

# Surgical Treatment of an Unusual Ski Injury: Combined Tibial Fracture With Anterior Cruciate Ligament Avulsion and Segond Lesion

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**Background:** Alpine skiing is considered to be a high-risk sport due to frequent knee injuries and lower limb fractures. The most common lower limb fracture is tibial shaft fracture, while the most common ligament injuries include anterior cruciate ligament (ACL) or medial collateral ligament tears. An injury rarely described in the literature is the association of a bony leg fracture with an ACL injury and Segond fracture.

**Indications:** While the tibial fracture can be managed with intermedullary nailing and proximal ACL tears can be managed with primary repair, the combination of treatments including fixation of the Segond fracture is uncommon.

**Technique Description:** We report combination treatment with nailing for the tibial fracture, primary repair for the ACL avulsion, and primary fixation of Segond fracture.

**Results:** Simultaneous reduction and fixation of the fracture and stabilization of the knee with ACL and anterolateral ligament repair in a single stage resulted in an excellent outcome with complete healing of tibial fracture, ACL repair, and Segond fixation at final follow-up.

**Discussion/Conclusion:** Even if combined leg fracture associated with ipsilateral ACL tear and Segond fracture is a very rare injury, the described technique based on 1-stage fixation of the 3 injuries is a viable option. This surgical technique can be considered a reparative treatment, with the goal of preserving the joint.

**Patient Consent Disclosure Statement:** The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

**Keywords:** ACL; ACL primary repair; Segond fracture; tibial fracture; peroneal fracture

## VIDEO TRANSCRIPT

Surgical Treatment of an Unusual Ski Injury: Combined Tibial Fracture With Anterior Cruciate Ligament Avulsion and Segond Lesion.

Author disclosures are displayed here and available online.

Skiing is considered a high-risk sport because of the high incidence of knee injuries and lower extremity fractures. The lower extremity is the most common site of injury in skiing, accounting for 43% to 77% of all injuries. In particular, the knee is the most common site of injury, and the most typical knee injuries are ligament sprains with anterior cruciate ligament (ACL) and medial collateral ligament tears. As for fractures, the most common are the tibial shaft fractures.<sup>15,4</sup>

The current video describes the technique used in the case of a 51-year-old amateur alpine skier. He reported

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a noncontact mechanism of injury that included knee flexion with valgus and internal rotation. As a result of the injury, the patient sustained a left leg fracture, treated with external fixation for damage control at another facility. Five days after his skiing injury, he presented to our orthopedic emergency department.

The radiographs revealed a left tibia and fibula (AO/OTA 42A) and the presence of a Segond fracture on the lateral tibial plateau. The presence of the Segond fracture suggested us to evaluate the stability of the knee. Physical examination of the left knee revealed a grade 2 Lachman and a grade 2 pivot shift. The patient denied neither any previous history of left knee injury nor any clinical instability of the knee.

The combination of an ACL lesion and a Segond fracture results in anterolateral rotatory instability.<sup>12</sup> In acute ACL injured knees, anterolateral ligament (ALL) tear is present in about 90% and a Segond fracture occurs in less than 10% of cases.<sup>8</sup>

The Segond fracture corresponds to an avulsion fracture of the anterolateral tibial capsule at the level of the distal insertion of the ALL.<sup>3</sup>

For the current patient, a 1-stage treatment was performed. After removing the previously placed external fixator, a closed reduction and internal fixation with intramedullary nail was performed, followed by a repair of the ACL and Segond fracture. The rationale for performing this treatment all at once was to take full advantage of the patient's biological potential. In the presence of a tibial shaft fracture, there may be a concomitant (often unrecognized) ligamentous injury. Therefore, combined treatment of the tibial shaft fracture with ligament repair may be a viable treatment option.

First, diagnostic arthroscopy was performed to assess the type of ACL tear and tissue quality. The ACL tear was type 1 according to Sherman's classification<sup>14</sup> with a good tissue quality of the tibial remnant, and this was suggestive for an ACL repair.

Standard anterolateral and anteromedial (AM) portals were used. After assessing ACL reparability, the tibial ACL remnant was prepared with 3 #2 fiber-wire stitches that were passed, respectively, in the AM bundle and posterolateral (PL) bundle using a scorpion suture passer (Arthrex Inc.). Then, a 3.5-mm femoral tunnel was drilled using an outside-in guide and positioned at the level of the femoral stump. An eyelet-provided guidewire was inserted out-in through the femoral tunnel, retrieved by the AM portal, and used as a passing suture.

Finally, the ACL sutures were fixed on the lateral femoral condyle by drilling a 4.5 socket and fixed using a 4.75 absorbable SwiveLock (Arthrex Inc.) with the knee in full extension.

