Use of Fast-Setting Bone Graft Substitute to Allow Single-Stage Revision Anterior Cruciate Ligament Reconstruction

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Background: The overall revision rate for primary anterior cruciate ligament reconstruction (ACLR) has increased over the past decade, with the commonest mode of failure being a combination of traumatic, technical, and biological factors. The challenge in revision ACLR is the need to address malpositioned or widened tunnels with the ideal scenario being single-stage revision, with widened and type 2 tunnels being the most difficult scenarios to deal with. Tunnels can be filled using autograft, allograft, and more recently described bone graft substitute (BGS). In this video, we describe a technique using fast-setting BGS to fill the problem of malpositioned tunnel or tunnels to allow single-stage revision ACLR.

Indications: This technique is indicated in patients undergoing revision ACLR where tunnels are nearly right (type 2) with no widening at the joint surface aperture.

Technique Description: Following preparation of the notch, the femoral tunnels are prepared in the normal fashion to remove all the previous graft and to create fresh bleeding surfaces. The fluid in the knee is completely drained, and the femoral tunnel is repeatedly dried with ribbon gauze that is left in place until ready to inject. The BGS, genex (Biocomposites Ltd), is mixed and loaded into the delivery syringe before injecting arthroscopically. After 15 minutes, the new anatomic femoral tunnel is then prepared in routine fashion. The same steps are repeated for the tibial tunnel.

Results: Twenty patients underwent single-stage revision ACLR using this technique. There have been no reruptures in this series. All eligible patients at the 12-month follow-up had grade 0 or 1 laxity on clinical examination and full incorporation of the BGS on radiographs. There were no complications related to the BGS during the intra- or postoperative period.

Discussion/Conclusion: We describe a technique that allows revision ACLR to be performed as single stage in a subset of patients with type 2 tunnels with successful short- to mid-term results. We have found this to be a safe and effective way to avoid 2-stage surgery in a subgroup of cases who have a challenging problem for surgeons to manage.

Patient Consent Disclosure Statement: The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

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In this video, we present the use of fast-setting bone graft substitute (BGS) to allow single-stage revision anterior cruciate ligament reconstruction (ACLR) in situations where large bone defects may have led to 2-stage surgery.

Author disclosures are listed here.

BACKGROUND

The overall revision rate for primary ACLR is approximately 3% at 2 years and 6% at 5 years.[14,15] The MARS group, in their detailed analysis, reported the commonest mode of failure being a combination of traumatic, technical, and biological factors. Technical error is reported to contribute to 24% of cases, with 70% of technical failures attributed to malpositioned tunnels.[5,12]

The challenge in revision ACLR is the need to address malpositioned or widened tunnels with the ideal scenario being single-stage revision. If the tunnels are not appropriate, then traditionally a 2-stage strategy is used, but this can expose the knee to ongoing instability, potential chondral and meniscal injury between stages, and prolonged rehabilitation.[13] Single-stage revision ACLR has been popularized with good clinical outcomes and low rerupture rates in both the normal and elite athlete population.[2,6,12,13]

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For 2-stage surgery, the patient's own bone can be used for grafting the tunnels, morselized freeze-dried allograft bone chips can be used, and allograft corticocancellous bone strips have been described to manage tibial tunnel widening by supplementing interference screw fixation of bone-patellar-bone graft.[9] Allograft bone dowels are commonly used, and more recently, synthetic BGSs have been shown to be as effective as allografts and autografts without the risk of disease transmission or morbidity with autograft harvest.[1,8,11,16]

BGSs possess osteoconductive properties, which help fill bone defects as a scaffold without the morbidity associated with autograft harvest.[3] Their use is common in trauma, and several are available on the market, usually formulated as a liquid that hardens over 10 to 15 minutes. They are usually synthetic and calcium based. Calcium sulfate grafts are rapidly absorbed within 1 to 3 months to create pores for early bone growth.[3,7] Calcium phosphate facilitates bone healing and remodeling over a longer period and is completely resorbed within 12 months.[7,17]

In revision ACLR, scenarios on the left-hand side of the grid are usually easier cases to manage. The same tunnels can be reused in type 1 tunnels. Type 3 tunnels are out of the way, and the previous tunnel can be ignored, including fixation devices, and new tunnels can be drilled. Widened and type 2 tunnels are significantly more difficult to manage. Although not part of the original classification, widened tunnels are a difficult scenario that can be managed by filling voids with big grafts or large fixation devices such as metal screws. BGS is also a potential option here and can be used in the same fashion as in trauma. Currently, the techniques to handle type 2 tunnels in 1 stage include a larger bone block, outside-in tunnel drilling, tunnel dilation, and potentially allograft bone dowels or a blocking screw. All these options are technically demanding, so most of these cases are revised using a 2-stage approach.

TECHNIQUE DESCRIPTION

We now describe a technique using fast-setting BGS to fill the problem of a malpositioned tunnel or tunnels to allow single-stage revision ACLR.

The product we use, genex (Biocomposites Ltd), is a calcium sulfate and B-tricalcium phosphate compound BGS. It comes in a pack consisting of a syringe, the calcium compound powder, a mixing liquid, and a spoon. In addition, we use 5 cm of cut thick suction tubing to help arthroscopic delivery when injecting the femoral tunnel. This is not necessary for the tibial tunnel.

For the technique, we will demonstrate in a 24-year-old woman with 2 unsuccessful ACLRs in her left knee, as seen on these 2-dimensional and 3-dimensional reconstructed views with the medial femoral condyle removed—an important part of the planning workup.

