bone dowel.

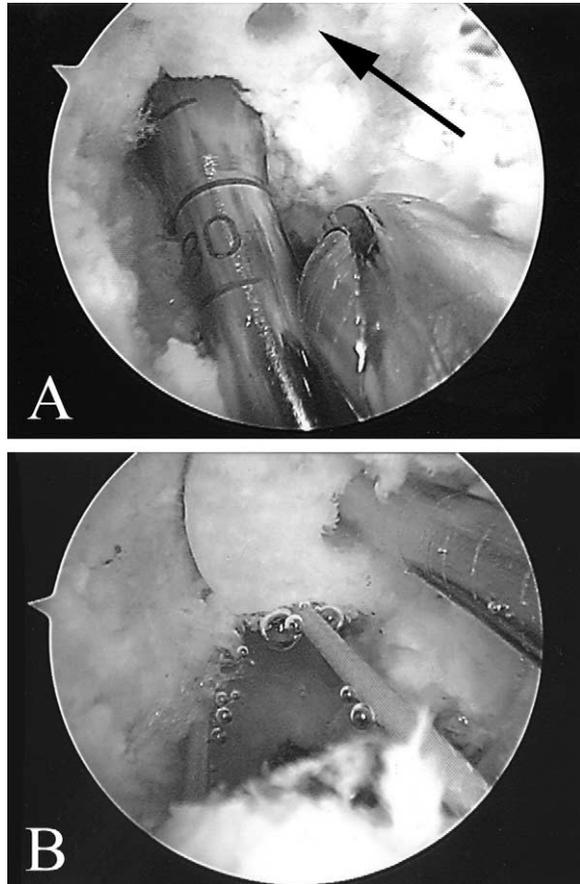


FIGURE 3. (A) Drilling of revision femoral tunnel adjacent to allograft plug (arrow). (B) Advancement of graft into the new tunnel.

DISCUSSION

Although this is a straightforward technique, we are aware of no descriptions in the literature of allograft bone grafting performed concurrently with revision ACL reconstruction. We have found this method useful in cases of malpositioned tunnels as well as in cases of osteolysis. We believe this method is useful both on the femoral and tibial sides to replenish bone stock and allow uncompromised placement and drilling of new tunnels. Properly placed, these bone dowels also provide adequate stability to allow use of the surgeon's choice of graft fixation devices, including interference screws.

Two qualifications are necessary. The first concerns cases in which the previous tunnel lies in the desired anatomic location and direction but tunnel widening or diminutive graft size prevents unmodified use of the original tunnel. In such cases, placement of an allo-

graft dowel followed by drilling of a new tunnel directly along the axis of the plug could theoretically result in allograft fragmentation and failure because only a small circumferential rim of plug may be left intact. In all cases, we attempt to deviate the angle of the new tunnel slightly while maintaining the correct anatomic articular starting point. The second caution relates to cases in which the previous femoral tunnel is too posterior and posterior wall integrity is compromised. Sufficient fit and stability of the allograft require bony contact throughout its circumference and, on these occasions, staged reconstruction or use of an over-the-top femoral technique may be more appropriate.

The use of cadaveric bone is also not without theoretical risk. Bacterial infection occurs in approximately 0.3% of ACL reconstructions⁷ and, although this risk should not be significantly higher with proper sterile handling of the allograft, viral transmission of the hepatitis or human immunodeficiency (HIV) virus is a concern. Thankfully, freeze drying appears to be an extremely safe method of allograft preparation. As of 1993, there had been more than 1,000,000 recipients of freeze-dried allograft tissue, with no documented cases of HIV or other virus transmission.¹⁵ Furthermore, in the 1 known case of HIV transmission through banked bone, recipients of the fresh-frozen tissue seroconverted, while none of the recipients of freeze-dried bone or freeze-dried soft-tissue grafts have done so.^{15,16}

Additionally, although it incorporates through the same processes as autograft bone, allograft is known to integrate more slowly than autograft and may cause immunologic reactions that interfere with the healing

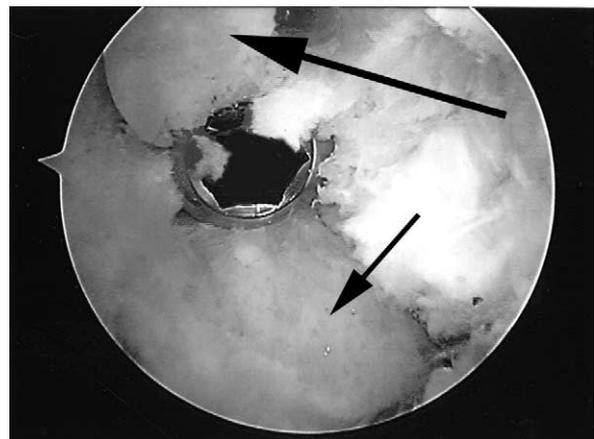


FIGURE 4. Final position of graft (small arrow), interference screw, and allograft dowel (large arrow).

process.¹⁷⁻¹⁹ Furthermore, the sterilization method used may decrease the mechanical properties of the allograft.^{20,21} Nevertheless, despite these issues, we have not observed lack of graft incorporation on post-operative evaluation. Finally, the cost of the allograft must also be considered. However, when weighed against the medical and societal costs of a 2-staged ACL reconstruction, a failed revision, or autograft harvest, the additional cost may be justifiable.

In summary, as the number of revision ACL reconstructions increases, more options will be necessary for managing the bony deficiencies often caused by tunnel malposition and osteolysis. The technique presented here is a simple method using press-fit allograft bone dowels to reconstitute bone stock and allow unimpeded placement of new tunnels. We have found use for this procedure in both femoral and tibial bony deficiencies. Although not appropriate in all cases, we believe it is a useful option for the arthroscopist who performs revision ACL reconstruction.

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