The InternalBrace procedure, which has been proven to be efficacious, can be applied in various ways throughout the knee. This augmentation helps prevent excess range of motion during the healing phase and may reduce the chances of secondary injury. In the setting of ACL reconstruction, the InternalBrace procedure helps protect against various modes of failure including creep and irreversible stretch, traumatic tearing, and slippage of the tendon-bone interface. The InternalBrace technique may also help protect small and vulnerable hamstring ACL reconstruction grafts from these modes of failure. Use the InternalBrace procedure to augment collateral ligament repairs and reconstructions and provide improved biomechanics, including greater stiffness and maximum load. Anatomic repair with augmentation may allow for early treatment using native tissues, while still providing a biomechanical environment conducive to early rehabilitation and motion. Compared to reconstruction techniques, there are several additional benefits of augmenting collateral ligament repairs including smaller drill holes and implants, no harvest-site morbidity with allograft, and no risk of tunnel convergence in multiligament procedures.

In Vivo Citations: Clinical Outcomes


- The purpose of this study is to evaluate clinical outcomes and patient-reported outcomes of patients who underwent primary ACL repair using suture tape augmentation.
- In this Level IV prospective case series, patients with an average age of 32.2 ± 7.2 years and a proximal tear of the ACL who underwent primary ACL repair with a minimum 2-year follow-up were included.
- Primary surgical repair of proximal ACL tears using suture tape augmentation results in a low rate of revision surgery, which 2 of 29 (6.9%) patients required.


- This comparison included 36 ACL repair patients and 71 ACL reconstruction patients.
- Patients who underwent ACL repair experienced less short-term postoperative pain and were prescribed fewer narcotics compared to patients who underwent ACL reconstruction.
- The mean visual pain score was significantly lower for ACL repair patients compared to ACL reconstruction patients.

- This study compared the effect of high-strength suture tape reinforcement (using the Internal Brace™ procedure) on dynamic elongation, stiffness behavior, and ultimate failure load in comparison to standard ACL reconstruction with small-diameter soft-tissue grafts.

- Tripled small-diameter and standard quadrupled tendon grafts were tested with and without suture tape reinforcement using an adjustable-loop device (ALD) for femoral fixation and an interference screw for tibial fixation.

- Tripled constructs showed a significantly worse performance than quadrupled constructs at higher loads. Reinforcement with suture tape significantly reduced total elongation in both the tripled and quadrupled groups. Failure loads were also significantly improved in the suture-augmented groups.

- The authors concluded that suture tape reinforcement for ACL reconstruction may provide an option for protecting autografts and allografts against irreversible lengthening during the maturation and remodeling phases of healing.


- Authors compared outcomes between anterior cruciate ligament reconstruction (ACLR) using hamstring grafts with and without suture augmentation (SA).

- “Patients who underwent ACLR with hamstring autografts or allografts with a minimum 2-year follow-up were reviewed.”

- “Postoperative average daily (0.60 ± 1.25 vs 1.66 ± 1.90) and maximum daily pain (1.57 ± 1.83 vs 3.35 ± 2.28) were significantly lower for the SA group (P < .014). SA was significantly correlated with improved time to return to preinjury activity level (9.17 ± 2.06 vs 12.88 ± 3.94 months; P = .002) and percentage of preinjury activity level (93.33% ± 13.22% vs 83.17% ± 17.69%; P = .010). There was a trend toward improved rate of return to preinjury activity level for SA.”

- Compared to standard hamstring ACLRs, the authors found suture-augmented hamstring ACLRs to be associated with improved PROMs, less pain, and a higher percentage of and earlier return to preinjury activity level without evidence of overconstraint.


- Forty-two patients with an acute ACL rupture and subsequent repair with independent suture tape reinforcement were followed for a minimum 2-year period.

- Patients with midsubstance, distal ruptures, poor tissue quality, retracted remnants, or multiligament injuries were excluded.

