Editorial Commentary: Anterolateral Ligament—Anatomy, Evaluation, and Future Applications to Knee Stability

Kevin G. Shea, M.D., Volker Musahl, M.D., and Tyler J. Stavinoha, M.D.

Abstract: Magnetic resonance imaging evaluation of anterolateral ligament injury may be reliable for individuals experienced and trained to identify it, but it does not reference a diagnostic gold standard. The structural anatomy and radiographic diagnosis may differ from those of more traditional ligaments, which should influence concepts of reconstruction.

See related article on page 2136

We read with great interest the study conducted by Helito, Helito, Assirati, Longo, Bordalo-Rodrigues, and Souza[1] entitled "Magnetic Resonance Imaging Evaluation of the Anterolateral Ligament in Acute Anterior Cruciate Ligament Injuries in an Adolescent Population." This report evaluated the frequency of anterolateral ligament (ALL) injury in adolescents who sustained anterior cruciate ligament (ACL) injury, a group notable for a rerupture rate as high as 28%[2,3] after isolated ACL reconstruction. The study's secondary analysis characterized the associated conditions, such as damage to the collateral ligaments, iliotibial band, and menisci, that may mark more severe injuries that similarly could theoretically benefit from surgical reconstruction beyond an isolated cruciate reconstruction.

However, a significant limitation of the study by Helito et al.[1] is encountered with the initial premise—namely, that one can rely on magnetic resonance imaging (MRI) evaluation of the ALL to evaluate injured knees. Helito et al. cited a recent systematic review by Puzzitiello et al.[4] to support the assertion that MRI is a valid modality by which to assess the ALL. The referenced study provided a rigorous evaluation of 13 studies available at the time. However, the study falls short of serving as a foundation for accepting MRI evaluation of ALL injury as a reference standard. Most included studies performed nonspecific, binomial identification, with only 2 studies attempting to specify injury location. In addition, although the reported reliability itself was high, the authors themselves admitted poor standardization of diagnostic criteria and provided no evidence to determine the sensitivity and specificity of the imaging modality. A concluding recommendation was made that imaging be evaluated by "individuals experienced in identifying healthy ALLs." Although Helito et al. certainly fit that criterion,[5,6] the broader conclusions and implications of their study must be evaluated with care.

We do applaud several points of the current study.[1] Clear criteria to identify ALL injury are defined, including precise injury location. The inclusion criterion of acute injury within 3 weeks has been shown to increase the sensitivity of MRI evaluation,[7] along with the older age group of adolescent patients reviewed.[4] Intraobserver and interobserver correlations were high for both the visibility of the ALL and the characterization of its injury, when present. Ultimately, however, the analysis relied on the evaluation of a single radiologist, and appropriate conclusions must be approached in a broader context of the literature. The authors described MRI as having shown high accuracy

Stanford University School of Medicine (K.G.S., T.J.S.) and University of Pittsburgh (V.M.).

The authors report the following potential conflicts of interest or sources of funding: V.M. receives support for consultation from Smith & Nephew. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

0749-8063/19432/$36.00
https://doi.org/10.1016/j.arthro.2019.04.007

in identifying ALL injury. Yet, the data do not define the accuracy but rather the precision. We might be hitting the outer rim of the target consistently but missing the center every time.

To the frustration—and perhaps also the fascination—of the community that has contributed to the literature in recent history, the nature and clinical relevance of the ALL remain elusive. Just as cadaveric dissections have differed on the presence[8-11] or absence[12-15] of the ALL, as well as its anatomic variation and parameters,[14-16] so too have biomechanical studies questioned the understanding of this area.[17,18] Studies have shown the ALL is absent in up to 88% of pediatric cadavers,[12] and when present, the femoral origin point has significant variability regarding the physeal scar and the lateral collateral ligament.[13] The function and biomechanical parameters of a modest "capsular thickening" are quite distinct from a substantial anatomic structure such as the medial collateral ligament, lateral collateral ligament, or ACL. Although MRI may be the gold standard by which we characterize ligament damage, evidence suggests that the anterolateral capsule may behave less like a traditional ligament but rather a sheet-like structure akin to the inferior glenohumeral ligament.[19,20]

Before expounding beyond the reproducibility of a radiographic diagnosis, we must remember that the clinical findings of identified anterolateral tissue injury have varied. In a study published in February 2019 and, as such, not addressed in the current study, Miyaji et al.[21] reported a poor correlation between MRI identification of anterolateral capsule injury and its effect on clinically evident rotatory knee laxity. Other studies have similarly questioned the accuracy of MRI interpretation[22,23] and the association with pivot-shift instability,[24] even in experienced hands. We believe this is evidence that a broader applicability of the current study's process and conclusions remains to be supported.