Following preparation of the notch, the femoral tunnels are debrided with reamers and curettes in the normal fashion to remove all the previous graft and to create fresh bleeding surfaces. The fluid in the knee is completely drained, and the femoral tunnel is repeatedly dried with ribbon gauze that is left in place until ready to inject. The genex product is then mixed and loaded into the delivery syringe before injecting arthroscopically. Fluid should not be switched back on until the genex has set at 15 minutes. A tourniquet is used during the case, and therefore bleeding is not encountered when the BGS is introduced.

The newly grafted tunnel is inspected after a minimum of 15 minutes to check the genex has set and to remove any debris with an arthroscopic shaver. We have not seen any short- or mid-term problems from minor amounts of remaining debris. The new anatomic femoral tunnel is then prepared in routine fashion and, in this case, by passing a guidewire, a 4.5-mm drill guide for the suspensory device, followed by the appropriately sized reamer for the prepared graft. The BGS is not brittle or fragile when reaming and behaves like normal corticocancellous bone. Debris from drilling is thoroughly washed from the joint.

We demonstrate the tibial tunnel technique in this case of a 34-year-old man with an unsuccessful ACLR in his right knee. The computed tomography scans confirm a shallow and medial tibial tunnel with significant widening of 17 mm but with no widening at the joint surface aperture. This allows the BGS to be contained during redrilling. The new tunnel starting point is made in a more midline and distal position, accepting some convergence with the previous tunnel but maintaining the same joint surface aperture. This technique addresses both widening and tunnel convergence but still allows a single-stage operation.

In this scenario, the new tibial tunnel is drilled and reamed to size first. The tunnel is once again dried with ribbon gauze. A cannulated tunnel dilator is now inserted to maintain the new tunnel while the BGS is injected into the remaining cavity from the previous tunnel. This also avoids BGS from entering in to the joint. The additional suction tube extension is not required as the tibial tunnel is easily accessible.

The arthroscope can be passed up the new tibial tunnel after 15 minutes to inspect the BGS wall that has been maintained by the tunnel dilators.

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RESULTS

Here are the early results of 20 patients who underwent single-stage revision ACLR. The demographics are shown in this slide. Patients were followed at regular intervals until 2 years postoperatively with additional telephone review annually. They underwent radiographic evaluation at 6 and 12 months.

Four patients had concomitant procedures along with the revision ACLR. Thirteen patients underwent a lateral extra-articular tenodesis. There have been no reruptures in this series. All eligible patients at the 12-month follow-up had grade 0 or 1 laxity on clinical examination and full incorporation of the BGS on radiographs. There were no complications related to the BGS during the intra- or postoperative period. One patient developed a deep vein thrombosis in the contralateral leg not related to the BGS.

DISCUSSION

In summary, we have described a technique that allows revision ACLR to be performed as a single stage in a subset of patients with type 2 tunnels. We have shown successful short- to mid-term results in our case series.

BGSs have several advantages compared to other tunnel management options. They can fill large bone voids, including irregular ones, without compromising fixation strength. This has been shown in cadaveric biomechanical evaluation of load to failure of bone-patellar tendon-bone grafts using interference screw femoral fixation with or without BGS.[11] BGSs have been shown to be biomechanically stable in cyclical loading tests, simulating 2 weeks of walking.[10] Additionally, there is extensive experience in trauma surgery, particularly when dealing with bone voids in tibial plateau fixation.[3,4]

Single-stage revision ACLR has been shown to be safe, and the significant improvements in patient function and clinical outcomes are comparable to 2-stage revision when using allograft bone dowels.[2,6] There is good incorporation of the bone with low rerupture rates and high return to play in elite athletes.[12,13] Serbin et al[8] have described a similar technique using fast-setting BGS for single-stage revision ACLR but without any results.

We have found many advantages using this technique. Although using the BGS requires some attention to detail, it makes the procedure more expeditious. We have shown how the BGS stability and strength allow redrilling of overlapping tunnels and satisfactory fixation, including the use of interference screws. It also remodels to normal bone over 12 months. As with any single-stage technique, the overall recovery is quicker, and surgery is more cost-effective.

There are some limitations to this technique. First, it is not appropriate for every revision ACLR. We have not used this technique for cases with significant widening at the joint surface tunnel aperture where redrilling would leave a 360° surround of BGS.

Second, we have a small cohort of patients with only short- to mid-term results, but failure of fixation or biological incorporation is likely to occur in the first 12 to 18 months, so we believe late failures specifically due to the BGS are unlikely.

We would be cautious about using BGS to reposition a tibial tunnel that is too posterior, and redrilling an anatomic tunnel would result in very high loading of genex at the back of the new tunnel.

The technique has a learning curve, and particular attention should be taken when preparing the femoral tunnel and injecting the BGS. Our top tip using the suction tube extension helps alleviate the difficulty in arthroscopic delivery of the BGS. Tunnels need to be meticulously dried before injecting the genex to allow it to set.

CONCLUSION

In conclusion, revision ACLR is becoming a frequent surgical procedure, with tunnel malposition being a difficult problem to contend with. There are many described techniques to help achieve a successful outcome in revision ACLR, but not all allow single-stage surgery. We have demonstrated a technique using a synthetic graft to deal with slightly malpositioned tunnels, which can be performed in a single stage. Although longer-term follow-up would be useful, we have found this to be a safe and effective way to avoid 2-stage surgery in a subgroup of patients who have a challenging problem for surgeons to manage. This seems a better option for both surgeons and patients.

Thank you for your attention.

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