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Hybrid Bone-Grafting Technique for Staged Revision Anterior Cruciate Ligament Reconstruction

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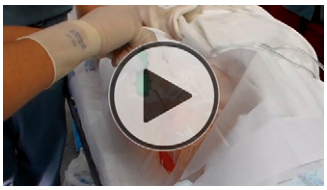

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Abstract

Background: Although most patients who undergo anterior cruciate ligament (ACL) reconstruction achieve long-term functional stability and symptom relief, graft rupture rates range from 2% to 10%[1,2]. A small subset of these patients require a 2-stage revision ACL reconstruction because of tunnel osteolysis or tunnel malposition that will interfere with the planned revision tunnel placement[3]. In the present article, we describe the hybrid use of arthroscopically delivered injectable allograft matrix in the femur and pre-shaped bone dowels in the tibia for the treatment of lower-extremity bone deficiencies.

Description: After induction of anesthesia, approximately 60 cc of bone marrow aspirate is harvested from the anterior iliac crest with use of sterile techniques and is processed to obtain bone marrow aspirate concentrate. Routine diagnostic knee arthroscopy is performed via the standard anterolateral and anteromedial portals. Any additional intra-articular pathology is addressed, followed by excision of the remnant graft material, removal of existing femoral hardware as needed, and exposure of the existing bone tunnels. The femoral tunnel is debrided arthroscopically, removing all soft-tissue remnants. The existing tibial tunnel is exposed via the previous anteromedial tibial incision when possible. Again, any existing tibial hardware is removed. The tibial tunnel is then prepared with use of a combination of sequential reaming and dilation. A shaver and curets are utilized to debride the sclerotic walls of the tunnel and remove the remnant graft material. A cannulated allograft bone dowel is then impacted into place over a guidewire, ensuring that the graft is not proud within the joint space. An injectable bone allograft matrix composite is prepared by manually mixing 5 mL of StimuBlast demineralized bone matrix (Arthrex) and 5 mL of FlexiGraft cortical fibers (Arthrex), along with the previously obtained bone marrow aspirate concentrate. Under dry arthroscopy, this bone graft is delivered into the femoral tunnel via a cannula with use of the anteromedial portal. Finally, a Freer elevator is used to contour the graft at the aperture of the tunnel. Graft osteointegration is mandatory prior to proceeding with the second stage of the procedure. Typically, a minimum 3-month follow-up is necessary to confirm adequate graft incorporation on computed tomography.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSEST/A349).

Alternatives: As an alternative to the 2-stage procedure, previous studies have suggested the use of a single-stage revision utilizing cylindrical allografts or multiple "stacked screws."[4-6] In addition, a number of bone allograft and autograft options have been described. Autologous bone graft can be harvested from the ipsilateral iliac crest or proximal aspect of the tibia with use of a variety of techniques[7-10]. Allograft bone options include cancellous bone chips and commercially available bone matrices or dowels[11-14]. Finally, another viable option is calcium phosphate bone graft substitutes[15]. There is a paucity of high-quality studies comparing available bone graft materials for revision ACL reconstruction; thus, no consensus exists regarding the optimal choice[16].

Rationale: A 2-stage approach is typically indicated for cases that demonstrate tunnel enlargement (>12 mm) that would compromise graft fixation or non-anatomic tunnel placement that will interfere with placement of the revision tibial tunnel[3]. The aim of the first stage is to re-establish adequate bone stock to optimize future tunnel placement and healing of the ACL graft during the second stage. We believe that this 2-stage approach is a reliable and safe method of treating enlarged, irregularly shaped bone tunnel defects while minimizing the risk of complications. Furthermore, the use of allograft material avoids the donor-site morbidity and volume limitations associated with the use of autograft bone. In the case of the femoral tunnel, the injectable bone graft composite has the advantage of being easily delivered arthroscopically while completely filling irregularly shaped tunnels. The use of bone marrow aspirate concentrate may improve the rate of graft healing as well as a hydrating substance to reduce viscosity and facilitate the flow of the bone graft material through the cannula[16,17]. For the tibia, especially in cases of lengthy tibial bone deficiencies, allograft bone dowels are commercially available off-the-shelf in a variety of different lengths and diameters to allow for adequate fill of bone defects.

Expected Outcomes: It is well known that outcomes following revision ACL reconstruction are inferior to those following primary ACL reconstruction, with a number of variables, beyond those associated with the surgical technique, influencing clinical outcomes[18]. Few studies have reported on the results of 2-stage revision ACL reconstruction with use of allograft bone; however, a high rate of allograft bone integration and improved bone quality at the time of revision ACL reconstruction have been reported[13]. Moreover, Mitchell et al. reported no differences in either subjective outcomes or failure rates between the 1-stage and 2-stage revision ACL reconstruction groups[11].

