

Editorial Commentary: The Segond Fracture Has Multiple Attachments: Yet Another Demonstration of the Anatomical Complexity of the Anterolateral Complex of the Knee



Freddie H. Fu, M.D., D.Sc. (Hon.), D.Ps. (Hon.), and Benjamin B. Rothrauff, M.D., Ph.D.

Abstract: The anterolateral complex (ALC) of the knee comprises multiple layers, with continued debate on the identity and function of the structures of the ALC. The Segond fracture, long considered pathognomonic of an anterior cruciate ligament injury, has now been shown to have several attachments to soft tissues of the ALC. To the extent that a Segond fracture, or injury to the ALC more broadly, increases knee rotatory instability in vivo is a question of ongoing investigation. By extension, it remains uncertain whether an untreated Segond fracture adversely affects outcomes and therefore warrants consideration for operative intervention. Prospective randomized studies of anatomic anterior cruciate ligament reconstruction with or without concomitant treatment of Segond fractures are needed to more definitively answer these questions.

See related article on page 1679

We congratulate authors Partezani Helito, Bartholomeeusen, Claes, Bordalo Rodrigues, and Partezani Helito on their publication, “Magnetic Resonance Imaging Evaluation of the Anterolateral Ligament and Iliotibial Band in Acute Anterior Cruciate Ligament Injuries Associated With Segond Fractures,” in which a review of the magnetic resonance imaging (MRI) scans of 48 patients with a combined anterior cruciate ligament (ACL) and Segond injury found the bony fragment attached to the anterolateral ligament (ALL) in all cases (100%) and to the iliotibial band (ITB) in 25 cases (52.1%).¹ These findings were similar to an earlier study by Flores et al.² in which MRIs of 146 knees with concomitant ACL tear and Segond fracture showed the bony fragment attached to the meniscotibial component of the mid-third lateral capsular ligament (synonymous with ALL) in 86 cases (58.9%), the posterior

fibers of the ITB in 8 cases (5.5%), and both the meniscotibial component of the mid-third lateral capsular ligament and posterior fibers of the ITB in 52 cases (35.6%). Our study of 36 patients with combined ACL tear and Segond fracture found 34 of 36 cases (94.4%) in which the bony fragment was attached to both the anterolateral capsule and ITB.³ Despite the variation across studies in the frequency in which the Segond fragment was found attached to the ITB and/or ALL, also called the capsule-osseous layer of the ITB, these studies consistently demonstrated multiple soft-tissue attachments. The present study¹ therefore supports the assertion of the International Anterolateral Complex (ALC) Consensus Group: “A number of structures attach to the area of the Segond fracture, including the capsule-osseous layer of the ITB, the ALL, and the anterior arm of the short head of biceps, and hence it is not clear which is responsible for this lesion.”⁴

As this study found the ALL attached to the bony fragment in all cases, it is suggested that it plays the most consistent role in this avulsion lesion. Interestingly, combined attachment of the ITB was associated with larger fragment sizes. As clinical examination of rotatory knee stability was not performed, it is unknown whether a larger fragment size (i.e., combined

University of Pittsburgh

The authors report the following potential conflict of interest or source of funding: F.H.F. reports educational support and hospitality payments from Smith & Nephew, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

© 2020 by the Arthroscopy Association of North America
0749-8063/20342/\$36.00

<https://doi.org/10.1016/j.arthro.2020.03.003>

ALL and ITB attachment) correlated with increased knee laxity. Melugin et al.,⁵ in a cohort study comparing outcomes following ACL reconstruction in patients with combined ACL tear and Segond fracture versus ACL tear alone, found that the combined injury was associated with significantly more preoperative instability, as measured by Lachman and pivot-shift testing. However, Ferretti et al.,⁶ in developing a classification of ACL injuries based on macroscopic appearance, did not conclusively demonstrate a greater pivot-shift grade for Segond fractures (type IV) as compared with ALL injuries without bony avulsion (types I-III). Similarly, in a study investigating the value of MRI findings in predicting preoperative knee laxity in patients with ACL tears, a Segond fracture was not found to be a significant predictor of high-grade Lachman or pivot-shift grades.⁷ A limitation in the study was the small incidence of Segond fractures. In a larger cohort study comparing 34 patients with a combined ACL tear and Segond fracture versus 349 patients with an ACL tear alone, the groups did not differ on measures of preoperative knee stability (i.e., Lachman, anterior drawer, pivot-shift, Telos stress radiographs).⁸

