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The Modifications of the Anterior Cruciate Ligament Rupture Physical Therapy Caused by the Anterolateral Ligament Injury

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Abstract

The anterolateral ligament (ALL) is a rotational stabilizer of the knee joint widely investigated the last 13 years as the possible cause of some anterior cruciate ligament (ACL) reconstructions failure. ALL injuries accompany 64% of ACL ruptures. Nevertheless, there are still no publications concerning changes in the ACL rehabilitation process due to the ALL concomitant rupture. We evaluated rotational stability in 12 athletes with the ACL rupture and concomitant ALL injury or Segond fracture treated conservatively before the treatment and 3 months later. The physical therapy comprised the range of motions and strengthening exercises during the immobilization period and thereafter. As only the knee joint was immobilized the physical therapy was conducted to the adjacent joints and muscles at the very beginning. A total of 83.33% of patients became pivot-shift negative in three months. In 16.67% pivot-shift test was questionable. Lachman test remained positive in 91.67%. The ACL is a more important structure than the ALL. So, our treatment strategy focuses mainly on it. Most changes in physical therapy are the immobilization and postponed axial loading with internal rotation. But even these minor changes may influence greatly the overall stability of the knee, particularly rotational stability. It seems to be the single case series assessing the rotational stability recovery after the ALL rupture conservative treatment we found in the scientific literature. Immobilization and non-weightbearing for up to 6 weeks may decrease the rotational instability in conservatively treated ALL injuries concomitant to the ACL ruptures. Further investigations of the physical therapy and rehabilitation of the anterolateral ligament injuries and Segond fractures are necessary.

Keywords: *anterolateral ligament, anterior cruciate ligament, rehabilitation*

Introduction

The anterolateral ligament (ALL) is the rotational stabilizer of the knee joint. It was first described by Segond in 1879 (Claes et al., 2013) and almost forgotten for a century. The ALL gained its popularity back again in 2007 due to the work of Vieira, da Silva, Berlfein, Abdalla and Cohen (2007). Perceptions of its function have changed over time and continue to do so today. ALL is an extremely important structure as its injuries accompany 64% of anterior cruciate ligament (ACL) ruptures (Lee et al., 2018). Nevertheless, there are still no publications concerning changes in the ACL rehabilitation process due to the ALL concomitant rupture.

Now, most of the anterolateral ligament ruptures are viewed through the lens of the ACL concomitant injuries.

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So, their rehabilitation and physical therapy should conform to the ACL injuries rehabilitation principles. And that is why we`ll focus firstly on the ACL concomitant anterolateral ligament ruptures and Segond fractures.

The aim of the study was to assess the necessity and the results of the changes in the rehabilitation process of the anterior cruciate ligament ruptures induced by the concomitant anterolateral ligament injuries or Segond fractures.

Methods

We evaluated rotational stability in 12 athletes with the ACL rupture and concomitant ALL injury (10 patients) and Segond fracture (2 patients) treated conservatively in a non-randomized prospective interventional study. The patients with the ALL injury and Segond fracture were analyzed together in a single group as the same entity because Segond fracture is considered to be the osseous avulsion of the ALL with the similar causes, symptoms and pathomechanics.

Inclusion criteria were: acute injury (up to one week), conclusive and complete rupture of the ACL and the ALL (or Segond fracture) on MRI, conclusive positive Lachman and pivot-shift test, absence of other injuries of the knee (except the tibial collateral ligament ruptures, non-displaced lesions of the medial meniscus, chondral lesions).

Exclusion criteria were: knee locking, contractures, other major injuries to the knee, time from trauma more than one week, inconclusive disputable MRI or clinical signs of the ACL or ALL complete rupture, negative or disputable Lachman or pivot-shift test, the necessity of early surgical treatment of the ACL rupture.

Patients received conservative treatment of 6 weeks of non-weight bearing with crutches and immobilization with a brace in full knee extension for 4 weeks. These braces were changed to the hinged braces with the flexion limit to 30° from the end of the fourth week up to the end of the sixth week. Then the physical therapy program with muscle strengthening and range of motions began (Figure 1). Hinged braces were utilized in further rehabilitation process only in 4 patients with concomitant tibial collateral ligament injuries.

