Combined ACL Reconstruction and Segond Fracture Fixation Fails to Abolish Anterolateral Rotatory Instability – A Case Report

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Abstract

The Segond Fracture (SF) is considered pathognomonic of an anterior cruciate ligament (ACL) tear. However, the precise anatomy of the soft tissue attachments responsible for avulsion of SF's have been a cause of controversy in the literature with some authors suggesting that they occur due to avulsion of the iliotibial band (ITB) and others reporting that it is the anterolateral ligament (ALL).

A thirty-one-year-old male patient presented with a work-related injury to his right knee that resulted in ACL tear and a SF. Open SF fixation and arthroscopic ACL reconstruction were performed. The anatomical dissection performed in order to fix the SF demonstrated that the avulsion had occurred as a result of the tibial attachment of the ALL with a completely intact ITB.

At one-year postoperative follow-up, the ACL graft had restored anterior tibial translation to within normal limits. However, residual rotational knee laxity was observed in the absence of any other secondary restraint lesions. This is an important finding because it highlights that patients with SF may be at increased risk of persistent instability after ACL reconstruction even in the presence of an anatomically correctly positioned and well-functioning ACL graft. It also demonstrates that anatomical reduction and fixation of SF at the time of ACLR does not necessarily restore normal knee kinematics and consideration should be given to recession of the fixation or augmentation of the ALL when dealing with this injury pattern.

A thirty-one-year-old male patient presented with a work-related injury to his right knee that occurred when he was struck by a truck at low speed. The mechanism of injury involved

anterior tibial translation, varus stress and internal rotation. Physical examination revealed the following findings: large joint effusion, range of motion 0-100º, no neurological or vascular deficit, positive Lachman's test with a soft end-point, a side-to-side anteroposterior laxity difference of 7mm measured by the Rolimeter device (Aircast, Europe), and a grade II pivot-shift (clunk).

Plain radiographs demonstrated a fracture of the anterolateral border of the tibial plateau (figure 1A) and MRI showed a complete anterior cruciate ligament (ACL) rupture with a concomitant 3x16x18mm fracture of the anterolateral tibial border (figure 1B). MRI did not demonstrate any other intra- or extra-articular injuries. Specifically, there was no evidence of injury to any other ligamentous structure, chondral injury, lateral condyle notch sign, or any type of meniscal tear.

Examination Under Anesthesia

The patient underwent an ACL reconstruction (ACLR) and open reduction and internal fixation of the Segond fracture five days following the injury. Examination under general anesthesia, prior to ACLR, confirmed the previous examination findings of a positive Lachman's test and a grade II pivot shift. Examination of other knee ligaments revealed no abnormality.

Lateral Surgical Exploration and Fixation of Segond Fracture

The patient was positioned supine on the operating table in the standard arthroscopy position. First, the anterolateral compartment was approached, as described by Daggett et al.[1] A curvilinear incision starting proximal to the lateral epicondyle and extending distally between the fibular head and Gerdy's tubercle was made. The iliotibial band (ITB) was identified, and found to be completely normal, with no visible tear, bruise or hematoma. A longitudinal incision was made along the posterior aspect of the ITB. The biceps femoris bursa was opened and the tendon was found at its fibular insertion. The lateral collateral ligament (LCL) insertion was then identified. An anterolateral tibial bony avulsion was observed. Attached to the bony tibial avulsion, a strong ligamentous structure overlapping the LCL was dissected. This ligament had a femoral attachment proximal and posterior to the lateral epicondyle, and a broad tibial insertion to the bony avulsion, consistent with the known anatomy of the anterolateral ligament (ALL) (Figure 2).[1] Despite the large bony avulsion, the joint capsule was intact, as evidenced by the absence of any leakage of the hemarthrosis from the joint. The

fracture was anatomically reduced and fixed with a 3.5mm cancellous screw and a washer with the knee in full extension and neutral rotation.

Arthroscopic Evaluation and ACLR

A thorough arthroscopic evaluation of the knee was performed. This confirmed the absence of medial and lateral meniscal injury (including the absence of ramp lesion or meniscal root avulsion), abnormal medial or lateral compartment opening, or chondral injury. The only abnormality present was an isolated complete rupture of the ACL at its femoral insertion. The ACL was reconstructed using the single anteromedial bundle biological augmentation (SAMBBA) technique with a tripled semitendinosus 9mm graft.[2] A 9mm tibial tunnel was drilled at the center of the native footprint with a guide set at 60º. A 9x25mm femoral socket was drilled with an outside-in technique (flip cutter, Arthrex, Naples, USA). The center was located at the anatomic insertion of the ACL, midway between "resident's ridge" and the posterior wall of the femoral condyle. The graft was passed through the joint via a suture loop retrieved through the tibial tunnel. Fixation was achieved using an adjustable loop cortical button (TightRope RT, Arthrex, Naples, USA) on the femoral side, and a 9x23mm absorbable biocomposite interference screw (Arthrex, Naples, USA) on the tibial side, fixed in 30 degrees of flexion, with a posterior drawer applied. The iliotibial band and skin were sutured, and no drains were used.

