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An uncommon cause of cemented unicompartmental knee arthroplasty failure: fracture of metallic components

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Abstract

Purpose Despite good overall clinical results, unicompartmental knee replacements (UKR) are not without their problems and failures have been reported. The most common causes of UKR failure are component loosening, poor patient selection, poor surgical technique, polyethylene wear and progression of arthritis in other compartments. The purpose of this study is to present a series of atraumatic fractures of metallic components in a UKR treated in a single orthopaedic centre.

Method Since 1999, 121 failed unicompartmental knee arthroplasties have been referred to our centre. In six of these, atraumatic breakage of a metal component in the cemented UKR was seen and included in this study. Preoperative alignment, BMI and implant longevity were documented. The femoral implant failed in 4 patients and the tibial implant in a further 2.

Results All the femoral implant fractures occurred within 3 years of UKR surgery (mean: 22.2 months, SD: 10.6 months). Tibial implant breakage occurred at a mean of 8.5 years (SD: 2.4 months) following UKR. All patients were treated with conversion to a navigated total knee replacement. A primary total knee arthroplasty was used in all cases with one patient requiring a tibial component incorporating a wedge and stem following breakage of the original UKR tibial implant.

Conclusion Fracture of the metallic components is a potential cause of failure of unicompartmental knee arthroplasty. In our experience, the incidence of this complication was 4.9 % of all UKR failures. Patients with a BMI greater than 30 and a progressive deterioration in limb alignment were at greater risk.

Level of evidence IV.

Keywords Unicompartmental Knee Arthroplasty · Metallic component breakage

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Introduction

The most common causes of UKR failure documented in the literature are aseptic loosening, polyethylene wear, patello-femoral pain, progression of arthritis in the contralateral compartment and infection [13, 21, 25]. Potential contributing factors to UKR failure include poor surgical technique and indications, high localized stresses with lack of congruency, flat designs, increased rotational freedom and use of thin polyethylene liners [3, 21, 25].

Post-operative metallic component fractures are a rare complication after knee replacement. Of 1,135 cases from the Swedish Knee Registry, only 24 cases of fracture of UKR metal components were reported, without any further detail regarding the type and cause [13]. Previous authors have attributed this complication to poor component support resulting from osteolysis of the femoral condyle secondary to polyethylene wear debris [6, 9, 11, 15–17, 20]. In 2002, Asharaf et al. reported 4 cases of femoral component breakage in a long-term follow-up review of lateral UKR. The authors suggested that the older design of the implants in this study might have contributed to the number of failures seen [3]. In 2004, Panousis et al. identified only 5 cases in the literature of metal component fracture after knee replacement surgery. All involved breakage of the metal femoral component and older implant designs were implicated in 4 of these cases [17]. No cases of fracture of the metal tibial component following UKR have previously been documented in the literature.

We believe that the incidence of this complication in a high volume UKR implantation centre is greater than previously thought. To our knowledge, no paper in the literature has dealt with this issue and in particular made suggestions about management. This study presents the authors experience over 10 years treating the largest documented series from a single centre to our knowledge of patients with broken femoral or tibial metal components following a UKR. The aim of the study is to give some insights into the prevention and management of these failed UKR through an analysis of the time to failure, site of failure, type of implant used and complexities of revision surgery.

Materials and methods

From 1999 to 2010, 121 failed UKR had been treated in our centre. Of these, 30 (25 %) implants were modular fixed bearing, 6 (5 %) were metal backed monoblock fixed bearing, 4 (3 %) were resurfacing only, 8 (7 %) were resurfacing with a tibial inlay component, 47 (39 %) were all polyethylene, and 26 (21 %) were mobile bearing. There were 4 (3 %) cases of infection, 20 (17 %) cases of wear and/or instability, 27 (22 %) cases of pain and/or progression of arthritis, 15 (12 %) cases of tibial fracture or severe subsidence, 49 (41 %) cases of aseptic loosening of either or both of the components and 6 (5 %) cases of atraumatic metallic components breakage.