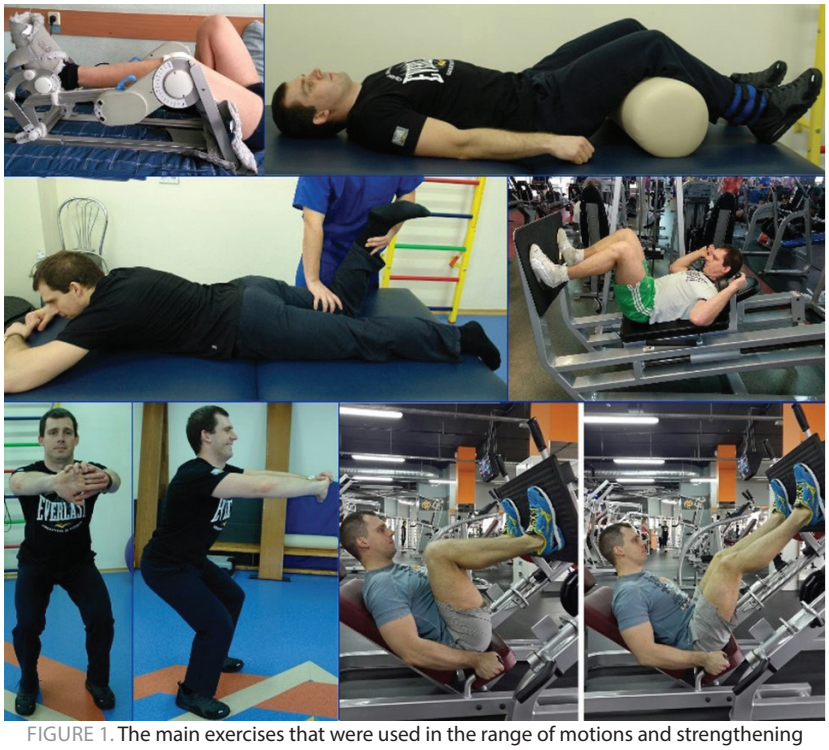

FIGURE 1. The main exercises that were used in the range of motions and strengthening program after the immobilization period and before the surgery

The physical therapy comprised the range of motions and strengthening exercises during the immobilization period and thereafter. As only the knee joint was immobilized the physical therapy was conducted to the adjacent joints and muscles at the very beginning. Range of motion program excluded internal rotation of the lower leg up to the end of the 8th week. Internal rotation with axial loading was excluded for up to 3 months. The muscle-strengthening program began after 8 weeks. There were no other restrictions in physical therapy. But the range of motions and strengthening were gradual.

Full passive extension of the knee including hyperextension as tolerated within the normal range of up to 10° began from the first day of treatment. The brace was unlocked for allowing passive hyperextension 2 times per day for 15-minute sessions of the knee locking exercises with a rolled towel or pillow under the heel and intermittent contracting the quadriceps muscle for 5 seconds to push the knee down and 5-10 seconds rest. After 6 weeks the knee locking exercises were discontinued.

Passive patella mobilization was initiated from the first day. At least three one-minute sets per day were recommended.

After four weeks of immobilization the knee flexion began with help of the knee bolster (2 hours per day) and continuous passive motion machine (CPM) (1 hour per day) with the flexion limit to 30° from the end of the fourth week up to the end of the sixth week. After 6 weeks from the beginning of the treatment full flexion was started with four 30 minute sessions of CPM per day. In a week passive flexion with rehabilitation therapist was added for two 20 minute sessions per day immediately after the CPM in cases when weekly ROM increment

was less than 20° per week.

Active ROM exercises were introduced after 4 weeks in the form of knee active flexion and extension as tolerated but not less than 20 minutes per day in a prone and upright position with the abovementioned ROM limitations of 30° flexion up to 6 weeks of treatment. After 6 weeks ROM limitations were discontinued.