Important Tips:

- Utilize computed tomography for preoperative assessment and measurement of the extent of osteolysis.
- If possible, obtain the operative report for the index ACL procedure in order to identify any preexisting hardware and to obtain any instrumentation that may be needed to facilitate hardware removal.
- Multiple bone dowel sizes are available off the shelf.
- A 70° arthroscope can aid in visualization of the entire tibial and femoral tunnel.
- Although the bone graft matrix can be injected while the joint is filled with irrigation fluid, we find it easier to administer the graft under dry arthroscopic conditions.
- Place the scope inside the tibial tunnel to confirm appropriate removal of soft tissue and hardware. Circumferential native cancellous bone should be visualized.
- It is acceptable to retain previous hardware if it does not interfere with the new tunnel placement.
- Utilize prior incisions to access the tibial tunnel.
- Do not underestimate the amount of bone graft needed for each tunnel.
- Avoid excessive force during impaction of the dowels.

Acronyms and Abbreviations:

ACLR = Anterior cruciate ligament reconstruction
BMAC = Bone marrow aspirate concentrate
MRI = Magnetic resonance imaging

CT = Computed tomography
BTB = Bone-patellar tendon-bone
DVT = Deep vein thrombosis
ROM = Range of motion

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References

1. Hettrich CM, Dunn WR, Reinke EK, Spindler KP; MOON Group. The rate of subsequent surgery and predictors after anterior cruciate ligament reconstruction: two- and 6-year follow-up results from a multicenter cohort. Am J Sports Med. 2013 Jul;41(7):1534-40.

2. Wright RW, Magnussen RA, Dunn WR, Spindler KP. Ipsilateral graft and contralateral ACL rupture at five years or more following ACL reconstruction: a systematic review. J Bone Joint Surg Am. 2011 Jun 15;93(12):1159-65.

3. Erickson BJ, Cvetanovich G, Waliullah K, Khair M, Smith P, Bach B Jr, Sherman S. Two-Stage Revision Anterior Cruciate Ligament Reconstruction. Orthopedics. 2016 May 1;39(3):e456-64.

4. 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 Dec;25(6):1308-17.

5. 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 Nov;27(11):3713-21.

6. Battaglia TC, Miller MD. Management of bony deficiency in revision anterior cruciate ligament reconstruction using allograft bone dowels: surgical technique. Arthroscopy. 2005 Jun;21(6):767.

7. Said HG, Baloch K, Green M. A new technique for femoral and tibial tunnel bone grafting using the OATS harvesters in revision anterior cruciate ligament reconstruction. Arthroscopy. 2006 Jul;22(7):796.e1-3.

8. Uchida R, Toritsuka Y, Mae T, Kusano M, Ohzono K. Healing of tibial bone tunnels after bone grafting for staged revision anterior cruciate ligament surgery: A prospective computed tomography analysis. Knee. 2016 Oct;23(5):830-6.

9. Franceschi F, Papalia R, Del Buono A, Zampogna B, Diaz Balzani L, Maffulli N, Denaro V. Two-stage procedure in anterior cruciate ligament revision surgery: a five-year follow-up prospective study. Int Orthop. 2013 Jul;37(7):1369-74.

10. Thomas NP, Kankate R, Wandless F, Pandit H. Revision anterior cruciate ligament reconstruction using a 2-stage technique with bone grafting of the tibial tunnel. Am J Sports Med. 2005 Nov;33(11):1701-9.

11. Mitchell JJ, Chahla J, Dean CS, Cinque M, Matheny LM, LaPrade RF. Outcomes After 1-Stage Versus 2-Stage Revision Anterior Cruciate Ligament Reconstruction. Am J Sports Med. 2017 Jul;45(8):1790-8.

12. Van de Pol GJ, Bonar F, Salmon LJ, Roe JP, Pinczewski LA. Supercritical Carbon Dioxide-Sterilized Bone Allograft in the Treatment of Tunnel Defects in 2-Stage Revision Anterior Cruciate Ligament Reconstruction: A Histologic Evaluation. Arthroscopy. 2018 Mar;34(3):706-13.

13. Theodorides AA, Wall OR. Two-stage revision anterior cruciate ligament reconstruction: Our experience using allograft bone dowels. J Orthop Surg (Hong Kong). 2019 May-Aug;27(2):2309499019857736.

14. Buyukdogan K, Laidlaw MS, Miller MD. Two-Stage Revision Anterior Cruciate Ligament Reconstruction Using Allograft Bone Dowels. Arthrosc Tech. 2017 Aug 14;6(4):e1297-302.

15. von Recum J, Schwaab J, Guehring T, Grützner PA, Schnetzke M. Bone Incorporation of Silicate-Substituted Calcium Phosphate in 2-Stage Revision Anterior Cruciate Ligament Reconstruction: A Histologic and Radiographic Study. Arthroscopy. 2017 Apr;33(4):819-27.

16. Salem HS, Axibal DP, Wolcott ML, Vidal AF, McCarty EC, Bravman JT, Frank RM. Two-Stage Revision Anterior Cruciate Ligament Reconstruction: A Systematic Review of Bone Graft Options for Tunnel Augmentation. Am J Sports Med. 2020 Mar;48(3):767-77.

17. Gianakos AL, Sun L, Patel JN, Adams DM, Liporace FA. Clinical application of concentrated bone marrow aspirate in orthopaedics: A systematic review. World J Orthop. 2017 Jun 18;8(6):491-506.

18. Lind M, Menhert F, Pedersen AB. Incidence and outcome after revision anterior cruciate ligament reconstruction: results from the Danish registry for knee ligament reconstructions. Am J Sports Med. 2012 Jul;40(7):1551-7.