

An Isolated Midsubstance ACL Tear Repaired With the BEAR System

Patrick F. Szukics,^{*†} DO , Brian E. Fliegel,[†] DO , William F. Baker,[†] DO, Hannah Popper,[†] DO, and Sean McMillan,[‡] DO

Investigation performed at Virtua Memorial Hospital Burlington County, Burlington, New Jersey, USA, and Jefferson Health New Jersey, Stratford, New Jersey, USA

Background: Anterior cruciate ligament (ACL) repairs, once widely abandoned due to historically high failure rates, have recently regained interest with the development of the bridge-enhanced ACL repair (BEAR) implant, a novel arthroscopic technique that uses a resorbable protein-based implant combined with autologous blood to primarily repair a midsubstance ACL tear. This technical note presents a step-by-step surgical method for performing an isolated midsubstance ACL repair using the BEAR implant.

Indications: The BEAR implant is indicated for skeletally mature patients at least 14 years of age with a complete rupture of the ACL, confirmed by magnetic resonance imaging. The complete ACL tear must have an attached stump to the tibia.

Technique Description: A diagnostic arthroscopy is used to confirm complete rupture of the ACL and presence of residual tibial stump. A self-retrieving suture passage device is used to whipstitch a total of 6 passes with #2 Vicryl suture from distal to proximal through the residual stump. A notchplasty followed by femoral and tibial tunnels is created in a standard fashion. An Endobutton, soaked in a bacitracin solution, is then loaded with the sutures that were previously passed through the residual ACL stump and then through the femoral tunnel and cinched down to bone. The 4 suture ends that are coming from the Endobutton are then passed through the BEAR implant with the use of a Keith needle and shuttled through the tibial tunnel. The BEAR implant is hydrated with 15 cc of the patient's blood and is shuttled through the anteromedial portal with the knee in full extension. The 4 tibial sutures passed through the graft and tibial tunnel are passed, and tensioned to the proximal tibia with a second Endobutton. Standard closure and dressings are applied.

Results: This new surgical implant and technique have shown noninferiority to ACL autograft reconstruction with respect to the International Knee Documentation Committee and anteroposterior laxity, with improved hamstring strength and decreased incidence of contralateral ACL tears at 2 years postoperative.

Discussion/Conclusion: While initial data remain promising, future long-term designed studies are needed to determine the clinical efficacy of the BEAR technique, particularly comparing itself with bone-patellar tendon-bone autograft ACL reconstruction.

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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VIDEO TRANSCRIPT

The following is a technical note on the bridge-enhanced anterior cruciate ligament (ACL) repair (BEAR) restoration procedure and subsequent rehab protocol.

This is a shift in philosophy as now ACLs can be repaired in acute settings.

Indications for the BEAR ACL restoration procedure have continued to evolve particularly in light of the current BEAR III clinical trial.²⁻⁷ Nevertheless, based upon historical data, recommendations for indication include patients over the age of 14 years with closed physes, as well as patients with either partial or complete ACL ruptures. The timing of the ACL surgery is up to the surgeon and the time line of 45 to 50 days, previously reported in literature, is no longer

*Address correspondence to Patrick F. Szukics, DO, Jefferson Health New Jersey, 1 Medical Center Drive, Stratford, NJ 08084, USA (email: Pat.szukics@gmail.com).

[†]Jefferson Health New Jersey, Stratford, New Jersey, USA.

[‡]Virtua Memorial Hospital Burlington County, Burlington, New Jersey, USA.

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a standard. However, the tissue must be viable intraoperatively to move forward.

Contraindications for the BEAR procedure include those who have had previous ACL surgeries, as well as previous knee infections. Risk factors that could adversely affect the ligament healing include the use of nicotine or tobacco products, recent corticosteroid injections within the last 6 months, chemotherapy, diabetes, and other autoimmune pathologies.

Prior to the commercialization of the BEAR ACL restoration procedure, several studies were undertaken looking at the safety and efficacy of the procedure. In 2019, Murray et al⁹ published a 2-year result looking at the first inhuman study. In this cohort, they found 10 patients undergoing the BEAR ACL restoration, as well as 10 patients undergoing ACL reconstruction with hamstring autograft and reported no graft failures in the BEAR group. They also found similar International Knee Documentation Committee (IKDC) scores as well as instrumented laxity with KT-1000 testing. Of note, they also reported significantly higher hamstring strength in the BEAR group compared with the ACL reconstruction group.