Muscle-strengthening exercises included isometric quadriceps contractions (5 seconds contraction with 5 seconds rest) from the first days. Patients performed at least three such 10-minute sessions per day. The maximal duration of the contraction time, quantity, and duration of these sessions were not limited. Closed kinetic chain strengthening exercises started after 6 weeks of treatment. They included leg presses and squats. We began with the leg press with the weight that allowed 20 repetitions per set for the first two weeks (2 sets per day). Then patients proceeded to the weight that allowed 15 repetitions per set and squats were added. After 8 weeks from the beginning of the treatment we decreased the frequency of leg presses and squats to 3 times a week but increased the intensity. One session consisted of two sets of squats (assisted firstly) followed by the three sets of the leg press with the weight that allowed 15 repetitions per set. The squat depth was as tolerated initially and increased gradually. Rest intervals between the sets were at least 2 minutes.

We evaluated rotational stability and anterior tibia translation with pivot-shift test, Lachman test, active and passive rotation angles measurements in 30°, 45°, 60°, 90° of flexion before the treatment and at the end of conservative treatment at three months.

All these patients were directed to the ACL reconstruction in three months after the near full range of motions was obtained.

This study research protocol was approved by institution's ethics committee (approval number №5, 12 December 2019). Each participant voluntarily provided written informed consent before participating. Since it is a small sample case study, only descriptive statistics were administered and analyzed.

Results

It is difficult to assess the quality of healing of the anterolateral ligament and adequacy of its functional recovery. One possible test is pivot-shift. But despite of its high specificity its sensitivity is rather low. We report only 12 patients that fulfilled our criteria because most patients with the ALL rupture have only inconclusive MRI signs or the signs of incomplete rupture. Many patients with definite ALL rupture MRI signs had other significant injuries leading to rotational instability or had a questionable pivot-shift test results. We did not include them in the investigation.

Ten of these 12 patients (83.33%) became pivot-shift negative in three months. In two patients (16.67%) pivot-shift test was questionable. Lachman test remained positive in eleven of these patients (91.67%). The one patient (8,33%) with a negative Lachman test nevertheless felt his knee given way. We didn`t notice the significant difference in the passive rotation angles in the injured and healthy contralateral knees in 30°, 45°, 60°, and 90° of flexion neither before nor after the conservative treatment. The maximal difference in the passive rotation in the injured and healthy contralateral knees was at 60° of flexion and amounted to 3.00°±1.82° before the treatment and 2.80°±2.24° after 3 months of treatment. The difference in the passive rotation at 30°, 45°, and 90° of flexion was even less. It totaled 2.63°±1.96° before the treatment and 2.60°±2.06° after 3 months of treatment at 30° of the knee flexion, 2.70°±1.66° and 2.70°±1.50° at 45°, 2.82°±1.02° and 2.00°±1.84° after 3 months of treatment at 90°. So, the pivot-shift test was the one and only possible way to access rotational instability. 83.33% of patients became pivot-shift negative in three months. So this may indicate the rotational stability improvement.

All the patients gained the full knee extension and flexion 121°±7° by the end of the 3rd month (after 6 weeks of immobilization and 6 weeks of rehabilitation). Muscle strength was estimated manually according to the Medical Research Council scale and equaled 5 grades in all the patients at the end of treatment. They were all ready for the ACL surgical reconstruction. Ten of them were already surgically treated. Two of them postponed surgery due to different non-medical reasons.

Of course, this is a small case series. But it seems to be the single case series assessing the rotational stability recovery after the anterolateral ligament rupture conservative treatment we found in the scientific literature.

Discussion

The ALL function is somewhat different from the ACL. The ALL is considered to be the lower leg internal rotation restraint. Its importance increases with the increase of the degree of the knee flexion being the most prominent with the knee flexion from 30° to 90° (Parsons, Gee, Spiekerman, & Cavanagh, 2015; Tavlo, Eljaja, Jensen, Siersma, & Krogsgaard, 2016). Sporadic publications endue the ALL with the function of anterior tibia translation restraint (Tavlo et al., 2016) similar to ACL. But most do not. According to the rotation, the ACL is the external and internal tibia rotation stabilizer at the same time (Dargel et al., 2007). But while flexing the knee beyond 35° its internal rotation restraining capabilities are inferior to the ALL (Parsons et al., 2015). So, we consider ACL to be mostly anterior translation and external rotation stabilizer in flexion.