The rehabilitation program used was the same as the standard protocol used for ACLR at our institution. The patient was discharged on the day of surgery and immediate, brace free, full weight bearing with crutches was allowed. Initial emphasis was placed on quadriceps activation with voluntary muscle contraction, and on achieving immediate full extension. Full range of motion through passive flexion and patellar mobilization were also allowed.

At one-year postoperative follow-up, the patient had a full, pain-free range of motion. The subjective IKDC score was 68.97. The Lysholm score was 79. Lachman's test showed a restored normal laxity with a firm end-point. The side-to-side difference was +2 mm, as measured by the Rolimeter (Aircast, Europe). These results confirm that the ACL graft had restored anterior tibial translation to within normal limits. However, residual rotational laxity was observed. The pivot shift test was positive, Grade II (Clunk). The KiRA test (Orthokey, Carrara, Italy) showed a differential range of 3.0. Plain radiographs showed union of the Segond fracture in a perfectly anatomic position and no ACL tunnel malposition.

Discussion

The lateral capsular sign was first described in 1879 by Dr. Paul Ferdinand Segond and is frequently referred to as the Segond fracture.[3] The SF is considered pathognomonic of an ACL tear. In patients with the radiographic diagnosis of SF, up to 95% are reported to have an ACL rupture.[4] However, in acute injuries of the ACL, SF is inconstant, ranging in incidence from 1.1% to 30%.[4–9] SF most commonly results from an internal rotation and varus stress on a flexed knee. These forces tension the anterolateral structures resulting in a bony avulsion of the anterolateral tibial plateau.[1,10] However, the precise anatomy of the soft tissue attachment responsible for the avulsed SF have been a cause of controversy in the literature with some authors suggesting that it is due to avulsion of either the ITB or anterolateral ligament (ALL).[4,11–13]

The anatomical dissection of the anterolateral structures in this clinical case help to delineate the pathoanatomy of SF. Previous reports have been a cause of confusion but in this case it was clearly demonstrated that the Segond fracture is the result of an avulsion of the tibial attachment of the ALL. The dissection revealed that the ITB was entirely normal and that the structure responsible for avulsing the SF passed superficial to the LCL to attach proximal and posterior to the lateral epicondyle. Furthermore, this structure was independent of both the ITB and LCL and had a broad attachment to the proximal tibia, posterior to Gerdy's tubercle.

This demonstration that the SF is due to an avulsion of the tibial attachment of the ALL is supported by the findings of several previous cadaveric studies, including biomechanical analyses, that have proposed that the ALL tibial attachment is linked to the SF fracture.[4,14–16] Claes et al. described that "anatomic data on the tibial ALL insertion site would match the constant anatomic location on the proximal tibia from where Segond fractures do avulse".[4] Dodds et al. stated that the ALL is the only structure inserting in the location where SFs occur.[15] Kennedy et al. showed that the location and strength of the tibial ALL attachment is sufficient to produce a SF, and in addition, several authors have reported iatrogenic SFs occurring during biomechanical tests aimed at evaluating the strength and stiffness of the ALL.[7,16]

Part of the reason for the previous controversy regarding which structure attaches to SF's is likely due to the fact that dissection of the anterolateral aspect of the knee can be difficult and this has led to conflicting evidence in the literature with regards to the anatomy, function and

even the existence of the ALL.[17] Based on many hours of cadaveric dissection, Daggett et al. provided a simple and reproducible dissection protocol by which the ALL can be easily found in all knees.[1] An important pitfall to avoid during ALL dissection is anterior to posterior ITB reflection, as this can make the ALL difficult to identify. ITB reflection must be performed from proximal to distal, until its insertion to Gerdy's tubercle. Surgeons have also tried to find the ALL at its femoral origin during many dissection studies, which can be considered almost impossible to do without damaging some of its fibers because of its surrounding tissue and fine insertion. The ALL must be first identified at its larger tibial insertion, between Gerdy's tubercle and the fibula head, and this is aided by posterior reflection of the biceps femoris.