In a larger, randomized cohort, they examined 65 patients undergoing the BEAR ACL restoration procedure, as well as 35 patients undergoing ACL reconstruction with hamstring autograft and followed them for 2 years out.⁸ This was a prospective randomized study which demonstrated noninferiority in IKDC scores, KT-1000 laxity, and also noted improved hamstring strength again in the BEAR group compared with the ACL reconstruction group.

Kramer and his team looked at a similar cohort of 65 patients undergoing the BEAR ACL restoration compared with 35 in the ACL reconstruction group using hamstring.¹ Followed out at 3, 6, 12, and 24 months, the BEAR group demonstrated more pronounced improvement, particularly at the 1-year mark with IKDC and Knee Injury and Osteoarthritis Outcome Score compared with the reconstruction group. Again, improved hamstring strength was found in the BEAR group and at the 1-year mark, 88% of the BEAR restoration group was cleared to return-to-sport compared with just 76% in the reconstruction group.

From a psychological readiness perspective, it was found that patients undergoing the BEAR procedure had higher ACL return-to-sport scores at 6 months compared with the ACL reconstruction group.¹⁰ It was theorized that less pain, increase in hamstring and quadriceps strength and decreased knee laxity were all positive predictors of the higher ACL return-to-sports scores at 6 months. It should be noted at 12 and 24 months, the scores were equal between the 2 cohorts.

In this case, our patient had no osteoarthritis, but had a midsubstance ACL rupture. She elected for the BEAR restoration procedure after counseling.

The patient is positioned supine with a thigh tourniquet placed. We use a lateral post for valgus access into the medial compartment of the knee.

The case begins with localization of a medial portal which is cheated slightly toward the patellar tendon. We make a 2-cm arthrotomy at the start of the case to allow for protection of the sutures during the remainder of the case. A cannula is

inserted for water management. After inspection of the rest of the knee, we then identify our ACL tear. Dissection is undertaken to free up the ACL from any place that may be scarred, such as the posterior cruciate ligament, and then we perform a gentle kidney bean notchplasty. Next using a self-retrieving suture device, we are able to pass a #2 Vicryl suture into the ACL stump. We try to get a total of 6 passes through the ACL; 3 coming from each limb. Care is taken with manipulation of the ACL, not to rip it. When passing each subsequent limb of suture, we want to ensure that we are going in different directions and planes of the ACL, to obtain a good, solid bite. In an effort to elongate the ACL and get maximal penetration, we can use a spinal needle to localize a transpatellar portal. Then, a grasping device can be inserted and we can pull on the ACL to elongate it. This will allow for passing more sutures through the ACL stump. Once we pass all our limbs of suture through the ACL, we then move to an outside-in approach for retro drilling. We make a small incision on the lateral aspect of the thigh down through the iliotibial band to the bone, and then use a retro drill to enter the joint. We place this just slightly anterior and superior to the native footprint of the ACL. Here we use a 4-mm hole and then pass a shuttling suture from an outside-in component. The suture is then retrieved, as we are viewing medially through the lateral portal, with a suture-grasping device. At this point, viewing is taken back through the lateral portal and we turn our attention to the tibial side. We drill just anterior to the ACL footprint on the tibial side again with a 4-mm hole and we will shuttle through a passing suture, as well, which will be pulled out through the transpatellar portal for docking purposes. We drill as close to the normal footprints as possible, without violating the center of the footprint to protect the blood supply that comes into the native ligament. Next, working through our medial cannula, we insert our shuttle suture from the femur back out through this medial portal. The free limbs from the ACL stump are placed into the loop, and we also place a FiberLink suture in a retrograde manner. This will be used for passing our sutures from outside the body, back down through the femur at a later time. Slack is taken out of the ACL sutures, but not tied until the conclusion of the case.