- Significant improvements in KOOS, VAS-pain, and VR-12 physical scores and a significant decrease of the Marx activity scale in comparison to pre-op scores were demonstrated. Two of the 42 patients (4.8%) reported a rerupture.

- This study confirms that ACL repair with this technique is a viable treatment option for patients with acute, nonretracted proximal ACL ruptures of good tissue quality.

■ This study evaluated the effects of an internal brace on the biomechanical properties of ACL reconstruction in a full-construct experimental model.

■ “Three groups (n=10 each) were tested in a full-construct porcine-bone model with human bone-patellar tendon-bone allografts using different reconstruction techniques: interference screw fixation on femur and tibia (S-S group), adjustable-loop device (ALD) fixation on the femur with tibial interference screw without suture tape (ALD-S group), and with internal brace (ALD-S-IB group).”

■ “The ALD-S-IB group (2.9±0.8 mm) displaced significantly less than the ALD-S (4.2±0.9 mm; p=0.015) and S-S group (4.3±1.1 mm; p=0.017). No significant difference was found between the ALD-S and the S-S group. Construct stiffness was significantly higher for the ALD-S-IB group (156±23 N/mm) and the ALD-S group (122±28 N/mm) than for the S-S group (104±40 N/mm; p=0.003 and p=0.0042), but there was no significant difference between both ALD groups.”

■ The authors concluded that these results indicate that internal bracing used with BTB grafts in ACL reconstruction improve construct biomechanics, which has clinical implications regarding initial construct stability.


■ Authors aimed to assess outcomes and complications of ACL repair using the *InternalBrace™* procedure at a minimum follow-up of 1 year.

■ Sixty-eight consecutive patients who underwent ACL repair using the *InternalBrace* procedure were followed for a minimum 1-year follow-up. KOOS and WOMAC scores were collected at set time points using an online outcomes system.

■ Improvement was observed in all KOOS and WOMAC domains, with the greatest improvement occurring in the first 3 months.

■ This study demonstrates that the ACL repair using the *InternalBrace* procedure is comparable with early ACL reconstruction results. There were 4 reinterventions, including one for rerupture.
In Vitro Citations: Biomechanical Validation


- In this study, the authors used human BPTB grafts (10 mm × 20 mm bone plugs on both sides) to reconstruct the ACL in juvenile porcine knees. Both groups used 8 mm-diameter biocomposite interference screws for fixation in the femur and tibia.

- The augmentation group differed from the control in that a FiberTape® suture for the InternalBrace™ technique was fixed independent of the graft using a TightRope® button on the femur and a SwiveLock® anchor on the tibia prior to fixation of the graft.

- Suture tape augmentation resulted in statistically significant improvements of time-zero biomechanical properties in terms of increased stiffness (104% increase) and ultimate failure load (57% increase) while not negatively affecting cyclic elongation, which may reduce the graft failure rate in a clinical setting.


- This study compared the biomechanical effects of MCL repair with suture tape using the InternalBrace procedure to standalone MCL suture repair in the setting of a concomitant ACL reconstruction using a six-degrees-of-freedom robotic system.

- The authors found that MCL repair with suture tape augmentation improved valgus and external rotation laxity when compared to standalone MCL repair.

- The suture tape augmentation construct did not lead to overconstraint of the joint.

- The authors note that these findings suggest that including MCL repair with suture tape augmentation in a combined ACL-reconstruction-MCL-repair procedure may result in lower failure rates and less residual laxity, shorter immobilization times, and faster return to play.


- This study compared dynamic elongation, stiffness, and ultimate load of standard and small grafts with and without suture tape reinforcement (using the InternalBrace procedure).

- Suture reinforcement of a small-diameter graft significantly reduced dynamic elongation (38%). A 15% decrease in dynamic elongation was also observed in a standard-diameter graft. The ultimate load of the small and standard grafts improved by 64% and 40% when compared to their respective controls.

- The authors concluded that independent suture tape reinforcement (using the InternalBrace procedure) of soft-tissue grafts for ACLR leads to significantly reduced elongation and higher ultimate load. The suture tape reinforcement technique may decrease the risk of graft tears, particularly when a small graft is used.

