

Patients With Anterior Cruciate Ligament Rupture and Ipsilateral Segond Fractures Have High Rates of Concurrent Knee Pathology

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Purpose: The purpose of this study was to determine the rates of concomitant knee pathology in patients with ACL injuries and Segond fractures. **Methods:** A retrospective study is undertaken with patients identified via query of CPT codes for ACL reconstruction from 2014 to 2020. All patients with preoperative radiographs were reviewed for the presence of Segond fractures. Operative reports were analyzed for the presence of concurrent pathology, including meniscus, cartilage, and other ligamentous injuries at the time of arthroscopic ACL reconstruction. **Results:** A total of 1,058 patients were included in the study. Segond fractures were identified in 50 (4.7%) patients. Ipsilateral concomitant knee pathology was identified in 84% of Segond patients. Thirty-eight (76%) patients had meniscal pathology with a total 49 meniscal injuries, of which 43 were treated operatively. Multiligamentous injuries were present in 16 patients (32%), with 8 patients undergoing further ligament repair/reconstruction at the time of surgery. Chondral injuries were identified in 13 patients (26%). **Conclusion:** A high prevalence of concomitant meniscal, chondral, and ligamentous injuries was found in patients with Segond fractures. These additional injuries may require further operative management and may place patients at increased risk for future instability or degenerative changes. Patients with Segond fractures should be counseled preoperatively on the nature of their injuries and risk of associated pathologies.

Introduction

Anterior cruciate ligament (ACL) injuries are one of the most common pathologies treated by orthopedic surgeons with ~200,000 primary ACL injuries occurring annually in the United States.¹ ACL injuries often occur when a valgus load is applied to a flexed knee with an externally rotated tibia, resulting in a pivot shift injury.² Given the complex nature of this pivot shift mechanism, the ACL is infrequently injured in isolation. Studies have demonstrated that concurrent meniscus injuries are found in 41-67% of primary ACL

reconstructions.^{3,4} In addition to ipsilateral meniscal pathology, chondral injuries are reported to occur in 16-46% of injuries and other ligamentous injuries in 8-33% of cases.^{3,5-7}

Although ACL tears are often not evident on radiography, the presence of an anterolateral complex (ALC) avulsion fracture is considered pathognomonic for an ACL injury.⁸ This radiographic finding, known as a Segond fracture, can be identified along the lateral aspect of the proximal tibia on an anteroposterior knee radiograph.⁸ The ALC has been demonstrated to play a role in resisting anterior tibial translation, as well as providing rotational support during the pivot shift mechanism in ACL injuries.⁹⁻¹¹ Given the role of the ALC in translational and rotational stability, the presence of a Segond fracture has been used as a surrogate for patients with a more severe pivot shift injury.¹²

Previous studies have found increased incidence of concomitant meniscal and chondral pathology with higher energy ACL injuries;^{13,14} however, these studies used bone bruising on magnetic resonance imaging (MRI) as a surrogate for energy imparted at the time of ACL injury. Specifically, they demonstrated that increased intensity of bone contusions on the lateral femoral condyle and lateral tibial plateau was associated

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with higher grade pivot shift, higher rates of meniscal injury, as well as ALC abnormalities.^{15,16} These findings suggest that more rotationally unstable injury patterns are associated with higher rates of concomitant pathology. A more recent study has demonstrated high rates of meniscal and chondral injuries in a pediatric population sustaining Segond fractures.¹⁷ Therefore, the purpose of this study was to determine the rates of concomitant knee pathology in patients with ACL injuries and Segond fractures. We hypothesize that patients with Segond fractures, a more rotationally unstable injury pattern, would also be at higher risk of concurrent knee pathology than those patients with ACL ruptures in the absence of a Segond fracture.

Materials and Methods

Institutional Review Board (IRB) approval was obtained from the University Hospitals IRB (IRB number: STUDY20210252) prior to the initiation of the study. Patients were identified by query of the billing database using current procedural terminology (CPT) code 29888 related to ACL reconstruction for all surgeries from October 2014 to January 2020. Preoperative plain radiographs were reviewed by two separate orthopedic residents for each patient and analyzed for the presence of a Segond fracture. A Segond fracture was documented for patients with an avulsion fracture on the anterolateral aspect of the proximal tibia that was visible on anteroposterior radiographs of the knee (Fig 1). Patients with a Segond fracture were included in our case series. Patients without preoperative radiographs of the knee available for review and those with history of prior ACL reconstruction were excluded from the study.

