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A Unique Pattern of Peri-Prosthetic Fracture Following Total Knee Arthroplasty: The Insufficiency Fracture

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ABSTRACT

An isolated periprosthetic compression fracture following total knee arthroplasty has not been described in periprosthetic fracture classifications. Thus, the purpose is to describe this unique type of fracture based on clinical and radiographic analysis and identify the incidence and potential risk factors of this fracture. A retrospective chart review was performed from a database of 5864 primary total knee. A total of 56 (0.9%) periprosthetic fractures were identified with 15 (26.8%) of them demonstrating an isolated lateral compression fracture. Patients exhibiting this fracture pattern had a mean preoperative varus deformity of 176.3° and had poor bone quality (T score: −2.1). It is important to recognize that a compression fracture is not an infrequent finding and that further workup maybe warranted when clinical suspicion is high.

The number of total knee arthroplasty (TKA) has been expected to increase by 673% to 3.48 million over the next decades [1]. While technology has advanced resulting in improved survivorship for total knee arthroplasty (TKA), peri-prosthetic fractures are one of the more common complications, with a reported incidence ranging between 0.3% and 5.5% in primary TKA [2–6].

Typically, these periprosthetic fractures occur above a well-fixed prosthesis [7–11] from a mechanism of lower energy trauma in combination with an axial-torsion force [12]. Furthermore, a number of predisposing factors have been associated with periprosthetic fractures including: osteoporosis [13–15], rheumatoid arthritis [14,16–18], steroid therapy [16–18], anterior femoral notching [13–15,19], neurological diseases, previous revision arthroplasty [13,14], local osteolysis [20], and infection [21]. Several classifications [21–25] have been proposed to categorize the wide variety of distal femur periprosthetic fracture patterns including those of Su et al [25] and Rorabeck et al [21]. Despite the many available fracture classifications, an isolated lateral femoral condyle compression fracture has not been included in any of the described classifications in the literature.

At our institution, we have encountered isolated lateral femoral condyle compression fractures; a fracture pattern that has received little attention or been thoroughly investigated. A potential reason for this is that the fracture pattern is frequently unseen on routine plain radiographs and requires dynamic stress radiographs or computed tomography for visualization. Furthermore, this fracture pattern has mainly been observed in patients with osteopenia and varus deformity, which has led us to hypothesize that this periprosthetic fracture pattern may be an insufficiency fracture, a fracture resulting from abnormal bone e.g. decreased bone quality. Thus, the purpose of this study is to (1) describe this unique type of fracture based on clinical and radiographic analysis, (2) determine the incidence of this fracture, (3) identify potential risk factors for developing this fracture, and (4) report the diagnostic methods used to identify this fracture pattern.

Materials and Methods

An institutional arthroplasty database was used to identify all patients who underwent primary total knee arthroplasty between March 2003 and February 2014. Following this query, a total of 5864 primary TKAs were identified. Over this eleven-year period, a total of 56 patients had periprosthetic fractures following primary TKA based on the International Classification of Diseases Version 9 (ICD 9) code for periprosthetic fracture, 966.44. Of these, fifteen had the documented fracture pattern of interest. None of the patients with this fracture pattern had any systemic inflammatory disease or was receiving immunosuppressive therapy. All procedures were performed by one surgeon with using a medial parapatellar approach and primarily cemented cruciate retaining knees.

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Fracture Identification

This compression fracture was defined as an isolated compression fracture in the lateral femoral condyle that was not found to occur intraoperatively. Clinical symptoms of this fracture include sudden pain following ambulation or any other events that may cause a compression mechanism.

Radiographic Analysis

Routine anteroposterior radiographs were taken for all patients during follow-up. The clinical suspicion (mismatch between X-rays and clinical manifestation) resulted in further radiological investigations. Dynamic stress (varus/valgus force) views were taken (Fig. 1a and b) followed by computed tomography scans (Fig. 2).

