The Segond Fracture of the Proximal Tibia: A Small Avulsion That Reflects Major Ligamentous Damage

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The Segond fracture is a small vertical avulsion injury of the lateral aspect of the proximal tibia just distal to the plateau. It results from excessive internal rotation and varus stress. The plain film and arthographic findings were studied in nine patients with the fracture. Although previous publications have relied primarily on the anteroposterior projection for diagnosis, the injury was apparent only on the tunnel view in two of our cases. The arthrogram was particularly important in identifying abnormalities of the anterior cruciate ligament (nine of nine cases) and/or meniscal tears (six of nine cases). The arthographic findings related to the lateral ligamentous damage depended on the severity of the injury and on the interval between the injury and the arthrogram.

In our series, the Segond fracture was uniformly associated with detachment of the capsular portion of the lateral collateral ligament and tears of the anterior cruciate ligament. In the majority of cases, there were associated injuries of the menisci and other supporting ligaments.

The small avulsion fracture of the proximal lateral tibia, referred to as the Segond fracture, is associated with extensive internal derangement of the knee joint [1, 2]. Originally described in cadaveric experiments by Paul Segond in 1836, it was first recognized on radiographs of patients in 1936 [3]. The purpose of this report is to describe the clinical and radiographic features of the fracture and its associated soft-tissue injuries.

Materials and Methods

A review of double-contrast arthrograms obtained between 1978 and 1987 yielded nine patients with Segond fractures. Clinical charts were available on all nine patients and were reviewed for age and gender of patient, athletic involvement, and the interval between the injury and the arthrogram. Plain film studies performed before the arthrogram included anteroposterior, lateral, tunnel, and Merchant (skyline projection with the knee flexed 45° and the tube angled 60°) views. The radiographs were reviewed by all three authors with attention to (1) the optimum projection for identifying the Segond fracture, (2) the appearance and alignment of the fragment, (3) the presence or absence of a joint effusion, and (4) the presence of other osteochondral or avulsion injuries. The double-contrast arthrograms were then examined with attention to (1) the integrity of the anterior cruciate ligament, (2) the presence or absence of demonstrable lateral capsular damage, and (3) the presence or absence of meniscal or other ligamentous tears. Surgical correlation was available in six of nine patients.

Results

The nine patients, eight men and one woman, were 18–41 years old (average, 28.7 years). Three patients sustained their injuries while skiing, two while playing baseball, one while playing tennis, one while playing soccer, and two during motor vehicle accidents. Five patients had a double-contrast arthrogram within 8 days of injury. The other four patients were studied 2 months, 5 months, 7 months, and 12 years, respectively, after sustaining the fracture.
Seven patients were seen because of pain. The other two indicated a disabling sensation of "wobbliness" or "giving-way." The pivot-shift test, specifically designed to detect anterolateral rotational instability, was positive in only one patient. In seven instances, the test was noted to be inadequate owing to muscle spasm or pain. In one case, the pivot-shift test was not specifically mentioned in the chart.

In all cases, the plain radiographs showed an avulsion fracture adjacent to the meniscotibial attachment of the middle third of the lateral capsular ligament (Figs. 1–3). The fracture fragments originated 2–10 mm (average, 5 mm) below the cortex of the tibial plateau. Their sizes varied from 4 to 27 mm (average, 13 mm). Displacement was minimal and ranged from 1 to 4 mm (average, 2 mm). The fracture fragment was aligned vertically in seven cases (Fig. 1) and tilted in two (Fig. 2). In six patients, the fracture and its site of origin could be identified on standard anteroposterior views. However, in two cases, the Segond injury could be diagnosed only on the tunnel projection (Fig. 3). In one additional patient, the fragment was poorly seen on the anteroposterior projection but definitely visible on the tunnel view. In seven cases, a joint effusion was seen on the lateral radiograph (Fig. 2).

Four patients had additional osseous injuries including an osteochondral defect in the anterior lateral femoral condyle (Fig. 4), an avulsion fracture of the tibial eminence at the insertion of the anterior cruciate ligament (Fig. 2), an avulsion of Gerdy tubercle at the insertion site of the iliotibial band (Fig. 5), and an avulsion of the fibular head at the insertion of the fibular collateral ligament (Fig. 6). Two additional plain film findings were heterotopic ossification in a torn anterior cruciate injury (Fig. 5) and abnormal widening of the lateral joint space on a standing anteroposterior film (Fig. 4).

