CASE REPORT

Combined ACL reconstruction and Second fracture fixation fails to abolish anterolateral rotatory instability

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SUMMARY

The Second fracture (SF) is considered pathognomonic of an anterior cruciate ligament (ACL) tear. However, the anatomy of the soft-tissue attachments responsible for the avulsion of SFs has been a cause of controversy. A 31-year-old male patient presented with an 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 demonstrated that the avulsion of SFs had occurred because of the tibial attachment of the anterolateral ligament (ALL) with an intact iliotibial band. At 1-year postoperative follow-up, the ACL graft had restored anterior tibial translation to within normal limits. However, residual rotational knee laxity was observed. This finding highlights that patients with SF may be at increased risk of persistent instability after ACL reconstruction. Consideration should be given to recession of the fixation or augmentation of the ALL when dealing with this injury pattern.

BACKGROUND

The precise anatomy of the soft-tissue attachments responsible for avulsion of Second fractures (SFs) has 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). This case is important because it clarifies the situation regarding anatomy of the anterolateral compartment of the knee.

CASE PRESENTATION

A 31-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°–100°, no neurological or vascular deficit, positive Lachman's test with a soft end point, a side-to-side anteroposterior laxity difference of 7 mm 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 3×16×18 mm fracture of the anterolateral tibial border (figure 1B). MRI did not demonstrate

any other intra-articular 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.

INVESTIGATIONS

Examination under anaesthesia

The patient underwent an ACL reconstruction (ACLR) and open reduction and internal fixation of the SF 5 days following the injury. Examination under general anaesthesia, 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.

TREATMENT

Lateral surgical exploration and fixation of Second 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 ITB was identified, and found to be completely normal, with no visible tear, bruise or haematoma. 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 ALL (figure 2).¹ Despite the large bony avulsion, the joint capsule was intact, as evidenced by the absence of any leakage of the haemarthrosis from the joint. The fracture was anatomically reduced and fixed with a 3.5 mm 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

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Figure 1 (A) Anteroposterior radiograph of the right knee demonstrating avulsed Second fracture fragment (white arrow). (B) Axial MRI of the same knee showing avulsed Second fracture fragment (white arrow).

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 9 mm graft.² A 9 mm tibial tunnel was drilled at the centre of the native footprint with a guide set at 60°. A 9×25 mm femoral socket was drilled with an outside-in technique (flip cutter; Arthrex, Naples, Florida, USA). The centre 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 (Tight-Rope RT; Arthrex) on the femoral side, and a 9×23 mm absorbable biocomposite interference screw (Arthrex) on the tibial side, fixed in 30° of flexion, with a posterior drawer applied. The ITB and skin were sutured, and no drains were used.

The rehabilitation programme 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

Figure 3 Postoperative radiographs of the right knee at 1-year follow-up demonstrating healing of the Second fracture in a perfectly anatomical position and no anterior cruciate ligament reconstruction tunnel malposition.

motion through passive flexion and patellar mobilisation was also allowed.

OUTCOME AND FOLLOW-UP

At 1-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 SF in a perfectly anatomic position and no ACL tunnel malposition (figure 3).

DISCUSSION

The lateral capsular sign was first described in 1879 by Paul Ferdinand Segond and is frequently referred to as the SF.³ The

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 iliotibial band (ITB). The biceps femoris tendon has been reflected. (B) Reflection of the biceps femoris tendon allows the lateral collateral ligament (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.

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 has been a cause of controversy in the literature with some authors suggesting that it is due to avulsion of either the ITB or ALL.^{4 11-13}

The anatomical dissection of the anterolateral structures in this clinical case helps to delineate the pathoanatomy of SF. Previous reports have been a cause of confusion but in this case, it was clearly demonstrated that the SF 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 5 14 15} 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 SFs do avulse'.⁴ Dodds *et al* stated that the ALL is the only structure inserting in the location where SFs occur.¹⁴ Kennedy *et al* showed that the location and strength of the tibial ALL attachment are sufficient to produce an 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 15}

Part of the reason for the previous controversy regarding which structure attaches to SFs 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.¹⁶ 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 fibres 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 six 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 anatomical 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.¹⁷ Unfortunately, the study had numerous limitations. The authors used only plain radiographs and MRI to evaluate for the presence of SF. However, it is recognised that these imaging modalities are not as sensitive as ultrasound, which detects SF at a rate of approximately 30% in ACL injured knees.⁸ From proximal to distal, several portions of the ALL can be injured.¹⁸ The preoperative MRI showed a large distal tibial bony avulsion. Unfortunately, in this case, the ALL was considered retracted and its signal, path and thickness were difficult to analyse properly. Gaucher *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.¹⁷ Another major limitation was that they did not report the rate of recognised risk factors for ACL graft failure, for example, preoperative 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 with 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 recognised 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 a recent Expert Group consensus paper, SF has recently been described as one of the indications for ALL reconstruction.²⁴ 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 because 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.²⁵ However, direct repair of an ALL injury allows restoration of normal ligament tension, whereas the 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, multilevel 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.²⁶ Interstitial damage of a ligament can occur, and secondary laxity may be present even

after fracture fixation.²⁷ As a true ligament, the ALL might have similar intrinsic behaviour 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 multilevel 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 fibres.

Learning points

- Confirmation of previous cadaveric and clinical studies: avulsion of the Segond fracture (SF) is due to the attachment of the anterolateral ligament (ALL) to this region of the proximal tibia.
- This case report suggests that interstitial injury, possible elongation and multilevel injury may occur to the ALL during SF.
- Simply fixing the fracture may not be enough to restore normal knee kinematics.