This means that we should protect the injured ALL from knee flexion and internal rotation whether it reconstructed or not.

The anterolateral ligament is located close to the joint capsule. Several authors believe it to be the capsular thickening (Cho & Kwak, 2019; Helito et al., 2013; Kennedy et al., 2015). Our previous investigations and the publications of other researchers (Dodds, Halewood, Gupte, Williams, & Amis, 2014, Parker & Smith, 2018; Runer et al., 2015;) show that at least the outer layer of this ligament is completely extracapsular. Nevertheless, we observe intimate adherence of its inner layer to the joint capsule. The anterolateral ligament is not intraarticular as ACL. So, we may somewhat rely on its healing potential. Furthermore, its structure and location resemble more the tibial collateral ligament than the fibular one. It even more adds to our insight concerning the anterolateral ligament healing potential. Another reason for the possibility of its spontaneous healing in appropriate conditions is the fact that most of its ruptures are not transverse. According to the surgical revisions, 57% of all the ALL injuries are ruptures of its fibers and lateral capsule on different levels (Sonnery-Cottet et al., 2017). All these factors give us the opportunity to reach the anterolateral ligament ruptures healing with conservative treatment. But we are still not sure about the anterolateral ligament or Segond fracture healing potential with the preservation of

their function. The functional outcome may be different for these two entities. Also, we may assume that the ALL may heal with sufficient final rigidity only in cases of early treatment. The later we begin its treatment the more indications for its surgical reconstruction.

We know very little about the isolated anterolateral ligament injuries, though isolated Segond fractures occur (Ollat, 2009; Peltola, Mustonen, Lindahl, & Koskinen, 2011; Ringenberg, Sealy, & Tiller, 2015). But this ligament is the comparably newly described structure. So, we may expect more reports about its isolated injuries in the nearest future. And we should be ready to propose appropriate treatment and rehabilitation strategy. As we consider Segond fracture to be the avulsion fracture as the result of the anterolateral ligament overstretching the rehabilitation strategy may be similar for both of them.

It is generally accepted that the optimal time interval for the ACL reconstruction surgery is the day of injury or period of time usually later than 3-4 weeks after the injury after the inflammation and edema subside (Meuffels et al., 2012). So, if we see the patient without the joint locking in this suboptimal for the ACL surgery time window, we propose to begin with conservative treatment of all the concomitant injuries, even if this wouldn`t influence the ACL itself. The isolated ACL rupture requires immobilization and crutches for only a short period of time, usually in the acute period. The patient should withdraw from them as soon as movements and weightbearing are tolerated. Many patients do not require them at all from the very beginning. But in case of concomitant Segond fracture or anterolateral ligament rupture, we propose immobilization and non-weightbearing with crutches for 4-6 weeks. In cases, if incomplete ruptures of the anterolateral ligament the immobilization may be as short as 3-4 weeks with a subsequent range of motion exercises in the hinged brace. But non-weightbearing should continue up to 6 weeks. Even in cases of early range of motions exercises, we recommend excluding internal rotation in the knee joint for at least up to 6 weeks. But internal rotation with axial loading (while standing or squatting) should be excluded longer. We do not know exactly how long because of the absence of appropriate studies. Taking into account the thinness of the ligament we consider a little bit more time without internal rotation of the lower leg while axial loading as the scar tissue at the site of the ligament healing needs to mature to withstand loading forces. We should understand that laboratory testing of the ALL and the ACL tension in different degrees of the knee flexion and rotation should not be completely extrapolated to the real loading conditions, where axial loading, tibial slope angle et al. influence the anterior tibia translation and resulting tension forces in the ligaments. It was investigated that ALL is the main rotational stabilizer in deep squats while the ACL is the principal rotational stabilizer in not deep ones (Kang, 2019). So, we also may expect that squatting with slight external rotation of the feet may be less dangerous for the healing ALL or Segond fracture as well as squatting not deeper than 30° of knee flexion that may be utilized in the early rehabilitation period.

