



# GraftLink® Technique Scientific Update

With more than 10 years of clinical history, the GraftLink technique continues to be one of the fastest growing ACL reconstruction techniques performed worldwide. The clinical benefits of the GraftLink technique—including single-hamstring harvest, larger graft diameter, minimally invasive sockets, and strong, adjustable cortical fixation on the femur and tibia—are now supported in a number of biomechanical and clinical studies. The following document summarizes articles supporting successful outcomes with the GraftLink technique.

Lowenstein NA,  
Haber DB,  
Ostergaard PJ,  
Collins JE,  
Matzkin EG

## Clinical Results

[All-Inside anterior cruciate ligament reconstruction using quadrupled semitendinosus: comparable 2-year outcomes in male and female patients.](#) *Arthroscopy*. 2021;37(10):3140-3148. doi:10.1016/j.arthro.2021.03.077

- In this study, 2-year functional outcomes were determined using an all-inside quadrupled semitendinosus anterior cruciate ligament reconstruction (ACLR) technique in male and female patients.
- The study consisted of 100 patients (62 female, 38 male, average age 31.3 years). Mean graft diameter was 9.4 mm for female patients and 9.8 mm for males. Autografts less than 9 mm in diameter were augmented with gracilis.
- Of the 100 patients followed, there was only one graft retear. Three had contralateral side ACL tears, and one required an arthroscopy for a meniscus tear at four-years post-op.
- The conclusion states “[a]natomic all-inside quadrupled semitendinosus ACL reconstruction improves functional outcomes similarly to previous studies between baseline and clinical follow-up at 1 and 2 years’ postoperatively and is comparable in both male and female patients.” The key takeaway, however, was that outcome scores, patient satisfaction, and return to normal sporting activities were similar between males and females with 79% of male and 78% of female patients reporting a return to sport.

Parkes CW,  
Leland DP,  
Levy BA,  
et al

[Hamstring autograft anterior cruciate ligament reconstruction using an all-inside technique with and without independent suture tape reinforcement.](#) *Arthroscopy*. 2021;37(2):609-616. doi:10.1016/j.arthro.2020.09.002

- This is a 1:2 matched-cohort comparison of patients who underwent hamstring autograft ACLR with and without independent suture tape reinforcement.
- This is a Level III, retrospective comparative study.
- ACLR with hamstring autografts and independent suture tape reinforcement result in low complication, low graft failure, and low reoperation rates.

Kamitani A,  
Hara K,  
Arai Y,  
et al

[Adjustable-loop devices promote graft revascularization in the femoral tunnel after ACL reconstruction: comparison with fixed-loop devices using magnetic resonance angiography.](#) *Orthop J Sports Med.* 2021;9(2):2325967121992134. doi:10.1177/2325967121992134

- Level 3 cohort study: 42 patients underwent ACLR using quadrupled semitendinosus autograft and inside-out tunnel preparation.
- This is the first study to compare graft revascularization between FLD (Smith & Nephew Endobutton™ CL) and ALD (Arthrex TightRope® implant) in vivo, focusing on the contact area between the graft and femoral tunnel wall.
- MRA imaging at three-months post-ACLR revealed that blood flow reached the superior end of the tendon graft in the femoral tunnel in more patients who underwent ACLR with an ALD than an FLD.
- Findings suggest early (0 to 3 month) revascularization occurs in the superior end of the socket more readily due to the increased graft-to-bone contact area associated with ALD than FLD, which leaves a gap between the graft tip and the superior end of the socket.
- This is a landmark study as the conclusion confirms the long-discussed value of the TightRope implant's ability to retention and fully seat grafts to achieve the "potted-plant" effect.

Smith PA,  
Cook CS,  
Bley JA

[All-inside quadrupled semitendinosus autograft shows stability equivalent to patellar tendon autograft anterior cruciate ligament reconstruction: randomized controlled trial in athletes 24 years or younger.](#) *Arthroscopy.* 2020;36(6):1629-1646. doi:10.1016/j.arthro.2020.01.048

- All-inside quadrupled semitendinosus grafts are suitable in high-risk patients as BTB alternative.
- This randomized controlled trial compared clinical outcomes of knee ACL autograft reconstruction using all-inside quadrupled semitendinosus vs bone-patellar tendon-bone (BPTB) in a high-risk athletic population 24 years or younger.
- ACL reconstruction with an all-inside quadrupled semitendinosus autograft construct is equivalent to patellar BPTB autograft.