Outcome Measures

Alignment deformities were measured from preoperative weight bearing full length lower extremity radiographs using Agfa viewer (Agfa-Gevart, Mortsel, Belgium). Flexion deformities were measured preoperatively using a goniometer. Bone densitometry was performed to characterize the severity of osteoporosis and was measured using T scores. Osteopenia and osteoporosis were based on T score thresholds of −1.0 and −2.5 respectively as established from the World Health Organization criteria [26]. All the measurements and radiographic reports were reviewed by a trained physician (AS).

Outcome Variables

A retrospective chart review was then performed in these patients with periprosthetic fractures to obtain and review the following clinical information: imaging, intraoperative observations, bone density, flexion, and alignment deformities.

Results

Of the 5864 primary TKAs, a total of 56 TKAs (0.9%) subsequently developed a peri-prosthetic fracture. Of these fractures, 15 knees had the described pattern (26.7% of the peri-prosthetic fractures), an isolated femoral compression fracture. There were 4 males and 10 females (one female had bilateral insufficiency fracture) with insufficiency fractures occurring at an average age of 63.7 years (range 52–71 years, Table 1). All patients were diagnosed within the first 21 days of surgery (15.2, 7–21 days).

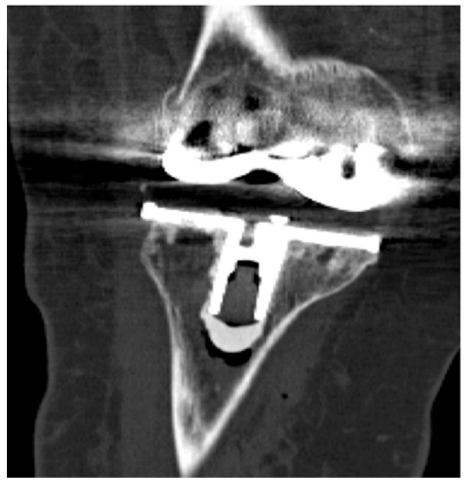

Fig. 2. CT scan showing bone compression in the lateral femoral condyle.

All patients reported sudden onset of pain that disabled them from further ambulation. Of the 14 patients, 11 patients reported no history of trauma, 2 had knee torsion, and 1 experienced blunt trauma at the site of the fracture.

Radiographic Assessment

Plain anteroposterior radiographs showed pathologies in the lateral condyle of femur in all reviewed fracture cases. However, in seven of the radiologist reports, the fracture pathology was not reported despite an observed increase in varus deformity. In suspicious cases for periprosthetic fracture, dynamic stress varus and valgus views were performed (Fig. 1b) and the diagnosis was confirmed with a CT scan by detecting the bone compression in the lateral femoral condyle.

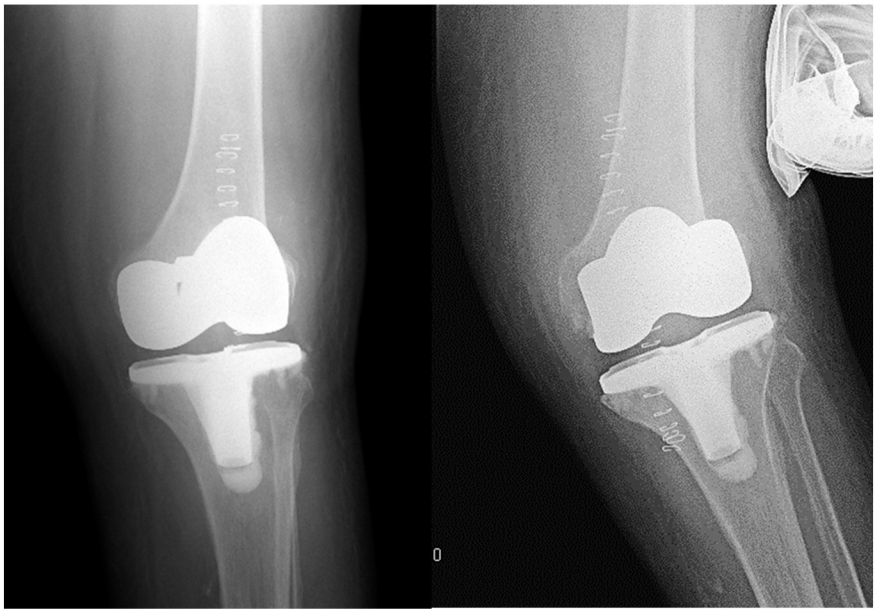

Fig. 1. Compression fracture not visualized on anteroposterior film (a) until valgus stress view.

