Fatigue Fractures of Total Knee Prostheses
A Cause of Knee Pain


Abstract
Femoral component fracture is a rarely reported complication in cemented total knee arthroplasty. We present a case of new-onset acute unresolved knee pain caused by fatigue fracture of the medial condyle of the femoral component 11 years after primary total knee replacement. This was identified and subsequently revised with a revision prosthesis. The patient had an uneventful recovery, and his symptoms resolved. Considering that the aging population and the rate of obesity are increasing and that there is an exponential increase in the number of joint arthroplasties; this case sheds light on a rare cause of acute non-traumatic knee pain following knee arthroplasty that could be present with or without evidence of osteolysis. We also review the literature of cases of fractured cemented and uncemented knee replacements and discuss the causes proposed.

A round 70,000 total knee replacements (TKR) are performed in the UK each year. Around 6% of these are revision procedures.1 The most common indication for revision is aseptic loosening (35%) followed by infection (23%) and pain (18%). Component fracture represents less than 1% of indications for revision TKR according to the recent UK data.1

Femoral component fracture is a rarely reported complication of total knee arthroplasty. The 1990s saw an increased incidence of implant fractures with the two largest series reported with the uncemented Whiteside Ortholoc II knee replacements (Dow Corning Wright, Arlington, TN, USA)2,3 with a combined total of 10 fractures and range of fracture between 25 and 132 months post implantation. It may present with acute pain, progressive pain, or returning deformity. It occurs more commonly in the medial condyle of the femoral component and is associated with a varus deformity either pre or postoperatively.3,4 Although a rare entity in itself, its incidence is less in cemented replacements.2

The major patient associated risk factor for implant fatigue fracture is obesity. Levels of obesity are rising worldwide.5-13 In the USA, the number of people with a body mass index (BMI) greater than 40 has increased 70% in the past 10 years.11 Similar trends have been noted in Europe and in Asia.5,9,14-16 Implants in the future will be required to withstand higher and higher loads, leading to an increased frequency of fatigue failure.

We present a case of a fracture of the medial femoral condyle of a Press Fit Condylar (PFC) cemented implant (DePuy, Johnson & Johnson, Raynham, Massachusetts, USA) 11 years after implantation, and we review the literature of fractured cemented and uncemented total knee components.

Case Report
A 64-year-old male patient (BMI of 39) with grade IV osteoarthritis and 5° of correctable varus deformity of the left knee underwent a left sided PFC total knee arthroplasty in December 1999. He had a fully cemented fixed bearing TKR (size 5 femoral component and a size 4 tibial tray) with an 8 mm polyethylene insert. Patella resurfacing was not carried out. A good clinical and radiological result was achieved with correction of the varus deformity and 0° to 110° of active
movement at the 1-, 2-, and 5-year follow-up. He subsequently underwent an uneventful right total knee replacement in year 2000 achieving a good level of activity and pain free knee.

One hundred and thirty four months (11.2 years) after primary surgery the patient was referred by his primary physician with sudden onset of left knee pain. There was no history of a fall, trauma, or injury. The pain was progressive in nature and was focused in the anteromedial aspect of the knee. His walking distance decreased from 4 miles to 0.5 miles. He weighed 124 kg (BMI 39) at the time.

On examination, there was noticeable left knee swelling. The joint was warm, but there was no erythema or any stigmata of infection. He was afebrile and haemodynamically stable. His range of movement had reduced acutely from 0° to 110° to a limited range of movement of 5° to 75° active flexion. No other obvious deformity was detected.

Blood biochemistry revealed an ESR of 17 mm/hr (normal range: 1 to 13 mm/hr) and a CRP of 6 mg/L (normal range: 0 to 10 mg/L). Plain radiographs of the left knee demonstrated a suspicion of a loose tibial component. An indication of a step was noted in the femoral condyle, and a fracture was considered (Figs. 1 and 2), including the possibility of aseptic loosening, and a revision knee arthroplasty was planned.

Intraoperative findings revealed a transverse fracture through the weightbearing aspect of the medial condyle of the femoral component (Fig. 3). There was significant wear to the medial aspect of the polyethylene implant (Fig. 4). The tibial plate was undamaged. Osteolysis was noted on the medial femur.

Bone biopsies were taken and sent for microbiology and histology. They revealed no evidence of infection but
Polyethylene particles were present within foreign body granulomas. A Total Condylar III knee replacement (DePuy, Johnson & Johnson, Raynham, Massachusetts, USA), including a cemented size 4 femur with fluted femoral stem, 2 x 4 mm posterior augment, 1 x 4 mm distal augment; and a cemented size 4 tibial tray with fluted rod, were implanted.

<table>
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<th>Age of Implant (months)</th>
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<td>PFC</td>
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### Table 1
Cemented Implant Fractures (Femoral Component)

### Table 2
Uncemented Implant Fractures

### Table 3
Demographics of Patients with Prosthesis Fractures

Key: PFC = Press Fit Condylar; LCS = Low Contact Stress; FNK = Flexible Nichidai Knee.
The patient made an uneventful recovery and has regained pain-free satisfactory function. He was discharged with no further follow-up 18 months after revision.

