Editorial Commentary: The Anterior Cruciate Ligament May Be Safer Wearing a Suture Tape Augmentation Seat Belt: Click It or Ticket

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Abstract: Bone-patellar tendon-bone autograft for anterior cruciate ligament (ACL) reconstruction has the most data to support its use. However, there may still be room for improvement, and younger age, insufficient rehabilitation, altered neuromuscular patterns, and precocious return to play can increase risk of graft failure. High strength suture augmentation of soft-tissue repair or reconstruction has gained traction in a variety of applications for the knee, including medial collateral and posteromedial corner, lateral collateral ligament, posterior cruciate ligament, and ACL. For ACL reconstruction, the technique consists of using either suture or suture tape fixed at the femoral and tibial ACL footprints to allow for independent tensioning to back up the separately tensioned ACL reconstruction. The static augment serves as a load-sharing device, allowing the graft to see more strain during earlier levels of graft strain, until graft elongation occurs to a critical level whereby the augment will experience more strain than the graft. Hence, the "seat belt" analogy. This is distinct from static augmentation, where the high strength suture is fixed to the graft. Static augmentation (without tensioning separately from the graft) results in a load-sharing device and increased stiffness, but potential stress shielding compared with the "seat belt." If suture tape augmentation improves patient outcome, it is a worthwhile to "click it."

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For many sports surgeons, bone—patellar tendon—bone (BTB) autograft is the gold standard for anterior cruciate ligament (ACL) reconstruction. This is for good reason. It is the most used graft for ACL reconstruction in elite and collegiate athletes and has the most data to support its use.[1] However, there may still be room for improvement. Studies have reported graft failure rates as high as 29%, and this is likely due to a variety of factors.[2-4] We know that younger age at the time of reconstruction, insufficient rehabilitation, altered neuromuscular patterns, and precocious return to play can play a role in failure. But what can the surgeon do technically to prevent this? Sure, a multitude of studies have looked at transtibial versus independent tunnel drilling, tunnel position, graft choice, and graft size, and I am not here to beat a dead horse on these topics.

Today I would like to talk about seat belts (or check reins if you prefer). I read with great interest "Suture Tape Augmentation Improves the Biomechanical Performance of Bone—Patellar Tendon—Bone Grafts Used for Anterior Cruciate Ligament Reconstruction" by Matava, Koscso, Melara, and Bogunovic.[5] The authors should be commended for their efforts in designing and carrying out this study, as no previous study has evaluated the biomechanical performance of suture tape augmentation of BTB ACL reconstructions. The InternalBrace (Arthrex, Naples, FL) concept has gained traction in a variety of applications for the knee, including medial collateral and posteromedial corner reconstruction and repair,[6-9] lateral collateral ligament repair,[10] posterior cruciate ligament avulsion repair[11] and ACL repair,[12-15] and reconstruction.[16,17] For ACL reconstruction, the technique consists of using either suture or suture tape fixed at the femoral and tibial ACL footprints to allow for independent tensioning to back up the separately tensioned ACL reconstruction. The static augment serves as a load-sharing device, allowing

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the graft to see more strain during earlier levels of graft strain, until graft elongation occurs to a critical level whereby the augment will experience more strain than the graft. Hence, the "seat belt" analogy.

Matava et al. compared 16 juvenile porcine knees reconstructed with and without suture tape augmentation (8 in each group) of human cadaveric BTB grafts, and the authors found no difference in graft displacement during load-at-failure tensile testing. Interestingly however, the augmented group demonstrated a 104% increase in postcyclic graft stiffness and a 57% increase in load at failure compared with the nonaugmented BTB grafts. My first question regarding the study was the use of juvenile porcine knees. The authors cite 2 studies reporting similarities between porcine and young adult human knees, which was news to me.[18,19] Their first citation reported on interspecies differences in bone composition, density, and quality, whereas their second study reported similar tendon biomechanical qualities between porcine flexor and extensor tendons as compared with human semitendinosus grafts. Regarding the first citation, this establishes that porcine bone is similar to human bone with respect to bone mineral density and fracture stress values and not through biomechanical testing of the ACL. Notably, the second citation is largely irrelevant to the study at hand, since the authors employed human BTB grafts for their reconstructions. Ideally this study would have been performed with human cadaveric knees, but I do not believe this is a disqualifying feature of the study, rather something to notice.