In the five patients in whom arthrograms were obtained within 8 days of injury, aspiration at the time of the study yielded 5–50 ml of bloody fluid. Three of the four patients studied over a 1-month period after injury had no fluid.

![Fig. 1.—Segond fracture with characteristic arthographic findings. 4 days before presentation, this 26-year-old man fell while playing tennis. A, Anteroposterior view shows 9-mm avulsion fracture arising from lateral tibial cortex. Site of origin is 3 mm below plateau. B, Overpenetrated cross-table lateral view during double-contrast arthrogram shows absence of normal anterior cruciate ligament (arrow). C, Arthrogram of posterior horn of lateral meniscus shows compression of normal tendon sheath.](image1)

![Fig. 2.—Segond fracture plus fracture of tibial eminence. This 35-year-old woman presented 4 days after a fall sustained while skiing. A, Tunnel view shows both 10-mm avulsion fracture of lateral tibial cortex (straight arrow) as well as second fracture of tibial eminence (insertion of anterior cruciate ligament) (curved arrow). B, Lateral view reveals large effusion and confirms avulsion fracture of tibial plateau anterior to tibial spines (arrow).](image2)
Fig. 3.—Segond fracture seen only on tunnel projection. An 18-year-old man had chronic pain and "giving-way" of his knee. 7 months earlier, he sustained a fall while playing soccer. A, Anteroposterior view of knee is unremarkable. B, Tunnel view reveals vertically aligned 12-mm avulsion injury arising from meniscal tibial attachment of lateral capsular ligament.

Fig. 4.—Segond fracture associated with osteochondral fracture and meniscal injury. A 21-year-old man had pain and "instability" of the right knee. 2 weeks earlier he had sustained a twisting injury while playing baseball. Standing anteroposterior radiograph shows Segond fracture (straight arrow), osteochondral defect in lateral femoral condyle (curved arrow), and abnormal widening of lateral cartilage space.

Fig. 5.—Segond fracture associated with fracture of Gerdy tubercle. A 33-year-old man was seen 12 years after a motorcycle accident. Tunnel view reveals lateral fragments arising from Gerdy tubercle (straight arrow) and insertion of lateral capsular ligament (Segond fracture) (curved arrow). Heterotopic ossification is noted in distribution of anterior cruciate ligament. A loose body is also present. Double-contrast arthrogram showed absence of both cruciate ligaments. Both menisci were torn.

Fig. 6.—Segond fracture and avulsion of proximal fibula. Anteroposterior view shows fractures of fibular head (straight arrow) and lateral aspect of proximal tibia (curved arrow). Arthrogram revealed absence of normal anterior cruciate ligament and extravasation of contrast material into lateral soft tissues.

In all nine patients, the arthograms showed a torn or absent anterior cruciate ligament (Fig. 1). One study showed an additional tear of the posterior cruciate ligament. In four patients, studied within 8 days of injury, extravasation from the lateral capsule was seen. In three additional patients, compression of the popliteus tendon sheath reflected edema or adhesions (Fig. 1) [4]. In one patient, disproportionate widening of the lateral compartment with minimal stress was noted. Meniscal tears were present in six of nine patients—three lateral, two medial, and one both lateral and medial.

Surgical correlation was available in six cases (four arthroscopy and two open exploration). In five patients, the tear of the anterior cruciate ligament was confirmed. In one case, the anterior cruciate was incompletely visualized at surgery. In five instances, distal detachment of the lateral capsular ligament was documented. In two patients, additional lateral injuries were shown (iliotibial band, biceps, and popliteus insertion). Five of the six patients with meniscal tears had surgical or arthroscopic exploration that confirmed cartilage injury.

Discussion

A review of the soft-tissue structures on the lateral side of the knee joint is necessary to understand the sites of avulsion injuries associated with lateral instability of the knee.

The stability of the lateral aspect of the knee joint relies on a combination of interdigitating intra- and extracapsular liga-
ments and muscular structures [5]. The anatomy of these lateral soft-tissue structures is complex and still controversial. The lateral soft-tissue structures can be divided into superficial, intermediate, and deep layers [6, 7] or into anterior, middle, and posterior subdivisions [1, 8, 9]. The soft-tissue structure that is most relevant to the Segond fracture is the deepest layer, referred to as the lateral capsular ligament (Fig. 7) [6].