Discussion

Fatigue is the term used to describe the effect of cyclical loading and unloading on a material. This leads to material micro fracture, especially in materials which microscopically contain sharp angled corners that can exacerbate stresses leading to fatigue fracture. Fatigue striations have been noted on fracture surfaces on scanning electron microscopy, usually running from posterior to anterior.2,17

Fracture of metal implants in joint replacements is a rare but devastating complication of arthroplasty, requiring revision surgery. Fractures of the femoral component have been most widely reported in uncemented Ortholoc II knee replacements.2,3,17,18 This has been attributed to an area at the junction of the posterior bevel and medial femoral condyle where the thickness of the implant is reduced to 3 mm. This has been deemed insufficient to withstand the load and stresses applied to modern implants and left the device susceptible to fatigue fracture. The size of the implant correlated to the fracture rate, revealing the smallest components being most susceptible to fracture.2,18 The Ortholoc II has, therefore, been withdrawn from the market. Subsequently, fatigue fracture has been described in case reports in Genesis II, LCS RP (Low Contact Tress Rotating Platform knee, DePuy), and more recently in PFC prosthesis, such as the one described in this case.19-21 In 2011, Saito described this problem for the first time in bilateral TKRs.22

In this case, the fracture was subtle and only conclusively identified retrospectively on the lateral knee radiograph. Scrutiny of the implant’s integrity was not adequately undertaken prior to exploration, as this is a rare occurrence; and therefore, more common causes of painful knee arthroplasty were considered primarily.

Mechanism of Failure

Studies published to date regarding femoral fatigue fracture have offered suggestions as to the potential mechanism of fracture. They can be divided into design factors, patient factors, and factors exacerbating stresses. Design factors suggest inherent weaknesses in the structure of the implant, such as described with the Ortholoc II.2 Patient factors suggested included weight and varus deformity either pre- or postoperatively (i.e., failure of surgical correction of the original varus deformity or suboptimal implant alignment), as both increase prosthesis stress.2-4 Cemented devices may allow more uniform load bearing, while uncemented porous-coated prostheses often restrict bone growth to isolated areas.22,24

In those cases where histopathological analysis was carried out on the specimens at the time of revision surgery, two major contributions to failure were noted. The first was failure of bony ingrowth into uncemented prostheses, which allowed the development of fibrous tissue and weakened the supporting matrix to the prostheses.3,17,23-25 Loads were then distributed in a non-uniform manner. The second was osteolysis, with or without evidence of immunogenic activity.19-21 The destruction or absence of cancellous bone around the prosthesis contributes to abnormal loading in the same way as failure of bony ingrowth. Loosening has been extensively demonstrated to predispose the patient to prosthesis fracture; however, most data comes from femoral stems of total hip arthroplasty rather than knee arthroplasty,26-28 and some investigators detail specifically a lack of osteolysis noted at the time of revision surgery.22

In the case of our patient, there was clear evidence of polyethylene failure, but no evidence of metallosis around the medial femoral or tibial component to indicate direct metal component contact during weightbearing. Eight millimeter ultrahigh molecular weight polyethylene inserts are the minimum thickness recommended to keep the bearing contact stress below the insert’s yield strength. Failure in this case may indicate that the minimum insert size should be increased in obese patients. This is likely to become an increasing consideration given the obesity epidemic. Evidence for osteolysis levels in obese patients is equivocal with many investigators showing no difference, but one study showed a five time increase in focal osteolysis in TKR in patients with a BMI greater than 40.1-3

Comparison with Other Reports

There have been 20 fatigue fractures in uncemented femoral components and 4 in cemented implants currently reported in the literature. There has only been one case affecting the lateral condyle, and this was in an uncemented Ortholoc II. The other femoral component fractures involved the medial condyle. These cases are demonstrated in Tables 1 and 2. Table 3 describes the demographics of the patients in whom these failures occurred.

Of the cemented femoral component fractures, two were Whiteside Ortholoc prostheses. These fractured at the junction of the posterior bevel and the distal surface of the medial femoral condyle. This has been found to be a fault in the design of this prosthesis, which is shorter and thinner in comparison with other knee prostheses.29

It is important to note that fatigue fracture is not exclusive to total knee arthroplasty, but it has also been noted with unicompartmental knee replacements30-32 and in resurfacing arthroplasty.33

Conclusion

The number of total knee replacements conducted worldwide has increased dramatically in the last 5 years. As our population ages, the burden of osteoarthritis will become more important. The number of knee arthroplasty procedures performed has increased from 56,000 in 2005 to over 70,000 in the UK in 2010. Kurtz and coworkers in 2008 reviewed trends in all joint replacements in the USA and predicted that in by 2030, 572,000 joint replacements and 97,000 revisions procedures will be carried out annually in the USA.1,34 The incidence of obesity is increasing in similarly dramatic num-
bers. The increased load and consequent increase in fatigue will lead to higher arthroplasty failure rates in the future.

Early detection of polyethylene wear and replacement of the insert could prevent metal fatigue fracture and the need for a much larger and physiologically stressful metal component revision procedure.

As more arthroplasty surgery is carried out world-wide with lienent restrictions relating to body habitus and weight, component fracture is likely to become a more prevalent complication. Presently, it is a rare cause of knee pain after TKR; however, surgeons should remain vigilant and maintain a high index of suspicion with a patient who presents with acute onset pain, evidence of a varus deformity, and concomitant obesity, especially since component fractures can be easily missed on plain radiography.

**Disclosure Statement**

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

**References**