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Table 1
Demographics.

Characteristic	Value (mean, range)
Age (year)[a]	63.8 (52–71)
Weight (kg)[a]	84 (74–112)
Height (cm)[a]	162 (146–179)
BMI (kg/cm^2)[a]	36.51 (27.2–44.1)
Gender	
Male	4 (29%)
Female	10 (71%)

[a] The values are given as mean (range).

Bone Densitometry and Deformity Analysis

Bone densitometry scans revealed that the 14 patients with insufficiency fractures were found to have a mean T score in the osteoporotic range (mean −1.7, −1.0 to −3.1, Table 2). 10 patients with insufficiency fractures were in the osteoporotic range, and 4 patients were in the osteopenic range. In addition, there was marked varus deformity (mean 16.3°, range: 10.3–23.1) in the insufficiency fracture patients (Table 2).

Intraoperative Findings and Management

All cases with clinical findings suggestive of insufficiency fracture underwent revision TKA. As expected, severe bone loss and low bone quality were observed in the lateral femoral condyle during all the revisions. Intraoperative findings in four knees revealed collapse of the lateral femoral condyle with consequent loosening of the femoral implant. In two knees, severe collapse of the lateral femoral condyle and concomitant lateral collateral ligament failure necessitated the use of more constrained implants with a rotating hinge (LCCK, Zimmer, Warsaw, IN). During implant removal, large residual bone stock was adherent to the removed tibial and femoral implant (Fig. 3) and severe bone loss was apparent in all cases, which required a metaphyseal tibial tantalum cone (Tantal, Zimmer Warsaw, IN) in 6 cases. Intraoperative assessment in all cases revealed that there were no instances of anterior femoral notching, local osteolysis, polyethylene wear, or signs of infection. Furthermore, bone at the fracture site was observed to be soft and spongy and the fracture did not extend past the anterior flange. Because of the severe bone loss, frequent loosening of the femoral component (n = 4), and Su type III classification, revision to a longer prostheses with stemmed femoral and tibial components were used in all condylar knee type implants to bypass the fracture. None of the cases was treated with intramedullary nails, open reduction and internal fixation with fixed angle devices, or nonoperative management. Following revision TKA, all knees were stable and no other procedures were required. Postoperatively, patients started ambulating within 10–14 days but were limited to partial weight bearing for a total of 6 weeks.

Discussion

With the increasing frequency of peri-prosthetic fractures [27] that has paralleled the increase in yearly life expectancy [28] and the expected increase in number of TKAs [1], it is important to understand and recognize periprosthetic fractures to allow efficient and proper management. Our study reports on a periprosthetic fracture pattern that, to our knowledge, has not been previously described and is difficult to detect. Furthermore, patients with decreased bone quality and varus deformity appear to be at greater risk for this fracture pattern.

This study had a number of limitations, and our findings should be interpreted in light of these issues. First, the study is retrospective and is thus dependent on the completeness of the chart. Second, the rarity of peri-prosthetic fractures resulted in a relatively small sample size despite a large number of charts and images that were reviewed. Third, the incidence of this fracture pattern may be underreported since we may not be able to capture readmissions if they present to a different hospital with this fracture. Fourth, given the relatively low incidence of this fracture pattern, it was difficult to determine if there were any other risk factors predisposing to this injury, especially since there was no control group. However, this fracture pattern was not observed in any patients with systemic inflammatory disease, femoral notching, or immunosuppressive therapy and the age of the patients did not appear excessive (mean 63.7). Lastly, the decision to obtain varus and valgus stress films and CT scans were based on the surgeon's clinical suspicion and thus the protocol is likely subject to considerable variability between physicians.