This is not to suggest that reconstruction of the ALL is inappropriate. ALL reconstruction, like lateral extra-articular tenodesis, is nonanatomic by definition. Similarly to the Latarjet procedure for shoulder instability—which creates significant shoulder anatomy alteration to address an important clinical problem—surgeons may consider supplementary ALL reconstructions that do not closely duplicate the dimensional and biomechanical features of the native knee structures. The extra-articular lateral capsular—iliotibial band ligament reconstruction period of the 1970s and 1980s may be considered in this process to avoid making the mistakes of previous generations. Regardless, surgeons should carefully consider the anatomy and biomechanical parameters of the ALL as they contemplate any knee stabilization procedures.

In the end, we applaud and congratulate Helito et al.[1] for their work, and we look forward to future studies with similarly defined diagnostic criteria. In addition, although the debate will not be settled with a single anatomic, imaging, or surgical study, we look forward to continued collective discovery, careful reflection on the accuracy of our data, and the results of well-designed, multicenter, prospective cohort and randomized controlled studies. Ongoing studies, such as the upcoming STAbiLiTY (Standard ACL Reconstruction vs ACL + Lateral Extra-Articular Tenodesis Study) trial,[25] will improve our understanding of the ALL and the anterolateral complex of the knee. Increasing use of prospective data collection, with the use of general and condition-specific patient-reported outcome measures, may be the final chapter to this developing novel.

References

1. Helito CP, Helito PVP, Assirati LFB, Longo CH, Bordalo-Rodrigues M, Souza FF. Magnetic resonance imaging evaluation of the anterolateral ligament in acute anterior cruciate ligament injuries in an adolescent population. *Arthroscopy* 2019;35:2136-2142.
2. Webster KE, Feller JA, Leigh WB, Richmond AK. Younger patients are at increased risk for graft rupture and contralateral injury after anterior cruciate ligament reconstruction. *Am J Sports Med* 2014;42:641-647.
3. Astur DC, Cachoeira CM, da Silva Vieira T, Debieux P, Kaleka CC, Cohen M. Increased incidence of anterior cruciate ligament revision surgery in paediatric verses adult population. *Knee Surg Sports Traumatol Arthrosc* 2018;26:1362-1366.
4. Puzzitiello RN, Agarwalla A, Zuke WA, Garcia GH, Forsythe B. Imaging diagnosis of injury to the anterolateral ligament in patients with anterior cruciate ligaments: Association of anterolateral ligament injury with other types of knee pathology and grade of pivot-shift examination: A systematic review. *Arthroscopy* 2018;34:2728-2738.
5. Helito CP, Helito PV, Leão RV, Louza IC, Bordalo-Rodrigues M, Cerri GG. Magnetic resonance imaging assessment of the normal knee anterolateral ligament in children and adolescents. *Skeletal Radiol* 2018;47:1263-1268.
6. Helito CP, Helito PV, Costa HP, et al. MRI evaluation of the anterolateral ligament of the knee: Assessment in routine 1.5-T scans. *Skeletal Radiol* 2014;43:1421-1427.
7. Kosy JD, Soni A, Venkatesh R, Mandalia VI. The anterolateral ligament of the knee: Unwrapping the enigma. Anatomical study and comparison to previous reports. *J Orthop Traumatol* 2016;17:303-308.
8. Vincent JP, Magnussen RA, Gezmez F, et al. The anterolateral ligament of the human knee: An anatomic and histologic study. *Knee Surg Sports Traumatol Arthrosc* 2012;20:147-152.
9. Claes S, Luyckx T, Vereecke E, Bellemans J. The Segond fracture: A bony injury of the anterolateral ligament of the knee. *Arthroscopy* 2014;30:1475-1482.