Putnis S,  
Neri T,  
Grasso S,  
Linklater J,  
Fritsch B,  
Parker D

[ACL hamstring grafts fixed using adjustable cortical suspension in both the femur and tibia demonstrate healing and integration on MRI at one year.](#) *Knee Surg Sports Traumatol Arthrosc.* 2020;28(3):906-914. doi:10.1007/s00167-019-05556-6

- Clinical study that evaluated healing and integration of hamstring grafts with TightRope implant in ACL reconstructions.
- Two hundred thirty-three patients were analyzed for graft failure rate and subjective IKDC, Tegner and Lysholm scores, and MRI imaging.
- "Significant improvements were seen in all clinical scores ( $p < 0.001$ ). MRI analysis showed 71% with fully integrated grafts in the tibia and 24% in the femur, with the remainder all showing greater than 50% integration."



Kulshrestha V,  
Sood M,  
Kumar S,  
Kawale A

[Original study: early patient-reported functional outcome of all-inside ACL reconstruction as compared to anteromedial portal technique.](#) *Eur J Orthop Surg Traumatol.* 2021;10.1007/s00590-021-02912-6. doi:10.1007/s00590-021-02912-6

- In this randomized study, 80 young active males requiring ACLR surgery were equally randomized to anteromedial portal technique and all-inside technique.
- The mean improvement in Tegner score was significantly better as compared to the anteromedial portal technique group.
- All-inside ACLR provides a better chance of return to preinjury level of activity with accompanied patient satisfaction as compared to anteromedial portal technique.

Kouloumentas P,  
Kavroudakis E,  
Charalampidis E,  
Kavroudakis D,  
Triantafyllopoulos GK

[Superior knee flexor strength at 2 years with all-inside short-graft anterior cruciate ligament reconstruction vs a conventional hamstring technique.](#) *Knee Surg Sports Traumatol Arthrosc.* 2019;27(11):3592-3598. doi:10.1007/s00167-019-05456-9

- Prospective clinical study of 90 patients comparing all-inside ACL reconstruction with a semitendinosus tendon autograft and TightRope® implant on both the femur and tibia (GraftLink® technique) (45) to the “conventional technique” of semitendinosus/gracilis autograft with a TightRope implant on the femur and an interference screw on the tibia (45). Two-year outcomes were compared using knee scores, knee stability testing, and isokinetic testing.
- Results showed similar knee scores and stability but a significant difference in flexor muscle strength with the all-inside (GraftLink technique) group at two-years post-op.
- All-inside ACLR is a viable technique that also “provides an advantage over ACL reconstruction with an ST/G graft in terms of improved knee flexion strength at higher angular velocities.”

Monaco E,  
Fabbri M,  
Redler A,  
et al

[Anterior cruciate ligament reconstruction is associated with greater tibial tunnel widening when using a bioabsorbable screw compared to an all-inside technique with suspensory fixation \[published online November 7, 2018\].](#) *Knee Surg Sports Traumatol Arthrosc.* 2019;27(8):2577-2584. doi:10.1007/s00167-018-5275-x

- This comparative study evaluated clinical outcomes and tunnel widening for 44 patients following ACLR performed with an all-inside technique (Group A) or a bioabsorbable tibial screw and suspensory femoral fixation (Group B).
- There were no significant differences in clinical outcome measures or femoral tunnel widening between the all-inside (Group A) or button and screw constructs (Group B). However, there was a significantly larger increase in tibial tunnel widening, at both the middle and articular portions, in Group B.
- These findings suggest that button and screw constructs (Group B) result in significantly greater tibial tunnel widening when compared to all-inside constructs (Group A). This is clinically relevant to rebut concerns arising from biomechanical studies regarding the possibility of increased tunnel widening with an all-inside technique.



Yasen SK,  
Borton ZM,  
Eyre-Brook AI,  
et al

[Clinical outcomes of anatomic, all-inside, anterior cruciate ligament \(ACL\) reconstruction.](#) *Knee.* 2017;24(1):55-62. doi:10.1016/j.knee.2016.09.007

- Two-year outcomes of 108 patients treated with ACL reconstruction using the GraftLink® technique (FlipCutter® reamer, ACL TightRope® implant, and quadrupled semitendinosus autograft).
- The GraftLink technique demonstrated good medium-term subjective and objective outcomes with a low complication and failure rate.

Lopes R,  
Klouche S,  
Odri G,  
Grimaud O,  
Lanternier H,  
Hardy P

[Does retrograde tibial tunnel drilling decrease subchondral bone lesions during ACL reconstruction? A prospective trial comparing retrograde to antegrade technique.](#) *Knee.* 2016;23(1):111-115. doi:10.1016/j.knee.2015.09.010

- Retrograde drilling (FlipCutter reamer) of the tibia resulted in less bone edema, and subsequent pain, than the antegrade drilling with standard cannulated reamers.