After the cohort was established, chart review via the electronic medical record (EMR) was performed to collect patient data, including age, body mass index, laterality of injury, smoking status, activity/sport at time of injury, chronicity of injury at time of surgery (considered chronic if surgery was greater than 6 weeks after initial injury and acute if less than 6 weeks), comorbidities, including diabetes mellitus and chronic kidney disease, type of graft used for reconstruction, and presence of MCL laxity on initial exam. The operative reports for each patient were then reviewed, and data were collected for presence of meniscal tears, ipsilateral ligamentous injuries, chondral injuries, and additional procedures performed at the time of ACL reconstruction. The grades of the chondral injuries were based on the Outerbridge classification, as documented in the operative report, with Outerbridge Grade I defined as chondral softening and swelling, grade II as partial-thickness chondral defect with fissures not exceeding 0.5 inches in diameter and not reaching subchondral bone, grade III as fissures greater than 0.5 inches in diameter or reaching subchondral bone, and grade IV as cartilage erosion exposing subchondral bone.¹⁸

Descriptive statistical analysis was performed to include mean and standard deviation for all continuous variables. Incidence was calculated for those patients sustaining chondral injuries, meniscal injuries, and ipsilateral ligamentous injuries. In addition, rates of chondral injury, meniscal injury and ligamentous injury were compared to rates described in prior literature using one-sample Student's *t*-tests. All data were stored electronically in a safe manner in accordance with the IRB system and analyzed using Statistical Package for Social Sciences (SPSS) (version 24; IBM SPSS).

Results

Query of the billing database revealed 1,058 patients available for review who also had preoperative radiographs. Fifty patients of these 1,058 patients (4.7%) had Segond fractures identified on their preoperative radiographs and were included for review in this case series. Twenty (40%) were female patients, and 30 (60%) were males. Laterality was equally split between right and left knees. The average patient age was 27 years (Table 1).

All 50 patients underwent ACL reconstruction, while no patients underwent ALL reconstruction. The grafts used for ACL reconstruction were as follows: 10 hamstrings autograft, 13 quadriceps autograft, 15 bone-patellar tendon-bone (BTB) autograft, and 12 allografts.



Fig 1. An anteroposterior (AP) radiograph of a right knee demonstrating an avulsion from the anterolateral proximal tibia consistent with a Segond fracture.

Table 1. Demographic and Injury Data of the 50 Patients Included in the Study

	Segond Patients (<i>n</i> = 50)
Age* (Years)	27 ± 13
Body mass index*	28.3 ± 8.0
Sex	Male: 30 (60%) Female: 20 (40%)
Laterality	L = 25 (50%) R = 25 (50%)
Contact injury	6 (12%)
Acute Injury	42 (84%)

n = number of patients.

*The values are presented as the mean and standard deviation.

At the time of arthroscopy, 84% of patients were identified to have concurrent pathology. In total, 38 (76%) patients had concurrent meniscal pathology. This was significantly higher than previous reports of 62% of patients sustaining meniscal injuries ($P = .26$), but no different from studies showing rates up to 73% ($P = .63$).^{22,23} The 38 patients with meniscal pathology included a total of 49 meniscal injuries. Nine had isolated medial meniscus tears, 18 had isolated lateral meniscus tears, and 11 had tears of both the medial and lateral menisci. Five of the medial meniscus tears (25%) and 2 of the lateral meniscus tears (7%) were bucket handle tears. Lateral meniscal root tears were present in 10% of all patients. Forty-three of these meniscus tears required operative intervention, and 6 were treated non-operatively. Of those treated surgically, partial meniscectomy was performed in 25 cases (58%), while meniscal repair was performed in 18 cases (42%). On the basis of location, 25 lateral meniscal tears were treated operatively, 14 by meniscectomy and 11 by repair, while 4 lateral meniscal tears were managed nonoperatively. Eighteen medial meniscus tears underwent operative intervention. Eleven tears were treated with meniscectomy, and 7 tears underwent repair. Two medial meniscus tears were managed nonoperatively.

There were 16 patients (32%) who had concomitant injury to an additional knee ligament. This was a significantly higher rate from prior studies showing an 8% rate of multiligamentous injury ($P < .001$), but no different from studies demonstrating rates of 33% ($P = .881$).^{6,7} Ten patients had concurrent MCL injuries, 3 patients had MCL and PCL injuries, 1 patient had a concomitant PCL injury, 1 patient had PCL and LCL injuries, and 1 patient had an LCL injury. Of all patients with Segond fractures, 8 patients (16%) required additional ligament repair at the time of ACL reconstruction: 4 required MCL repair, 1 MCL and PCL reconstruction, 1 PCL reconstruction, 1 posterolateral corner and LCL reconstruction, and 1 LCL reconstruction.