The aim of the technique was to reattach the ACL remnant at the level of the femoral insertion site, to promote the biological healing processes to the native femoral stump.

Surgical exploration of the anterolateral structures was then performed through a previously made 5-cm skin incision at the level of the lateral compartment.

The superficial layer of the iliotibial tract appeared swollen and ecchymotic.

The Segond fracture was repaired using 2 metal anchors (4.5 Corkscrew, suture anchor; Arthrex) inserted at the level of lateral tibial plateau.

In addition, the anterolateral capsule was reinforced with periosteal stitches using Vycril #2. Finally, closure was performed in the standard way with Vycril #2.0 for the subcutaneous tissue and Nylon #2.0 for the skin.

A short range of motion (ROM) knee brace was applied, locked in extension for the first week, and then unlocked for an additional 3 weeks. Weightbearing with brace and crutches was allowed.

In the first postoperative week, the focus was on pain and swelling control, with cryotherapy and anti-inflammatory drugs. ROM exercises are started 1 week after surgery with the goal to achieve and maintain a full extension and progressively recover the flexion. The brace was removed 4 weeks after surgery. The patient performed periodic clinical-radiographic checkups.

Approximately 3 months after surgery, the patient underwent tibial nail dynamization surgery removing the interlocking screws proximal to the fracture site to allow bone compression.<sup>16</sup>

At the time of nail dynamization, a second look arthroscopy was performed. The second look arthroscopy showed a macroscopically normal ACL with a firm attachment to the femoral insertion and an almost complete synovial coverage. The tension of the ligament was good as evaluated by probing.

The patient underwent a follow-up 1 year after surgery and the radiographs showed complete healing of the leg fracture and magnetic resonance imaging (MRI) showed a grade 1 signal intensity of the repaired ACL according to Howell scale<sup>10</sup> (Figures 1 and 2). The patient went back to his daily living activities, and at the last follow-up, he was able to perform his required sport activity. At final follow-up at 1 year, Knee injury and Osteoarthritis Outcome Score (KOOS) was 96%, International Knee Documentation Committee (IKDC) score was 82%, and Tegner Lysholm Knee Scoring Scale (TKLSS) score was 97%. In addition, laxity measurement as evaluated with arthrometer KT-1000 revealed 2.0 mm side-to-side difference.

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With regard to the clinical results of ACL repair, Ferreira et al<sup>5</sup> showed that the results of patients undergoing ACL primary repair with a pull-out technique were noninferior to those of standard reconstruction at 2-year follow-up. The same results were later confirmed in a more recent study by Ferretti et al.<sup>6</sup>

Ferretti et al<sup>7</sup> showed that the appearance of an acutely repaired ACL gets normal within 6 months and demonstrated good functional outcomes, restoration of knee ROM, and rotational stability.

The surgical treatment of the Segond fracture is still controversial. Ferretti et al<sup>9</sup> reported 2-year postoperative results on their series of ACL repair with fixation of a concomitant Segond fracture. The authors showed good clinical outcomes, restoration of rotational stability, and maintenance of knee ROM, while in a recent



**Figure 1.** Radiographic control showing complete healing of the tibial shaft fracture and the Segond fracture at 1 year follow-up.



**Figure 2.** Sagittal T1-TSE at 1 year postoperatively. Morphology: grade 1 (normal); signal intensity: grade 1 (isointense) TSE turbo spin-echo.

systematic review, Nagai et al<sup>13</sup> showed no differences in clinical outcomes and failure rate comparing patients with an untreated Segond fracture and patients without the Segond fracture. They concluded that an unrepaired Segond fracture does not appear to have any significant negative effect on postoperative stability or risk of graft failure or revision surgery after ACL reconstruction.<sup>13</sup> However, the Segond fracture should only be considered as the tip of an iceberg of other ALL tears without bony avulsion, so-called Segond lesion. Instead, the term Segond

fracture should be reserved only when a fracture fragment is visible on radiograph or advanced imaging.<sup>2</sup>

The strategy of treating leg fractures with an early transition from external fixation to nailing is consistent with what has been reported in the literature.

Bhandari et al<sup>1</sup> conducted a meta-analysis showing that shorter durations of external fixation resulted in an 83% reduction in the risk of infection compared with longer durations ( $P < .001$ ); at the same time, planned conversion from external fixation to intramedullary nailing resulted in a 92% fracture union rate. This type of combined leg fracture, ACL lesion, and Segond fracture is very uncommon. In literature, only 1 case is reported, in an article by Marshall et al,<sup>11</sup> but it's not clear if the ACL and tibial shaft fracture were ipsilateral or contralateral.

However, as the injury mechanism of a tibial shaft fracture in skiers usually involves a high-energy rotation of the tibia, the concomitant ACL and ALL injury should be suspected.