Schurz M,  
Tiefenboeck TM,  
Winnisch M,  
et al

[Clinical and functional outcome of all-inside anterior cruciate ligament reconstruction at a minimum of 2 years' follow-up.](#) *Arthroscopy.* 2016;32(2):332-337. doi:10.1016/j.arthro.2015.08.014

- All-inside ACLR using the GraftLink technique leads to improved functional outcomes in active patients at a minimum follow-up of two years.
- No difference was noted in stability between the ACL-reconstructed and contralateral normal knee at two years.

Lubowitz JH,  
Schwartzberg R,  
Smith P

[Cortical suspensory button versus aperture interference screw fixation for knee anterior cruciate ligament soft-tissue allograft: a prospective, randomized controlled trial.](#) *Arthroscopy.* 2015;31(9):1733-1739. doi:10.1016/j.arthro.2015.03.006

- Radiographs did not show significant tunnel widening of suspensory fixation versus interference screw fixation.
- "Our results show no significant differences in knee AP stability or other outcomes comparing all-inside ACL allograft reconstruction using aperture fixation and all-inside ACL allograft reconstruction using suspensory fixation."

Benea H,  
d'Astorg H,  
Klouche S,  
Bauer T,  
Tomoaia G,  
Hardy P

[Pain evaluation after all-inside anterior cruciate ligament reconstruction and short term functional results of a prospective randomized study.](#) *Knee.* 2014;21(1):102-106. doi:10.1016/j.knee.2013.09.006

- The results show that postoperative pain, knee stability, range of motion, and transplant positioning were slightly better using the all-inside technique.
- The all-inside technique, which is a promising option for minimally invasive ACLR, can be considered a "reliable procedure with very good results for pain, stability, and knee function."

Blackman AJ,  
Stuart MJ

[All-inside anterior cruciate ligament reconstruction.](#) *J Knee Surg.* 2014;27(5):347-352. doi:10.1055/s-0034-1381960

- "Reports suggest similar results in the early postoperative period when compared with traditional techniques."
- "Current all-inside techniques offer the advantages of improved cosmesis, less postoperative pain, decreased bone removal, and gracilis preservation."



Lubowitz JH,  
Schwartzberg R,  
Smith P,  
et al

[Randomized controlled trial comparing all-inside anterior cruciate ligament reconstruction technique with anterior cruciate ligament reconstruction with a full tibial tunnel.](#) *Arthroscopy*. 2013;29(7):1195-1200. doi:10.1016/j.arthro.2013.04.009

- All-inside ACLR resulted in less postoperative pain and similar clinical outcomes compared with a full-tunnel technique.

## Biomechanical Strength

Vertello CJ,  
Piepenbrink M,  
Smith PA,  
Wilson AJ,  
Wijdicks CA

[Biomechanical testing of three alternative quadrupled tendon graft constructs with adjustable loop suspensory fixation for anterior cruciate ligament reconstruction compared with four-strand grafts fixed with screws and femoral fixed loop devices.](#) *Am J Sports Med*. 2019;47(4):828-836. doi.org/10.1177/0363546518825256

- A biomechanical study comparing three all-inside GraftLink® technique configurations with a technique using a femoral fixed-loop suspensory device and tibial screw (button and screw technique).
- The three GraftLink constructs exhibited small yet statistically significant biomechanical differences among each other. “Constructs that used tibial screw fixation had lower ultimate failure load and higher total elongation compared with the quadrupled tendon constructs.”
- Using adjustable, retensionable suspensory fixation devices on both the femur and tibia offers improved biomechanical performance compared to a femoral fixed-loop device and tibial screw.

Noonan BC,  
Bachmaier S,  
Wijdicks CA,  
Bedi A

[Intraoperative preconditioning of fixed and adjustable loop suspensory anterior cruciate ligament reconstruction with tibial screw fixation – an in vitro biomechanical evaluation using a porcine model.](#) *Arthroscopy*. 2018;34(9):2668-2674. doi:10.1016/j.arthro.2018.04.014

- Biomechanical evaluation of three ACLR techniques—adjustable-loop device (ALD) without intraoperative preconditioning (group 1), ALD with intraoperative preconditioning (group 2), and continuous-loop device (group 3)—using suspensory femoral fixation and interference screw tibial fixation.
- Surgical placement of an interference screw imparted a time-zero laxity of 0.53 mm and loss of tension (62%).
- The operating characteristics of the TightRope® implant allow for restoration of screw-induced graft slackening and optimizing tension. This was not possible with a fixed-loop device (Endobutton). Total elongation varied across groups, with group 2 (preconditioned ALD) showing the least elongation (group 1: 2.22 ± 0.52, group 2: 0.65 ± 0.29, and group 3: 1.79 ± 0.28).
- “ACLR with femoral TightRope fixation and intraoperative preconditioning allows for the restoration of time-zero screw-imparted slack and leads to significantly reduced cyclic elongation in accordance with native ACL function.”