Our results showed that almost all of the patients had severe varus deformity. We hypothesize that this is a type of insufficiency fracture due to this deformity and the subsequent poor bone quality in the lateral femoral condyle. A possible mechanism of injury is that the preoperative sever varus results in osteopenia in the lateral femoral condyle from decreased stresses in this area, which then reduces the bone turnover, Wolff's law [29]. When these patients start full weight bearing after undergoing a primary TKA and restoration of neutral alignment, normal biomechanical forces will be applied on the poor bone leading to the collapse of the lateral femoral condyle. Given that varus deformity likely predisposed the patient to this fracture pattern, one can speculate that severe valgus deformity may lead to a medial condyle compression fracture. However, we have not seen a medial condyle compression fracture, which may be attributed due to the relative rarity of severe valgus deformity. Furthermore, the overall decreased bone quality in the high frequency of osteopenic patients seen in this study may also contribute to this fracture pattern. As a result, sudden onset of pain and severe deformity of the limb with no history of trauma may be observed.

We have found that this specific fracture pattern is difficult to diagnose, detected in only eight out of fifteen plain radiographs, and often requires visualization with a valgus stress view or a CT scan. Unlike fracture patterns described by current peri-prosthetic classification systems [21–24,30], a clear fracture line is usually not observed with these insufficiency fractures. Instead, increased compressive forces across the lateral femoral condyle will cause a significant amount of detectable bone loss. Furthermore, the compression fracture is often hidden behind the femoral component and thus requires advanced imaging or stress views to better visualize the fracture. Together, these factors may explain the lack of documentation of this fracture pattern in the literature.

The patient's clinical description of the pain from this periprosthetic fracture reveals that this fracture can be very debilitating to the patient despite an otherwise asymptomatic film. Thus, clinical suspicion of this fracture should be considered when abrupt onset of pain that prohibits ambulation and/or sudden alignment deformity frequently during weight bearing is found in a patient with severe preoperative deformity and poor bone quality. In these patients, we encourage the physician to consider a periprosthetic fracture and obtain dynamic stress views or CT scans even if a radiology report is negative. We recommend that management of this fracture includes supplying the bone deficiency using proper augments, bypassing the fracture with stemmed components, and utilizing constrained implants in cases of instability.

In summary, the periprosthetic fracture described in our study, an isolated lateral femoral condyle fracture, is not an infrequent finding following TKA. The risk of insufficiency fracture is presumably greater in patients with high BMI, poor bone quality, and severe preoperative

Table 2
Preoperative Measures.

Characteristic	Value
T Score[a]	−1.7 (−1, −3.1)
Varus Deformity (degree)[a]	16.3 (10.3–23.1)
Flexion Contracture (degree)[a]	7.18 (5.9–10.4)

[a] The values are given at mean (range).

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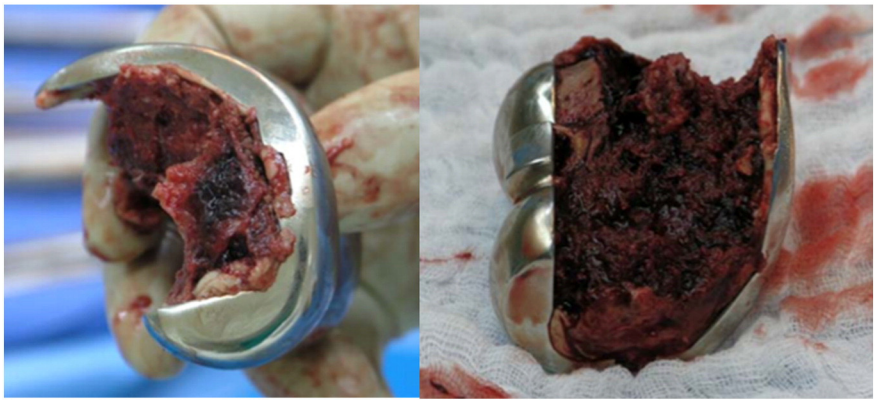

Fig. 3. Severe bone loss observed in the lateral femoral condyle.

varus deformity. The sudden onset of localized pain or deformity is often suggestive of this fracture pattern, although it is not always detectable in anteroposterior plain radiographs. It is recommended that further investigation be performed in all symptomatic patients with these clinical manifestations or risk factors.

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