Next, we move to the outside portion of the case. A free button can be used to pass both limbs of the purple Vicryl suture through the button. These are placed through the 2 central holes. Included in this button we have a total of two #2 Ethibond sutures, which are placed in a retrograde manner. These will be going back down through the femur and shortly through our FiberLink suture. Once we pass both limbs of the ACL stump through the button, we place a snap through the end of it as we tie this at the conclusion of the case. At this point, all 4 limbs from the button, from the #2 Ethibond sutures, are passed back down in a retrograde manner through the femur using that shuttle suture of FiberLink. Next, the joint is taken dry and we reach through the medial portal and grab our tibial shuttling suture. We then begin to irrigate the joint with antibiotic solution. After completing the irrigation, we will place a lap sponge and a Yankauer into the joint and drain the joint out, keeping it dry. We then take a Keith needle and pass down all 4 limbs

of Ethibond through the BEAR implant. Once this is done, the 4 limbs are passed through the tibial shuttling device and taken back out through the tibia. The BEAR is still outside the body and we begin the rehydration process. Twenty cc of the patient's whole blood is then used to reconstitute the BEAR. You should be careful not to get the bottom of the implant wet as we are going to use this to push into the joint. After rehydration is complete, we then go ahead and save any remaining blood, in case we need to rehydrate at a later time. Next, as we pull gentle tension on our tibial sutures, we will then insert our BEAR implant through the 2-cm arthrotomy and into the notch. The leg is taken out into extension and does not bend from this point on. We then tie our 2 purple sutures, which were #2 of Vicryl, over top of the button on the femoral side and then we tie the 4 limbs of Ethibond over the top of the separate button on the tibial side. These can be tied in a rather loose, but in a snug manner with care taken not to snap the sutures.

Next we will move onto the rehab protocol. The rehab is very unique for this type of ACL. Imagine this is similar to a patellofemoral cartilage case, where we limit flexion and weightbearing in the first 6 weeks.

Patient understanding is key, as is therapists' understanding.

We try to limit range of motion and weightbearing in the first 4 weeks, with 50% weightbearing and integrated range of motion, with 0° to 30° at 2 weeks, 0° to 60° at 4 weeks, and 0° to 90° at 6 weeks.

Working to maintain full knee extension and begin activating quad isometric contractions began around 4 to 7 weeks.

At the 4- to 6-week mark, we can advance from partial weightbearing to full weightbearing and also begin to discontinue the crutches once we demonstrate adequate quadriceps control. Again, we are limiting our range of motion to 90° at the 6-week mark. Once we transition out of the large ACL brace, we can then get them into a smaller ACL brace for stability purposes.

Our goal from weeks 7 to 12 is to obtain full range of motion. However, we make this a very stepwise progression and commonly 0° to 110° is seen up until the 3-month mark. We can work on our quadriceps and hamstring strengthening and allow for aqua jogging at the 8-week mark, if permitted.

Phase 4 is from weeks 12 to 20, at which point we are working to obtain our full range of motion and improve our muscle strength.

We are focusing on quadriceps, hamstrings, and core, as well as we can begin some neuromuscular training on wobble boards. We can also add in cardiopulmonary training such as ellipticals, StairMaster, and flutter kicks in the pool. At the 18-week mark, we can allow for straight-line running if there is adequate quadriceps strength.

Phase 5 goes from week 20 to week 30 and now we can introduce hop testing and hop training.

Again, we are working on agility, as well as double-leg training. Neuromuscular control is very important and we need to ensure that the athlete is not pushing too hard.

Phase 6 goes from week 30 to week 36, at which point, running patterns at 75% speed can be introduced.

We begin jumping as well if there is no difficulty, and then we can move onto some more agility such as hopping, shuffling, and vertical jumps. Sport-specific training can begin at a reduced speed.

Phase 7 is from week 36 to week 52, and this is where we want to make sure we have 85% contralateral strength and also focus on return-to-play activities.

Again, we have to make sure our athletes are braced appropriately as this can decrease the risk of injury within the first year. Sport-specific return-to-play is undertaken after which we see adequate hop strength testing as well as neuromuscular control. In my practice, patients are not permitted to return to the field after a BEAR ACL restoration procedure until a minimum of 9 months.

ORCID iDs

Patrick F. Szukics  <https://orcid.org/0000-0001-7505-1409>
 Brian E. Fliegel  <https://orcid.org/0000-0001-9376-1690>

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