- The authors evaluated posteromedial anatomic repair with internal bracing and compared it with the intact state, repair alone, and allograft reconstruction.
- Three groups of 9 cadaveric, fresh-frozen matched pairs (54 knees) were tested to failure at 30° under valgus load in a biomechanical testing apparatus.
- The authors concluded that posteromedial knee repair with internal bracing is superior to repair alone and similar to allograft reconstruction for all parameters measured. They also eliminated the concern of overconstraint of the medial knee in the internal brace group.

**In Vivo Citations: Translational Research**


- Eighteen rabbits underwent bilateral ACL reconstruction with autograft, FiberTape® suture, or FiberTape suture-augmented autograft.
- At eight weeks, both FiberTape suture alone and FiberTape suture-augmented autograft demonstrated improved ultimate load to failure, elongation, and energy absorption when compared with autograft. FiberTape suture samples also demonstrated increased bone mineral density in the bone tunnel.
- The authors concluded that FiberTape suture increases the biomechanical performance of intra-articular ligament reconstructions in a verified rabbit model at eight weeks. Additionally, FiberTape suture did not demonstrate any deleterious effects, such as adversely affecting bone tunnel healing or invoking a prolonged elevation in inflammation.


- The authors sought to assess the intra-articular use of a nonabsorbable braided suture tape for its biocompatibility when implanted next to the native ACL in a canine model.
- No severe inflammatory or immune responses, bony erosions, or premature OA development were noted during the 6-month study period, even in a “worst-case” scenario model.
- Results of this study support the biocompatibility and safety of intra-articular suture tape for augmentation of ACLR or repairs.
- “The hypothesis was accepted as study results support the biocompatibility of suture tape in the canine knee.”

The study objective was to describe and validate a translational canine model for all-inside ACL reconstruction (ACLR) using a quadriceps tendon allograft with internal brace (QTIB).

Results suggest that a QTIB construct used in ACLR can provide sustained knee stability and function without the development of premature OA in a valid preclinical model.

The authors concluded that the configuration of the QTIB prevented early failure, allowed for direct, four-zone graft-to-bone healing, and functional graft remodeling while avoiding problems noted with use of all-synthetic grafts.

Systematic Review/Meta-Analysis


This systematic review and meta-analysis was the first to examine ACL primary repair using the InternalBrace™ technique exclusive of other techniques and included 9 studies consisting of 346 patients with a mean age of 32.5 years and a mean minimum 2-year follow-up.

The authors concluded that ACL repair using the InternalBrace technique is a safe technique for treatment of proximal ruptures, which have the most potential for healing, with a failure rate of 10.4% at a mean follow-up of 2.7 years.

Meta-analysis of PROMs—including KOOS, Lysholm, and IKDC—revealed mean scores greater than 87% of max for all and mean side-to-side difference in AP laxity of 1.2 mm.


This systematic review summarized 22 technical, animal, biomechanical, and clinical studies focused on ACRs augmented with suture tape to assess the pertinent literature currently available and “determine what evidence exists to support and oppose the technique in clinical practice.”

Cited advantages of suture-tape-augmented grafts include evidence of gradually increasing load-sharing characteristics, 12.2% to 73.0% greater load to failure, and 17.0% to 60.2% reduced elongation.

No significant difference in complications, rates of ligamentization, histological findings, or evidence of stress shielding was found.

PROMS in clinical studies include improved or equivalent outcomes in IKDC scores and return to sport.


An electronic database search was conducted, identifying 89 publications describing preclinical and clinical studies on outcomes of ACL repair.

Proximal ACL tears demonstrated better healing potential than distal or mid-substance tears in the setting of primary repair. Internal bracing increased the success rate of ACL repair.

“ACL repair may be a viable option in young patients with acute, proximal tears. The use of internal bracing, biological augmentation, and scaffold tissue may increase the success rate of repair.”


References