Although improved postcyclic graft stiffness and load at failure are promising results in this biomechanical study as a proof-of-concept, we are still left with more questions than answers. Does this time-zero improvement justify the increased time and cost associated with the procedure? Are there specific indications for when to add this "seat belt" to your graft? As pointed out by the authors, only one study has compared the clinical outcomes of augmented and nonaugmented BTB ACL reconstructions, and these authors found no difference with respect to return to play or Knee Injury and Osteoarthritis Outcome Score.[20] However, there is a significant difference in how Peterson et al. performed their augmentation. Most notably, the augmented group fixed their device to the graft, rather than through an independent tensioning mechanism, as described in the present study by Matava et al. Likely, this direct graft fixation leads to an increase in graft stiffness, but also stress shielding, and thus, no "seat belt." In addition, their device was resorbable polycaprolactone-based poly(urethane urea), rather than the nonabsorbable ultra-high molecular weight polyethylene/polyester suture tapes used in the present study, with the former degrading by hydrolysis over time. Therefore, the study by Peterson et al. is definitely a comparison of apples and oranges, and additional comparative clinical studies examining independent suture tape augmentation of BTB ACL reconstructions are warranted.

Other studies have compared clinical outcomes of independent suture tape augmentation of hamstring ACL reconstructions. To my knowledge, my coauthors and I published the first comparative study evaluating the use of suture tape augmentation for hamstring ACL reconstructions in this journal.[16] A total of 60 patients were matched 1:1 by age, sex, body mass index, graft type (autograft vs allograft), and revision status, and we found at a mean 30-month follow-up that ACL reconstructions performed with augmentation had improved patient-reported outcomes and time to return to preinjury activity level and percentage of preinjury activity level without a difference in graft failures or revision rates. One criticism of the study was the fairly large difference in return to preinjury activity level (9.2 vs 12.9 months), and I would like to address by discussing how we defined return to play. The vast majority of orthopaedic sports medicine literature has evaluated return to play as when an athlete simply returns to play. We did not, and I encourage others to follow suit so that we can be granular about how our athletes recover from injuries and surgery. Many athletes are able to return to play, but a significant portion are unable to return to play at their preinjury level of performance.[21] This may explain some differences between our study and a later study by Parkes et al. that performed a 1:2 matched-cohort comparison between patients undergoing hamstring autograft ACL reconstruction with and without independent suture tape augmentation.[17] The authors found similar return to sports rates, International Knee Documentation Committee, and Lysholm scores but greater Tegner activity scores (7.1 vs 6.4) and a lower proportion of graft failures (1 of 36 vs 4 of 72) in the augmented group. Clearly, more work is required in the realm of suture tape augmentation for both soft-tissue and BTB ACL reconstruction.

As rising health care costs become more impactful every day for the sports surgeon, implant cost, the cost of added time to procedures, and the intrinsic value of any variation of a procedure should be considered. Independent suture tape augmentation may add slightly to the cost of ACL reconstruction, thereby impacting both overhead and a patient's medical bill. However, this should not be the only consideration, and a patient's outcome with respect to their patient-reported outcome and ability to return to play at their preinjury level should be paramount. Although we may never have a clear answer as to whether independent suture tape augmentation for ACL reconstruction is superior to the standard nonaugmented procedure, I believe future work will make this muddy water clearer, and Matava et al certainly have laid the groundwork and feasibility of this for BTB ACL reconstruction.