10. Helito CP, Demange MK, Bonadio MB, et al. Anatomy and histology of the knee anterolateral ligament. *Orthop J Sports Med* 2013;1:2325967113513546.
11. Helito CP, do Prado Torres JA, Bonadio MB, et al. Anterolateral ligament of the fetal knee: An anatomic and histological study. *Am J Sports Med* 2017;45:91-96.
12. Shea KG, Polousky JD, Jacobs JC Jr, Yen YM, Ganley TJ. The anterolateral ligament of the knee: An inconsistent finding in pediatric cadaveric specimens. *J Pediatr Orthop* 2016;36:e51-e54.
13. Shea KG, Milewski MD, Cannamela PC, et al. Anterolateral ligament of the knee shows variable anatomy in pediatric specimens. *Clin Orthop Relat Res* 2017;475:1583-1591.
14. de Lima DA, Helito CP, de Lima LL, de Castro Silva D, Cavalcante ML, Leite JA. Anatomy of the anterolateral ligament of the knee: A systematic review. *Arthroscopy* 2019;35:670-681.
15. Watanabe J, Suzuki D, Mizoguchi S, Yoshida S, Fujimiya M. The anterolateral ligament in a Japanese population: Study on prevalence and morphology. *J Orthop Sci* 2016;21:647-651.
16. Sabzevari S, Rahnemai-Azar AA, Albers M, Linde M, Smolinski P, Fu FH. Anatomic and histological investigation of the anterolateral capsular complex in the fetal knee. *Am J Sports Med* 2017;45:1383-1387.
17. Bell KM, Rahnemai-Azar AA, Irarrazaval S, et al. In situ force in the anterior cruciate ligament, the lateral collateral ligament, and the anterolateral capsule complex during a simulated pivot shift test. *J Orthop Res* 2018;36:847-853.
18. Al Saiegh Y, Suero EM, Guenther D, et al. Sectioning the anterolateral ligament did not increase tibiofemoral translation or rotation in an ACL-deficient cadaveric model. *Knee Surg Sports Traumatol Arthrosc* 2017;25:1086-1092.
19. Guenther D, Rahnemai-Azar AA, Bell KM, et al. The anterolateral capsule of the knee behaves like a sheet of fibrous tissue. *Am J Sports Med* 2017;45:849-855.
20. Guenther D, Sexton SL, Bell KM, et al. Non-uniform strain distribution in anterolateral capsule of knee: Implications for surgical repair [published online March 11, 2019]. *J Orthop Res*. https://doi.org/10.1002/jor.24270.
21. Miyaji N, Hoshino Y, Tanaka T, et al. MRI-determined anterolateral capsule injury did not affect the pivot-shift in anterior cruciate ligament-injured knees [published online February 4, 2019]. *Knee Surg Sports Traumatol Arthrosc*. https://doi.org/10.1007/s00167-019-05376-8.
22. Marshall T, Oak SR, Subhas N, Polster J, Winalski C, Spindler KP. Can the anterolateral ligament be reliably identified in anterior cruciate ligament–intact and anterior cruciate ligament–injured knees on 3-T magnetic resonance imaging? *Orthop J Sports Med* 2018;6:2325967118796452.
23. Devitt BM, O'Sullivan R, Feller JA, et al. MRI is not reliable in diagnosing of concomitant anterolateral ligament and anterior cruciate ligament injuries of the knee. *Knee Surg Sports Traumatol Arthrosc* 2017;25:1345-1351.
24. Lee DW, Lee JH, Kim JN, Moon SG, Kim NR, Kim JG. Evaluation of anterolateral ligament injuries and concomitant lesions on magnetic resonance imaging after acute anterior cruciate ligament rupture. *Arthroscopy* 2018;34:2398-2406.
25. Standard ACL Reconstruction vs ACL + Lateral Extra-Articular Tenodesis Study (STAbiLiTY). ClinicalTrials.gov identifier NCT02018354. https://clinicaltrials.gov/ct2/show/study/NCT02018354?id=NCT02018354&rank=1. Accessed March 18, 2019.