In the case of concomitant tibial collateral ligament rupture which is common in ACL injuries and well susceptible to healing with conservative treatment (Shea & Carey, 2015) immobilization seems to be even more advisable. We believe that it is wise to give the possibility for as many structures of the knee to heal by themselves as possible. Surgical treatment with early range of motion is another possible option. But surgical treatment usually includes reconstruction with the sacrifice of several tendons that are also of some importance. So, in most cases when achieving an early range of motion is not critically important immobilization for up to 4-6 weeks in full extension is an acceptable treatment strategy.

In cases of necessity of surgical ACL reconstruction before the complete healing of the anterolateral ligament rupture or Segond fracture their simultaneous reconstruction is also recommended in selected patients (Bonanzinga et al., 2017; Hardy, Casabianca, Hardy, Grimaud, & Meyer, 2017; Inderhaug, Stephen, Williams, & Amis, 2017; Nitri et al., 2016). Usually, the indications are ACL revision surgery, high-grade pivot shift test, young sportsmen, pivoting activities, and patients undergoing meniscus repair (Sonnery-Cottet, Vieira, & Ouanezar, 2019). But after such simultaneous reconstruction several authors also advise less aggressive rehabilitation with prolonged intermittent brace immobilization with a gradual range of motion exercises for 4 weeks postoperatively but immediate weight-bearing with brace and crutches as tolerated. The muscle-strengthening program they recommend to begin from 8 weeks postoperatively (Ferretti, 2017). Though the outcome depends on the reconstruction method and its strength as well as on the surgeon's philosophy as no comparative studies were ever conducted.

Further, the third group of patients – are those with their ACL reconstructed surgically on the 1st day from injury. Resulting from the study, we, as researchers recommend immobilizing the knee in case of concomitant anterolateral ligament rupture or Segond fracture. If their ALL or Segond fracture simultaneous repair was conducted the decision about the necessity of immobilization is made by the surgeon depending on the method and strength of reconstruction.

It is accepted today that not all the patients need the anterolateral corner rigid stabilization procedures. But even less rigid healing of the anterolateral ligament may improve knee stability and the results of ACL surgery.

If an early range of motions in the group of patients without already conducted ACL reconstruction is necessary, we consider flexion with simultaneous external rotation. This potentially may decrease tensioning of the healing anterolateral ligament but most of all doesn`t prevent it completely. But after the ACL reconstruction flexion with external rotation puts the ACL transplant into tension condition and should better be avoided.

Yes, most changes in physical therapy we can propose are the immobilization and postponed axial loading with internal rotation. In general, the physical therapy and rehabilitation principles in anterolateral ligament injuries are similar to those in ACL injuries. ACL is a more important structure. So, our treatment strategy focuses mainly on it. But even these minor changes may influence greatly the overall stability of the knee, particularly rotational stability, in some patients.

Conclusions

Immobilization and non-weightbearing for up to 6 weeks may decrease the rotational instability in conservatively treated anterolateral ligament injuries concomitant to the anterior cruciate ligament ruptures. Further investigations of the physical therapy and rehabilitation of the anterolateral ligament injuries and Segond fractures are necessary.

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Conflict of Interest
The authors declare that there are no conflicts of interest.

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References

Bonanzinga, T., Signorelli, C., Grassi, A., Lopomo, N., Jain, M., Mosca, M., Iacono, F., Marcacci, M., & Zaffagnini, S. (2017). Kinematics of ACL and anterolateral ligament. Part II: anterolateral and anterior cruciate ligament reconstruction. *Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA*, *25*(4), 1062–1067. https://doi.org/10.1007/s00167-017-4496-8

Cho, H. J., & Kwak, D. S. (2019). Anatomical Consideration of the Anterolateral Ligament of the Knee. *BioMed research international*, *2019,* ID 5740473. https://doi.org/10.1155/2019/5740473

Claes, S., Vereecke, E., Maes, M., Victor, J., Verdonk, P., & Bellemans, J. (2013). Anatomy of the anterolateral ligament of the knee. *Journal of anatomy*, *223*(4), 321–328. https://doi.org/10.1111/joa.12087