While identifying soft-tissue attachments of the Segond fracture and the relationship of this pathology with knee laxity is of obvious interest in understanding knee biomechanics, arguably the more important question is whether the Segond fracture affects clinical outcomes, and, by extension, whether additional treatment is necessary. In a cross-sectional study of 552 patients undergoing primary ACL reconstruction and 47 patients undergoing revision ACL reconstruction, a Segond fracture was present in 6% of the former group and none of the latter.⁹ No additional operative procedure was performed for patients with concomitant Segond fracture, yet none had subsequent graft failure.⁹ In the aforementioned cohort study by Melugin et al.,⁵ patients with a combined ACL tear and Segond fracture had equivalent pivot-shift grades, graft failure rates, and activity levels following anatomic ACL reconstruction (without Segond fracture treatment) as compared with patients with ACL tear alone. Yoon et al.⁸ and Slagstad et al.¹⁰ reported similar findings. Taken together, these studies have suggested that additional treatment of a Segond fracture is not necessary.

That said, it has been appropriately argued that cohort studies may be inherently limited by confounding differences between groups, compromising the strength of conclusions.¹¹⁻¹³ To more definitively determine whether treatment of the Segond fracture is clinically beneficial requires a prospective randomized study in which all enrolled patients have a combined ACL injury and Segond fracture. To date, this study has not been performed. It has also been argued that the Segond fracture is relatively rare, with damage to the soft

tissues of the anterolateral complex seen far more frequently than bony avulsion. Even in this study of patients with diagnosed Segond fractures, concurrent discontinuity or edema of the ALL was seen in 31 of 48 cases (64.6%).¹ In addition, the Segond fracture has classically been diagnosed on radiographs, which are less sensitive than MRI and ultrasound.¹¹⁻¹³ These are valid critiques. However, it must also be recognized that additional structures beyond the ALC are also frequently damaged in ACL injuries, structures of known importance for knee stability. For instance, this study found concomitant injury in the lateral collateral ligament (56.3%), medial collateral ligament (75.0%), lateral meniscus (35.4%), and medial meniscus (45.8%).¹ A related study by Lee et al.¹⁴ found evidence on MRI of ALL injury in over 64% of ACL ruptures, with ALL injury significantly associated with the presence of a lateral meniscus tear and lateral bone contusions. Increased laxity attributed to ALC injury may therefore also be due to other concomitant injuries (e.g., lateral meniscus tear). Clearly, the ALL and the associated Segond fracture are not the whole story to understanding and treating rotatory knee instability.¹⁵

As with all of medicine, treatment of any constellation of injuries must be tailored to each unique patient. In our practice of individualized, anatomic ACL reconstruction, appropriate graft choice and sizing is performed to best match the specific anatomy of the patient, while considering concomitant pathology (e.g., avoiding autografts with tendinopathic changes).¹⁶ Given the importance of the menisci in preserving joint integrity and providing secondary restraint to the ACL, meniscal tears are repaired whenever possible. If rotatory knee instability persists intraoperatively, which may be anticipated by comprehensive preoperative planning including clinical examination and imaging (i.e., radiographs, MRI, ultrasound), lateral extra-articular tenodesis (LET) may be considered. It is our experience that LET is seldom needed, even in patients with pronounced preoperative laxity and/or Segond fracture. Without specific treatment, we frequently observe healing of Segond fractures. That said, we do not discount a role for lateral augmentation. As Getgood et al.¹⁷ recently reported, combined anatomic ACL reconstruction with hamstring autograft and LET may reduce failure in high-risk young patients at 2-year follow-up. Awaiting findings on additional outcomes and long-term results, including rates of osteoarthritis, our institution has joined Getgood and colleagues to expand this trial to include quadriceps tendon and bone-patellar tendon-bone autografts.