The lateral capsular ligament extends from the patella and patellar tendon to the posterior cruciate ligament [9] and is divided into three sections. The anterior portion extends from the patellar tendon to the iliotibial band. The iliotibial band is superficial to the lateral capsular ligament and is an extracapsular structure that inserts proximally on the epicondylar tubercle of the femur and distally on Gerdy tubercle of the anterior tibia [7–10]. The middle section of the lateral capsular ligament is defined anteriorly by the iliotibial band and posteriorly by the fibular collateral ligament (Fig. 7) [8]. The fibular collateral ligament is also superficial to the lateral capsular ligament and is an extrasynovial structure that attaches to the femur proximally and both the tibia and fibula distally [3, 6, 7, 10]. The posterior third of the lateral capsular ligament extends from the fibular collateral ligament to the posterior cruciate ligament [8, 9].

The middle section of the lateral capsular ligament is thin but has strong attachments both to the femur (meniscofemoral portion) and to the tibia (meniscotibial portion) [2, 8, 9]. Within its middle third, the lateral capsular ligament divides into two layers or laminae that continue into the posterior third. The Segond fracture originates in the middle portion of the lateral capsular ligament at the site at which it changes from a single layer into two layers, specifically, at the meniscotibial attachment [1, 2, 6–9].

The Segond fracture or “lateral capsular sign” [1, 2] is found in 6–13% of patients with anterolateral rotational instability of the knee [1, 4, 11]. This type of internal derangement is characterized by “anterior rotational subluxation of the lateral tibial condyle relative to the lateral femoral condyle” [11]. Anterior rotational instability results from a traumatic tear of the middle third of the lateral capsular ligament [8] and/or injury to the anterior cruciate ligament [5, 8, 11–13]. This injury usually occurs during a fall and is due to internal rotation plus varus stress [1, 2, 13]. The injury produces abnormal tension on the central portion of the lateral capsular ligament [2, 8, 13]. Damage to other lateral ligaments can result in associated posterolateral or straight lateral instability [2, 12].

The sports most often resulting in anterolateral rotational instability are reported to be skiing, basketball, and baseball (55% in our series) [11]. Walking is usually unimpaired, but painful “giving-way” can be elicited by walking on rough ground, running, or “cutting” (when the patient stands on a straight leg with a fixed foot and pivots away from the affected side) [8, 13, 14]. The latter symptoms often are referred to as a “trick” knee [8, 13]. The most specific clinical test is the pivot-shift test, which is designed to reproduce a cutting maneuver [5, 7, 13, 14]. False negatives can result from a locked knee or guarding [1, 14].

On plain films, the presence of a Segond fracture directly reflects traumatic detachment of the meniscosynovial portion of the middle third of the lateral capsular ligament (Figs. 1–8) [1, 7, 11, 13, 15–18]. The fragment originates from the lateral cortex of the proximal tibia superior and posterior to Gerdy tubercle (Figs. 1–6) [1]. It does not affect the plateau but arises 2–10 mm distal to the articular surface. The fragments are small, ovoid, and usually oriented in a vertical or oblique direction (Figs. 1 and 2). Displacement is minimal. Several previous publications [1, 2, 11] have indicated that a Segond fracture is best detected on the anteroposterior projection. In our nine cases, two Segond fractures were seen only on the tunnel projection (Fig. 3).

The Segond fracture can coexist with damage to other lateral structures and other avulsion injuries. In 1936, Milch [3] reported a patient with both a Segond fracture and a
Meniscal injuries, both medial and lateral, have been reported in 66–70% of patients with anterolateral rotational instability of the knee [6–8, 11, 13, 14]. Six of the nine patients studied arthrographically had meniscal tears (three lateral, two medial, and one both). In five of these six patients, surgery confirmed meniscal injury.

In summary, the Segond fracture is a small osseous avulsion that indicates tears of the meniscotibial attachment of the middle one-third of the lateral capsular ligament and anterior cruciate ligament. In a majority of cases, meniscal damage and/or tears of other ligaments are present. The double-contrast arthrogram is useful in evaluating the integrity of the cruciates and menisci and in determining the extent of injury in patients with plain film evidence of a Segond fracture.

ACKNOWLEDGMENTS

We thank the orthopedic staff at the Hospital for Special Surgery for the case material and Thomas Wickewitz for help in interpreting the clinical material.

REFERENCES