Another important reason for the previous controversy is the over-reliance on laboratory studies and therefore the current report is important in confirming the findings of previous cadaveric studies in a clinical case. Additional clinical evidence is provided by Ferretti et al. who performed anterolateral knee exploration in patients undergoing ACLR.[13] In keeping with the surgical findings of the current case, they found that the ITB was completely normal in 33% (n=20) of cases but that in the remainder it was either ecchymotic or swollen. However, the rate of injury to the ALL was considerably higher (90%, n=54) than the rate of ITB injury. In 6 of the cases, Ferretti et al. reported the presence of SFs and also reported that this was due to avulsion of the ALL.[13]

The second major learning point from this case report is that anatomic reduction and fixation of SFs may not be enough to control anterolateral rotatory instability in the context of an anatomically correctly positioned and well-functioning ACL graft. A recent large retrospective cross sectional study concluded that SF is not a risk factor for ACL graft failure but did not specifically assess the rate of persistent instability.[18] Unfortunately, the study had numerous limitations. The authors used only plain radiographs and MRI to evaluate for the presence of SF. However, it is recognized that these imaging modalities are not as sensitive as ultrasound, which detects SF at a rate of approximately 30% in ACL injured knees.[8] Gaunder et al. reported that only 5.3% (29/552) of patients had an avulsion of the anterolateral tibia which suggests that some diagnoses of SF were likely missed.[18] Another major limitation was that they did not report the rate of recognized risk factors for ACL graft failure, for example pre-operative side-to side laxity difference, participation in contact sports, age, lateral femoral condyle notching, meniscal injury or an evaluation of tunnel position all of which confound the study. Finally, the authors did not have a robust follow up arrangement

and assumed that patients had not had a graft failure unless they had presented to their institution for revision. This raises concerns about the validity of the authors conclusions that recommended against repair of SF or ALL reconstruction at the time of primary ACLR. In contrast, evidence from a recent biomechanical cadaveric study has demonstrated that the mean anterior tibial translation and axial tibial rotation were both significantly higher in knees with combined ACL rupture and SF when compared to isolated ACL injured knees.[19] Furthermore, the findings in the current case suggest that SF may be an important reason for persistent instability.

Although persistent instability occurs in up to 30% of patients after ACLR, this can typically be attributed to secondary restraint lesions or technical error such as tunnel malposition.[20–22] In this case, the tunnels were well positioned, and apart from SF there were no other concomitant injuries. However, it is recognized that in the presence of injury to the anterolateral structures of the knee, isolated ACLR fails to restore normal knee kinematics unless ALL reconstruction or another type of lateral extra-articular tenodesis type procedure is performed.[23] In this case, it was assumed that reduction and fixation of the SF, in addition to ACLR, would therefore abolish the abnormal kinematics known to occur as a result of injury to the anterolateral knee structures. This strategy was supported by a recent case report which shows that repair of an acute ALL tear can abolish the pivot shift.[19] However, direct repair of an ALL injury allows restoration of normal ligament tension whereas fixation of the SF does not address any potential injury to the structure of the ALL itself. It is therefore postulated that a possible elongation, multi-level injury or partial failure of the ALL may have occurred and offers an explanation as to why the pivot shift persisted despite restoration of normal AP stability. These biomechanical concepts have already been described for another similar scenario: ACL injury in the setting of a tibial spine avulsion.[24] Interstitial damage of a ligament can occur, and secondary laxity may be present even after fracture fixation.[25] As a true ligament, the ALL might have similar intrinsic behavior to the ACL. Some clinical evidence to support this again comes from the surgical exploration study performed by Ferretti et al. because they found that 58% of patients had multi-level injury to the ALL in apparently isolated ACL-injured knees.[13] Similarly, other authors also report the identification of both proximal and distal ALL abnormalities occurring in the same knee, at the time of ACL rupture.[7]

These findings suggest that if the bony fragment is large enough to warrant surgical fixation,

recession of the fixation or further augmentation of the ALL should be considered to compensate for possible stretching of the ALL fibers.

In conclusion, this clinical case report confirms the findings of previous cadaveric and clinical studies that have suggested that avulsion of the SF is due to the attachment of the ALL to this region of the proximal tibia. The findings of this case report also suggest that interstitial injury, possible elongation and multi-level injury may occur to the ALL during SF and therefore simply fixing the fracture may not be enough to restore normal knee kinematics.

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Figure 1. A) Antero-posterior radiograph of the right knee demonstrating avulsed Segond fracture fragment (white arrow). B). Axial MRI of the same knee showing avulsed Segond fracture fragment (white arrow).

Figure 2. Intraoperative images of the lateral aspect of the right knee. (A) An incision has been made along the posterior aspect of the intact ITB. The biceps femoris tendon has been reflected. (B) Reflection of the biceps femoris tendon allows the LCL and the tibial attachment of the anterolateral ligament (ALL) to be easily identified. (C) The Segond fracture has clearly been avulsed by the ALL which passes deep to the ITB and is separate from it. The ALL is located superficial to the LCL and attaches proximal and posterior to the lateral epicondyle.

Figure 3. Postoperative radiographs of the right knee at 1 year follow up demonstrating healing of the Segond fracture in a perfectly anatomical position and no ACLR tunnel malposition.