In summary, the authors are to be congratulated on their study showing multiple soft-tissue attachments to the bony fragment of the Segond fracture, further clarifying the complex anatomy of the anterolateral complex. These findings are in agreement with the ALC

Consensus Statement. Whether combined ALL and ITB attachment, associated with larger fragment size, indicates injury severity and worse knee stability is indeed a question worthy of future research efforts. Likewise, indications for treating Segond fractures, and ALC injuries more broadly, remain to be more clearly defined.⁴

References

- Partezani Helito PV, Bartholomeeusen S, Claes S, Bordalo Rodrigues M, Partezani Helito C. Magnetic resonance imaging evaluation of the anterolateral ligament and the iliotibial band in acute anterior cruciate ligament injuries associated with Segond fractures. *Arthroscopy* 2020;36:1679-1686.
- Flores DV, Smitaman E, Huang BK, Resnick DL. Segond fracture: An MR evaluation of 146 patients with emphasis on the avulsed bone fragment and what attaches to it. *Skeletal Radiol* 2016;45:1635-1647.
- Shaikh H, Herbst E, Rahnemai-Azar AA, et al. The Segond fracture is an avulsion of the anterolateral complex. *Am J Sports Med* 2017;45:2247-2252.
- Getgood A, Brown C, Lording T, et al. The anterolateral complex of the knee: Results from the International ALC Consensus Group Meeting. *Knee Surg Sports Traumatol Arthrosc* 2019;27:166-176.
- Melugin HP, Johnson NR, Wu IT, Levy BA, Stuart MJ, Krych AJ. Is treatment of Segond fracture necessary with combined anterior cruciate ligament reconstruction? *Am J Sports Med* 2018;46:832-838.
- Ferretti A, Monaco E, Fabbri M, Maestri B, De Carli A. Prevalence and classification of injuries of anterolateral complex in acute anterior cruciate ligament tears. *Arthroscopy* 2017;33:147-154.
- Chang MJ, Chang CB, Choi JY, Je MS, Kim TK. Can magnetic resonance imaging findings predict the degree of knee joint laxity in patients undergoing anterior cruciate ligament reconstruction? *BMC Musculoskelet Disord* 2014;15:214.
- Yoon KH, Kim JS, Park SY, Park SE. The influence of Segond fracture on outcomes after anterior cruciate ligament reconstruction. *Arthroscopy* 2018;34:1900-1906.
- Gaunders CL, Bastrom T, Pennock AT. Segond fractures are not a risk factor for anterior cruciate ligament reconstruction failure. *Am J Sports Med* 2017;45:3210-3215.
- Slagstad I, Parkar AP, Strand T, Inderhaug E. Incidence and prognostic significance of the Segond fracture in patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2020;48:1063-1068.
- Cavaignac E, Saithna A, Monaco E, et al. Is treatment of Segond fracture necessary with combined anterior cruciate ligament reconstruction? Letter to the editor. *Am J Sports Med* 2018;46:NP13-NP14.
- Pan Z, Dong Q, Xu Y, Zhou H, Xu W, Mao Y. Is treatment of Segond fracture necessary with combined anterior cruciate ligament reconstruction? Letter to the editor. *Am J Sports Med* 2018;46: NP17-NP17.
- Saithna A, Cavaignac E, Monaco E, et al. Segond fractures are not a risk factor for anterior cruciate ligament reconstruction failure: Letter to the editor. *Am J Sports Med* 2018;46:NP23-NP24.
- Lee DW, Lee JH, Kim JN, et al. Evaluation of anterolateral ligament injuries and concomitant lesions on magnetic resonance imaging after acute anterior cruciate ligament rupture. *Arthroscopy* 2018;34:2398-2406.
- Sheehan AJ, Shin J, Patel NK, Lian J, Guenther D, Musahl V. The anterolateral ligament is not the whole story: Reconsidering the form and function of the anterolateral knee and its contributions to rotatory knee instability. *Tech Orthop* 2018;33:219-224.
- Hussein M, Van Eck CF, Cretnik A, Dinevski D, Fu FH. Individualized anterior cruciate ligament surgery: A prospective study comparing anatomic single- and double-bundle reconstruction. *Am J Sports Med* 2012;40:1781-1788.
- Getgood AMJ, Bryant DM, Litchfield R, et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-Year outcomes from the STABILITY study randomized clinical trial. *Am J Sports Med* 2020;48:285-297.