In conclusion, despite the rare lesion pattern, the proposed technique allowed us to simultaneously treat tibial shaft fracture, ACL tear, and Segond fracture. In particular, the acute phase treatment of the combined ACL and Segond injury promoted a biological healing process respecting the anatomy of the knee.

## REFERENCES

1. Bhandari M, Zlowodzki M, Tornetta P 3rd, Schmidt A, Templeman DC. Intramedullary nailing following external fixation in femoral and tibial shaft fractures. *J Orthop Trauma*. 2005;19(2):140-144. doi:10.1097/00005131-200502000-00012
2. Cavaignac E, Saithna A, Monaco E, Helito CP, Daggett M, Reina N, Sonnerly-Cottet B. Is treatment of Segond fracture necessary with combined anterior cruciate ligament reconstruction? Letter to the editor. *Am J Sports Med*. 2018;46(5):NP13-NP14. doi:10.1177/0363546518764420
3. Claes S, Luyckx T, Vereecke E, Bellemans J. The Segond fracture: a bony injury of the anterolateral ligament of the knee. *Arthroscopy*. 2014;30(11):1475-1482. doi:10.1016/j.arthro.2014.05.039

4. Davey A, Endres NK, Johnson RJ, Shealy JE. Alpine skiing injuries. *Sports Health*. 2019;11(1):18-26. doi:10.1177/1941738118813051
5. Ferreira A, Saithna A, Carrozzo A, Guy S, Vieira TD, Barth J, Sonnerly-Cottet B. The minimal clinically important difference, patient acceptable symptom state, and clinical outcomes of anterior cruciate ligament repair versus reconstruction: a matched-pair analysis from the SANTI Study Group. *Am J Sports Med*. 2022;50(13):3522-3532. doi:10.1177/03635465221126171
6. Ferretti A, Carrozzo A, Saithna A, et al. Comparison of primary repair of the anterior cruciate ligament and anterolateral structures to reconstruction and lateral extra-articular tenodesis at 2-year follow-up. *Am J Sports Med*. 2023;51(9):2300-2312. doi:10.1177/03635465231178301
7. Ferretti A, Monaco E, Annibaldi A, Carrozzo A, Bruschi M, Argento G, DiFelice GS. The healing potential of an acutely repaired ACL: a sequential MRI study. *J Orthop Traumatol*. 2020;21(1):14. doi:10.1186/s10195-020-00553-9
8. 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(1):147-154. doi:10.1016/j.arthro.2016.05.010
9. Ferretti A, Monaco E, Wolf MR, Guzzini M, Carli A, Mazza D. Surgical treatment of Segond fractures in acute anterior cruciate ligament reconstruction. *Orthop J Sports Med*. 2017;5(10):2325967117729997. doi:10.1177/2325967117729997
10. Howell SM, Clark JA, Blasler RD. Serial magnetic resonance imaging of hamstring anterior cruciate ligament autografts during the first year of implantation: a preliminary study. *Am J Sports Med*. 1991;19:42-47. doi:10.1177/036354659101900107
11. Marshall JL, Warren RF, Wickiewicz TL. Primary surgical treatment of anterior cruciate ligament lesions. *Am J Sports Med*. 1982;10(2):103-107. doi:10.1177/036354658201000208
12. Mazza D, Monaco E, Daggett M, Annibaldi A, Pagnotta SM, Carrozzo A, Ferretti A. Combined ACL and Segond repair in combined acute proximal ACL tears and Segond fracture. *Arthrosc Tech*. 2021;10(9):e2151-e2156. doi:10.1016/j.eats.2021.05.018
13. Nagai K, Kamada K, Kay J, Hoshino Y, Matsushita T, Kuroda R, de Sa D. Clinical outcomes after anterior cruciate ligament reconstruction in patients with a concomitant Segond fracture: a systematic review. *Am J Sports Med*. 2023;51(2):525-533. doi:10.1177/03635465211045689
14. Sherman MF, Lieber L, Bonamo JR, Podesta L, Reiter I. The long-term followup of primary anterior cruciate ligament repair. Defining a rationale for augmentation. *Am J Sports Med*. 1991;19(3):243-255. doi:10.1177/036354659101900307
15. Stenroos A, Pakarinen H, Jalkanen J, Mäkiä T, Handolin L. Tibial fractures in alpine skiing and snowboarding in Finland: a retrospective study on fracture types and injury mechanisms in 363 patients. *Scand J Surg*. 2016;105(3):191-196. doi:10.1177/1457496915607410
16. Vaughn J, Gotha H, Cohen E, et al. Nail dynamization for delayed union and nonunion in femur and tibia fractures. *Orthopedics*. 2016;39(6):e1117-e1123. doi:10.3928/01477447-20160819-01