Chondral injuries were present in 13 patients (26%): 4 involved the lateral femoral condyle, 6 involved the medial femoral condyle, and 3 involved the lateral tibial

plateau. Seven cases were Outerbridge Grade I chondral lesions, 4 cases were Grade II, and 3 cases were Grade III. Microfracture was performed in 2 patients (Table 2). There was no significant difference between the rate of concomitant chondral injury and the previous published rates of 17% and 19% ($P = .157$ and $.269$).^{23,27}

Discussion

The current study demonstrates a high incidence of concurrent pathology in those knees suffering an anterolateral complex injury at the time of ACL injury, as evidenced by a Segond fracture. 84% of patients studied had additional ipsilateral meniscal, chondral, or ligamentous knee injury. The high rates of concomitant injury, as evidenced in this current study further implicates a higher-energy mechanism required to cause a Segond fracture.

Prior studies investigating concurrent pathology in patients with Segond fractures have demonstrated similarly high rates. Kushare et al. investigated the rates of chondral injuries and meniscal pathology in pediatric and adolescent patients suffering Segond fractures. This study found 69.9% of included patients suffered meniscal injuries, and 22.6% had chondral injuries.¹⁷ In fact, the presence of a Segond fracture has been used as a surrogate for patients sustaining a higher energy injury.^{19,20} The rates of both chondral injuries and meniscal injuries are similar to the cohort presented in this current study. In a similar fashion, Sulaiman et al. demonstrated that patients with ACL injuries and Segond fractures had statistically significant higher rates of lateral meniscus injuries than compared to patients with ACL injuries in the absence of a Segond fracture.²¹

Although the current study does not have a comparison group, previous studies have demonstrated similarly high rates of associated pathology in all

Table 2. Rates of Observed Concurrent Pathology in the Segond Study Population

Meniscal Tear	Incidence
Medial	9 (18%)
Lateral	18 (36%)
Medial and lateral	11 (22%)
Total	Patients: 38 (76%) Injuries: 49
Chondral defect	
Medial femoral condyle	6 (12%)
Lateral femoral condyle	4 (8%)
Lateral tibial plateau	3 (6%)
Total	13 (26%)
Ligament injury	
MCL	10 (20%)
MCL/PCL	3 (6%)
LCL	1 (2%)
MCL/PCL/LCL	2 (4%)
Total	16 (32%)

Percentages represent percent of the total studied Segond population.

patients undergoing ACL reconstruction. In a retrospective study by Brambilia et al., 62% of 988 patients had associated meniscal or chondral injuries.²² In a similar fashion, Tandogan et al. found rates of concurrent meniscal pathology in 73% of their 764 patients, while 19% had chondral injuries.²³ Both studies also demonstrated increased rates of meniscal injuries with increased time from surgery to ACL reconstruction. Other risk factors identified included older age and number of instability episodes sustained after ACL injury. Neither study addressed Segond fractures as an indicator for higher risk of meniscal injuries, but the 76% identified in this study with concomitant meniscal injuries remains higher than both studies. The high rate of meniscal injuries is of importance, as numerous studies have demonstrated the acceleration of osteoarthritis in patients with meniscal injuries at the time of ACL repair.²⁴⁻²⁶ Recognizing this increased risk of meniscal injury can assist with preoperative planning and patient counseling, particularly as it pertains to the long-term natural history of these injuries.

Previous studies have demonstrated rates of multiligamentous knee injuries in patients sustaining ACL ruptures to be between 8 and 33%. The 32% rate of multiligamentous knee injuries in the present study falls in the upper end of previously reported rates.^{6,7,27} These rates are significant, as MCL laxity has been proven to be a risk factor for postoperative instability after ACL reconstruction.²⁸ In fact, failure to address concomitant ligamentous injuries at the time of ACL reconstruction has been reported as a risk factor for failure of ACL reconstruction.^{29,30} Although to our knowledge, there is no literature directly addressing the relationship between the presence of Segond fractures and higher rates of ACL rerupture or rates of instability,³¹⁻³³ the current study reports a substantial risk of concomitant ligamentous injury in patients with Segond fractures. Surgeons should be aware of this risk in order to identify and address these ligamentous injuries at the time of ACL reconstruction or in a staged fashion. This information is also valuable for counseling patients about the possibility of additional knee pathology that may need to be addressed during ACL reconstruction.

Limitations

The information presented in the current study represents a case series without a true comparison group; thus, rates of concomitant knee pathology were compared to prior reported data in the orthopedic literature. Additionally, the method of patient screening and inclusion identified only patients with known ACL injuries. This limits the ability to comment on rates of ACL injuries when Segond fractures are present. Finally, this study does not report on long-term outcome measures for these patients, such as re-rupture rate, treatment failure, and progression of osteoarthritis.

Conclusion

A high prevalence of concomitant meniscal, chondral, and ligamentous injuries was found in patients with Segond fractures. These additional injuries may require further operative management and may put the patients at increased risk for future instability or accelerated degenerative changes. Patients with Segond fractures should be counseled preoperatively on the nature of their injuries and risk of associated pathologies.

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