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REFERENCES

- 1 Daggett M, Busch K, Sonnery-Cottet B. Surgical dissection of the anterolateral ligament. *Arthrosc Tech* 2016;5:e185–8.
- 2 Sonnery-Cottet B, Freychet B, Murphy CG, *et al*. Anterior cruciate ligament reconstruction and preservation: the Single-Anteromedial Bundle Biological Augmentation (SAMBBA) technique. *Arthrosc Tech* 2014;3:e689–e693.
- 3 Segond PP. Recherches cliniques et expérimentales sur les épanchements sanguins du genou par entorse. *Prog Med* 1879;79:297340–1.
- 4 Claes S, Luyckx T, Vereecke E, *et al*. The Segond fracture: a bony injury of the anterolateral ligament of the knee. *Arthroscopy* 2014;30:1475–82.
- 5 Claes S, Vereecke E, Maes M, *et al*. Anatomy of the anterolateral ligament of the knee. *J Anat* 2013;223:321–8.
- 6 Flores DV, Smitaman E, Huang BK, *et al*. Segond fracture: an MR evaluation of 146 patients with emphasis on the avulsed bone fragment and what attaches to it. *Skeletal Radiol* 2016;45:1635–47.
- 7 Helito CP, Bonadio MB, Rozas JS, *et al*. Biomechanical study of strength and stiffness of the knee anterolateral ligament. *BMC Musculoskelet Disord* 2016;17:193.
- 8 Klos B, Scholtes M, Konijnenberg S. High prevalence of all complex Segond avulsion using ultrasound imaging. *Knee Surg Sports Traumatol Arthrosc* 2017;25:1331–8.
- 9 Van Dyck P, Clockaerts S, Vanhoenacker FM, *et al*. Anterolateral ligament abnormalities in patients with acute anterior cruciate ligament rupture are associated with lateral meniscal and osseous injuries. *Eur Radiol* 2016;26:3383–91.
- 10 Goldman AB, Pavlov H, Rubenstein D. The Segond fracture of the proximal tibia: a small avulsion that reflects major ligamentous damage. *AJR Am J Roentgenol* 1988;151:1163–7.
- 11 Shaikh H, Herbst E, Rahnama-Azar AA, *et al*. The Segond Fracture Is an Avulsion of the Anterolateral Complex. *Am J Sports Med* 2017;45:2247–52.
- 12 Campos JC, Chung CB, Lektrakul N, *et al*. Pathogenesis of the Segond fracture: anatomic and MR imaging evidence of an iliotibial tract or anterior oblique band avulsion. *Radiology* 2001;219:381–6.
- 13 Ferretti A, Monaco E, Fabbri M, *et al*. Prevalence and classification of injuries of anterolateral complex in acute anterior cruciate ligament tears. *Arthroscopy* 2017;33:147–54.
- 14 Dodds AL, Halewood C, Gupta CM, *et al*. The anterolateral ligament: Anatomy, length changes and association with the Segond fracture. *Bone Joint J* 2014;96-B:325–31.
- 15 Kennedy MJ, Claes S, Fuso FAF, *et al*. The anterolateral ligament. *Am J Sports Med* 2015;43:1606–15.
- 16 Sonnery-Cottet B, Saithna A, Helito C, *et al*. Regarding "anterolateral ligament of the knee, fact or fiction?". *Arthroscopy* 2016;32:1740–1.
- 17 Gaunders CL, Bastrom T, Pennock AT. Segond fractures are not a risk factor for anterior cruciate ligament reconstruction failure. *Am J Sports Med* 2017;45:3210–5.
- 18 Helito CP, Helito PVP, Costa HP, *et al*. Assessment of the anterolateral ligament of the knee by magnetic resonance imaging in acute injuries of the anterior cruciate ligament. *Arthroscopy* 2017;33:140–6.
- 19 Monaco E, Mazza D, Redler A, *et al*. Segond's fracture: a biomechanical cadaveric study using navigation. *J Orthop Traumatol* 2017;18:343–8.
- 20 Song GY, Hong L, Zhang H, *et al*. Clinical outcomes of combined lateral extra-articular tenodesis and intra-articular anterior cruciate ligament reconstruction in addressing high-grade pivot-shift phenomenon. *Arthroscopy* 2016;32:898–905.
- 21 Kraeutler MJ, Bravman JT, McCarty EC. Bone–patellar tendon–bone autograft versus allograft in outcomes of anterior cruciate ligament reconstruction. *Am J Sports Med* 2013;41:2439–48.
- 22 Zaffagnini S, Urrizola F, Signorelli C, *et al*. Residual rotatory laxity after anterior cruciate ligament reconstruction. *Curr Orthop Pract* 2016;27:241–6.
- 23 Inderhaug E, Stephen JM, Williams A, *et al*. Biomechanical comparison of anterolateral procedures combined with anterior cruciate ligament reconstruction. *Am J Sports Med* 2017;45:347–54.
- 24 Sonnery-Cottet B, Daggett M, Fayard JM, *et al*. Anterolateral Ligament Expert Group consensus paper on the management of internal rotation and instability of the anterior cruciate ligament - deficient knee. *J Orthop Traumatol* 2017;18:91–106.
- 25 Monaco E, Sonnery-Cottet B, Daggett M, *et al*. Elimination of the pivot-shift sign after repair of an occult anterolateral ligament injury in an ACL-deficient knee. *Orthop J Sports Med* 2017;5:232596711772887.
- 26 Noyes FR, DeLucas JL, Torvik PJ. Biomechanics of anterior cruciate ligament failure: an analysis of strain-rate sensitivity and mechanisms of failure in primates. *J Bone Joint Surg Am* 1974;56:236–53.
- 27 Levy HJ, Fowble VA. Type III tibial avulsion fracture with associated anterior cruciate ligament injury: Report of two cases in adults. *Arthroscopy* 2001;17:E20.

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