Dargel, J., Gotter, M., Mader, K., Pennig, D., Koebke, J., & Schmidt-Wiethoff, R. (2007). Biomechanics of the anterior cruciate ligament and implications for surgical reconstruction. *Strategies in trauma and limb reconstruction*, *2*(1), 1–12. https://doi.org/10.1007/s11751-007-0016-6

Dodds, A. L., Halewood, C., Gupte, C. M., Williams, A., & Amis, A. A. (2014). The anterolateral ligament: Anatomy, length changes and association with the Segond fracture. *The bone & joint journal*, *96-B*(3), 325–331. https://doi.org/10.1302/0301-620X.96B3.33033

Ferretti, A., Monaco, E., Wolf, M. R., Guzzini, M., Carli, A., & Mazza, D. (2017). Surgical Treatment of Segond Fractures in Acute Anterior Cruciate Ligament Reconstruction. *Orthopaedic journal of sports medicine*, *5*(10), 2325967117729997. https://doi.org/10.1177/2325967117729997

Hardy, A., Casabianca, L., Hardy, E., Grimaud, O., & Meyer, A. (2017). Combined reconstruction of the anterior cruciate ligament associated with anterolateral tenodesis effectively controls the acceleration of the tibia during the pivot shift. *Knee surgery, sports traumatology, arthroscopy: official journal of the ESSKA*, *25*(4), 1117–1124. https://doi.org/10.1007/s00167-017-4515-9

Helito, C. P., Demange, M. K., Bonadio, M. B., Tírico, L. E., Gobbi, R. G., Pécora, J. R., & Camanho, G. L. (2013). Anatomy and Histology of the Knee Anterolateral Ligament. *Orthopaedic journal of sports medicine*, *1*(7), 2325967113513546. https://doi.org/10.1177/2325967113513546

Inderhaug, E., Stephen, J. M., Williams, A., & Amis, A. A. (2017). Biomechanical Comparison of Anterolateral Procedures Combined with Anterior Cruciate Ligament Reconstruction. *The American journal of sports medicine*, *45*(2), 347–354. https://doi.org/10.1177/0363546516681555

Kang, K. T., Koh, Y. G., Park, K. M., Choi, C. H., Jung, M., Shin, J., & Kim, S. H. (2019). The anterolateral ligament is a secondary stabilizer in the knee joint: A validated computational model of the biomechanical effects of a deficient anterior cruciate ligament and anterolateral ligament on knee joint kinematics. *Bone & joint research*, *8*(11), 509–517. https://doi.org/10.1302/2046-3758.811.BJR-2019-0103.R1

Kennedy, M. I., Claes, S., Fuso, F. A., Williams, B. T., Goldsmith, M. T., Turnbull, T. L., Wijdicks, C. A., & LaPrade, R. F. (2015). The Anterolateral Ligament: An Anatomic, Radiographic, and Biomechanical Analysis. *The American journal of sports medicine*, *43*(7), 1606–1615. https://doi.org/10.1177/0363546515578253

Lee, D. W., Lee, J. H., Kim, J. N., Moon, S. G., Kim, N. R., Kim, D. H., & Kim, J. G. (2018). Evaluation of Anterolateral Ligament Injuries and Concomitant Lesions on Magnetic Resonance Imaging After Acute Anterior Cruciate Ligament Rupture. *Arthroscopy: the journal of arthroscopic & related surgery: official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, *34*(8), 2398–2406. https://doi.org/10.1016/j.arthro.2018.02.048

Meuffels, D. E., Poldervaart, M. T., Diercks, R. L., Fievez, A. W., Patt, T. W., Hart, C. P., Hammacher, E. R., Meer, F. v., Goedhart, E. A., Lenssen, A. F., Muller-Ploeger, S. B., Pols, M. A., & Saris, D. B. (2012). Guideline on anterior cruciate ligament injury. *Acta orthopaedica*, *83*(4), 379–386. https://doi.org/10.3109/17453674.2012.704563