Smith PA,  
Piepenbrink M,  
Smith SK,  
Bachmaier S,  
Bedi A,  
Wijdicks CA

[Adjustable- versus fixed-loop devices for femoral fixation in ACL reconstruction: an in vitro full-construct biomechanical study of surgical technique-based tibial fixation and graft preparation.](#) *Orthop J Sports Med.* 2018;6(4):2325967118768743. doi:10.1177/2325967118768743

- This was the first study to test biomechanical strength of the entire graft construct with an expanded cycling protocol.
- “The largest pull-to-failure force was observed for the TR, which was statistically significantly different than all other devices.”
- The ACL TightRope® implant is the only device that was effectively retensioned. Elongation with the ACL TightRope implant construct was comparable to fixed-loop devices.
- GraftMax™ button (ConMed) exceeded maximum elongation limits for ACL reconstruction.
- Ultrabutton™ (Smith & Nephew) adjustable fixation device lost the greatest amount of force during cycling.

Smith PA,  
DeBerardino TM

[Tibial fixation properties of a continuous-loop ACL hamstring graft construct with suspensory fixation in porcine bone.](#) *J Knee Surg.* 2015;28(6):506-512. doi:10.1055/s-0034-1394167

- All-inside GraftLink® continuous-loop soft-tissue graft with TightRope fixation provided adequate strength for tibial fixation in ACLR. The GraftLink construct had a significantly higher load to failure compared to interference screws with comparable cyclic loading.

Johnson JS,  
Smith SD,  
LaPrade CM,  
Turnbull TL,  
LaPrade RF,  
Wijdicks CA

[A biomechanical comparison of femoral cortical suspension devices for soft tissue anterior cruciate ligament reconstruction under high loads.](#) *Am J Sports Med.* 2015;43(1):154-160. doi:10.1177/0363546514553779

- A TightRope implant with retensioning increases the ultimate strength (1020 N), reduces the cyclic displacement to  $1.81 \pm 0.51$  mm, and is placed in the sub-2 mm category with fixed-loop devices.

## Graft Incorporation and Histology

Smith PA,  
Stannard JP,  
Pfeiffer FM,  
Kuroki K,  
Bozynski CC,  
Cook JL

[Suspensory versus interference screw fixation for arthroscopic anterior cruciate ligament reconstruction in a translational large-animal model.](#) *Arthroscopy.* 2016;32(6):1086-1097. doi:10.1016/j.arthro.2015.11.026

- Histologic assessments showed significantly better graft incorporation with the GraftLink ACL technique compared with grafts using interference screw fixation in tunnels.
- All GraftLink constructs were intact at 12 weeks; one interference screw construct failed and led to knee laxity.
- The GraftLink technique “was associated with superior tendon-to-bone healing compared with interference screw fixation in tunnels.”



Nuelle CW,  
Cook JL,  
Gallizzi MA,  
Smith PA

Gobbi A,  
Domzalski M,  
Pascual J,  
Zanazzo M

Tashiro T,  
Kurosawa H,  
Kawakami A,  
Hikita A,  
Fukui N

## Benefits of Single-Hamstring Harvest

Posterior single-incision semitendinosus harvest for a quadrupled anterior cruciate ligament graft construct: determination of graft length and diameter based on patient sex, height, weight, and body mass index. *Arthroscopy*. 2015;31(4):684-690. doi:10.1016/j.arthro.2014.10.013

- Harvesting the semitendinosus from a single posterior incision allowed for a quadrupled graft of desired length and diameter (8 mm or greater) in 95% of cases.

Hamstring anterior cruciate ligament reconstruction: is it necessary to sacrifice the gracilis? *Arthroscopy*. 2005;21(3):275-280. doi:10.1016/j.arthro.2004.10.016

- Harvest of a single-hamstring graft led to improved internal and external rotational torque postoperatively compared to harvest of two hamstring tendons.

Influence of medial hamstring tendon harvest on knee flexor strength after anterior cruciate ligament reconstruction. A detailed evaluation with comparison of single- and double-tendon harvest. *Am J Sports Med*. 2003;31(4):522-529. doi:10.1177/03635465030310040801

- “Tendon harvest causes significant weakness of hamstring muscle strength at high knee flexion angles, but such weakness can be minimized if the gracilis tendon is preserved.”