References

1. Erickson BJ, Harris JD, Fillingham YA, et al. Anterior cruciate ligament reconstruction practice patterns by NFL and NCAA football team physicians. *Arthroscopy* 2014;30: 731-738.
2. Kaeding CC, Pedroza AD, Reinke EK, Huston LJ, Spindler KP. Risk factors and predictors of subsequent ACL injury in either knee after ACL reconstruction: Prospective analysis of 2488 primary ACL reconstructions from the MOON Cohort. *Am J Sports Med* 2015;43: 1583-1590.
3. Leys T, Salmon L, Waller A, Linklater J, Pinczewski L. Clinical results and risk factors for reinjury 15 years after anterior cruciate ligament reconstruction: A prospective study of hamstring and patellar tendon grafts. *Am J Sports Med* 2012;40:595-605.
4. Webster KE, Feller JA. Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:2827-2832.
5. Matava MJ, Koscso J, Melara L, Bogunovic L. Suture tape augmentation improves the biomechanical performance of bone−patellar tendon−bone grafts used for anterior cruciate ligament reconstruction. *Arthroscopy* 2021;37: 3335-3343.
6. Gilmer BB, Crall T, DeLong J, Kubo T, Mackay G, Jani SS. Biomechanical analysis of internal bracing for treatment of medial knee injuries. *Orthopedics* 2016;39:e532-e537.
7. Whelan D, Leiter J, Sasyniuk T, et al. Double-row repair of the distal attachment of the superficial medial collateral ligament: A basic science pilot study. *Knee Surg Sports Traumatol Arthrosc* 2015;23:2820-2824.
8. Lubowitz JH, MacKay G, Gilmer B. Knee medial collateral ligament and posteromedial corner anatomic repair with internal bracing. *Arthrosc Tech* 2014;3:e505-e508.
9. Curley AJ, Davis WA, Argintar EH. A novel medial collateral ligament reconstruction technique using internally braced semitendinosus autograft. *Orthopedics* 2018;41:e738-e740.
10. Vermeijden HD, van der List JP, DiFelice GS. Primary repair of the lateral collateral ligament using additional suture augmentation. *Arthrosc Tech* 2020;9:e1073-e1077.
11. Yoon J-R, Park C-D, Lee D-H. Arthroscopic suture bridge fixation technique with multiple crossover ties for posterior cruciate ligament tibial avulsion fracture. *Knee Surg Sports Traumatol Arthrosc* 2018;26:912-918.
12. Burton DA, Schaefer EJ, Shu HT, Bodendorfer BM, Argintar EH. Primary anterior cruciate ligament repair using suture tape augmentation: A case series of 29 patients with minimum 2-year follow-up. *Arthroscopy* 2021;37:1235-1241.
13. Heusdens CHW, Hopper GP, Dossche L, Roelant E, Mackay GM. Anterior cruciate ligament repair with independent suture tape reinforcement: A case series with 2-year follow-up. *Knee Surg Sports Traumatol Arthrosc* 2019;27:60-67.
14. Douoguih WA, Zade RT, Bodendorfer BM, Siddiqui Y, Lincoln AE. Anterior cruciate ligament repair with suture augmentation for proximal avulsion injuries. *Sports Med Arthrosc Rehabil Ther Technol* 2020;2:e475-e480.
15. Jonkergouw A, van der List JP, DiFelice GS. Arthroscopic primary repair of proximal anterior cruciate ligament tears: Outcomes of the first 56 consecutive patients and the role of additional internal bracing. *Knee Surg Sports Traumatol Arthrosc* 2019;27:21-28.
16. Bodendorfer BM, Michaelson EM, Shu HT, et al. Suture augmented versus standard anterior cruciate ligament reconstruction: A matched comparative analysis. *Arthroscopy* 2019;35:2114-2122.
17. 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;37:609-616.
18. Aerssens J, Boonen S, Lowet G, Dequeker J. Interspecies differences in bone composition, density, and quality: Potential implications for in vivo bone research*. *Endocrinology* 1998;139:663-670.
19. Domnick C, Wieskötter B, Raschke MJ, et al. Evaluation of biomechanical properties: Are porcine flexor tendons and bovine extensor tendons eligible surrogates for human tendons in in vitro studies? *Archf Orthop Trauma Surg* 2016;136:1465-1471.
20. Peterson L, Eklund U, Engström B, Forssblad M, Saartok T, Valentin A. Long-term results of a randomized study on anterior cruciate ligament reconstruction with or without a synthetic degradable augmentation device to support the autograft. *Knee Surg Sports Traumatol Arthrosc* 2014;22:2109-2120.
21. Mohtadi NG, Chan DS. Return to sport-specific performance after primary anterior cruciate ligament reconstruction: A systematic review. *Am J Sports Med* 2018;46: 3307-3316.