Nitri, M., Rasmussen, M. T., Williams, B. T., Moulton, S. G., Cruz, R. S., Dornan, G. J., Goldsmith, M. T., & LaPrade, R. F. (2016). An In Vitro Robotic Assessment of the Anterolateral Ligament, Part 2: Anterolateral Ligament Reconstruction Combined with Anterior Cruciate Ligament Reconstruction. *The American journal of sports medicine*, *44*(3), 593–601. https://doi.org/10.1177/0363546515620183

Ollat, D., Marchaland, J.P., Mathieu, L. Barbier, O. & Versier, G. (2009). Is the Segond's fracture a reliable sign of anterior cruciate ligament (ACL) tear? A case report without associated ACL rupture. *European Journal of Orthopaedic Surgery & Traumatology, 19,* 203–206. https://doi.org/10.1007/s00590-008-0395-5

Parker, M., & Smith, H. F. (2018). Anatomical variation in the anterolateral ligament of the knee and a new dissection technique for embalmed cadaveric specimens. *Anatomical science international*, *93*(2), 177–187. https://doi.org/10.1007/s12565-016-0386-2

Parsons, E. M., Gee, A. O., Spiekerman, C., & Cavanagh, P. R. (2015). The biomechanical function of the anterolateral ligament of the knee. *The American journal of sports medicine*, *43*(3), 669–674. https://doi.org/10.1177/0363546514562751

Peltola, E. K., Mustonen, A. O., Lindahl, J., & Koskinen, S. K. (2011). Segond fracture combined with tibial plateau fracture. *American journal of roentgenology*, *197*(6), W1101–W1104. https://doi.org/10.2214/AJR.10.6095

Ringenberg, J., Sealy, D., & Tiller, R. (2015). Isolated Segond fracture in a pediatric patient. *The Physician and sportsmedicine*, *43*(2), 188–191. https://doi.org/10.1080/00913847.2015.1037229

Runer, A., Birkmaier, S., Pamminger, M., Reider, S., Herbst, E., Künzel, K. H., Brenner, E., & Fink, C. (2016). The anterolateral ligament of the knee: A dissection study. *The Knee*, *23*(1), 8–12. https://doi.org/10.1016/j.knee.2015.09.014

Shea, K. G., & Carey, J. L. (2015). Management of anterior cruciate ligament injuries: evidence-based guideline. *The Journal of the American Academy of Orthopaedic Surgeons*, *23*(5), e1–e5. https://doi.org/10.5435/JAAOS-D-15-00094

Sonnery-Cottet, B., Daggett, M., Fayard, J. M., Ferretti, A., Helito, C. P., Lind, M., Monaco, E., de Pádua, V., Thaunat, M., Wilson, A., Zaffagnini, S., Zijl, J., & Claes, S. (2017). Anterolateral Ligament Expert Group consensus paper on the management of internal rotation and instability of the anterior cruciate ligament - deficient knee. *Journal of orthopaedics and traumatology: official journal of the Italian Society of Orthopaedics and Traumatology*, *18*(2), 91–106. https://doi.org/10.1007/s10195-017-0449-8

Sonnery-Cottet, B., Vieira, T. D., & Ouanezar, H. (2019). Anterolateral Ligament of the Knee: Diagnosis, Indications, Technique, Outcomes. *Arthroscopy: the journal of arthroscopic & related surgery: official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, *35*(2), 302–303. https://doi.org/10.1016/j.arthro.2018.08.019

Tavlo, M., Eljaja, S., Jensen, J. T., Siersma, V. D., & Krogsgaard, M. R. (2016). The role of the anterolateral ligament in ACL insufficient and reconstructed knees on rotatory stability: A biomechanical study on human cadavers. *Scandinavian journal of medicine & science in sports*, *26*(8), 960–966. https://doi.org/10.1111/sms.12524

Vieira, E. L., Vieira, E. A., da Silva, R. T., Berlfein, P. A., Abdalla, R. J., & Cohen, M. (2007). An anatomic study of the iliotibial tract. *Arthroscopy: the journal of arthroscopic & related surgery: official publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, *23*(3), 269–274. https://doi.org/10.1016/j.arthro.2006.11.019.