All 6 cases of atraumatic metallic component fracture were included in this study. Component breakage occurred in medial placed implants in all cases, and femoral implant fractures occurred in patients who had undergone surgery prior to 2004. The median time from UKR to implant fracture was 22.2 months (range: 10–36 months) for the femoral and 8.5 years (range: 6.8–10.2 years) for the tibial components. The median age of the patients at revision was 71.3 years (range: 66–77 years). The median BMI of the patients was 32.4 (range: 30–35) with 3 females and 3 males. No patient had signs of active sepsis at presentation, and chronic sepsis was excluded with intraoperative microbiological specimens. Four of the broken prostheses were implanted in our hospital and 2 in other centres. The diagnosis was made in all cases with standard radiographs. All patients presented with a history of progressive pain in the absence of trauma and without any evident relationship between the onset of the symptoms and failure type.

Long-leg standing radiographs performed immediately after the original UKR implantation to determine mechanical axes (HKA angle) were available in 4 patients with a median HKA angle of 177.1° (range: 175–179°). No signs of implant malposition were seen on these immediate post-operative films. The pre-revision mechanical axes of the group demonstrated a varus deformity with a median HKA angle of 175.1° (range: 173–177). The median pre-revision Knee Society Score [12] was 34.6 (range: 28–40), and the median functional score was 30 (range: 20–45). The pre-revision median WOMAC index [4] was 29.6 (range: 24.1–37.9). Intraoperative bone loss was classified according to the Anderson Orthopaedic Research Institute Bone Defect Classification [8].

Informed consent was obtained from all patients, and the study was given approval by the Ethics Committee of the hospital.

Results

The femoral component fractures occurred in 2 UC-plus (Smith and Nephew, Memphis, TN, USA) implants, 1 St Georg Sled (Waldemar, Link, Hamburg, Germany) and 1 Allegretto (Zimmer, Warsaw, IN, USA) implant. Fracture of the tibial component occurred in 1 UC-plus (Smith and Nephew, Memphis, TN, USA) and 1 Allegretto (Zimmer, Warsaw, IN, USA) implant. No patient had a polyethylene insert thicker than 6 mm used at the original UKR.

All 3 UC-plus femoral component fractures occurred in the anterior half of the implant, while the Allegretto component fracture occurred in the posterior half of the implant (Fig. 1). In all cases, the femoral implant fracture occurred close to a femoral peg. The posterior half of the tibial component fractured in both patients and in each case, this was associated with macroscopic polyethylene wear (Fig. 2). Three of the broken femoral components were made of CrCoMo and one was manufactured in titanium (Allegretto; Fig. 3). Intraoperatively, according to the Anderson Orthopaedic Research Institute Bone Defect Classification, osteolysis was grade I in the femoral and grade II in the tibial cases.

All revision procedures were performed with a cemented TKR using a computer-assisted “tibia first” technique.

Fig. 1 Fracture of the posterior aspect of the femoral implant adjacent to the peg

In three of the patients with a femoral implant fracture, the revision procedure was performed using a cruciate retaining (CR) TKR. A posterior stabilized (PS) TKR was used in one patient with a femoral implant failure. Revision TKR was performed using a posterior stabilized prosthesis in both patients with a tibial implant fracture, combined with a medial wedge augmentation and short tibial stem in one case. No intraoperative or post-operative complications were seen at revision surgery.

At median 5.9 years (range: 1–9 years) follow-up, the median Knee Society Score was 81.1 (range: 77–85), the median functional score was 80 (range: 70–90), and the median WOMAC index was 85.1 (range: 50.3–87.9). The median post-operative HKA angle was 179° (range: 178°–180°) with all revision implants positioned within 3° of an ideal HKA angle of 180°. There were no radiological signs of loosening at latest follow-up.

Discussion

The most important finding of the study was an unexpectedly high (4.9 %) incidence of UKR metallic component fracture seen in our centre over the 10-year period. A possible explanation for this high number is that our departments experience with UKR means that complex revision cases are routinely referred to our centre. This may have resulted in the increased incidence of this uncommon complication of UKR surgery compared to that reported in the literature [3, 6, 9, 16, 17].

All the cases of femoral component fracture were referred to us before 2003 and all occurred within 3 years of implantation. In none of these cases was evidence of either bone loss or component wear seen. The femoral component failed in the anterior half of the implant in both the UC-plus and St George Sled implants, while the posterior half was involved in the Allegretto prosthesis. In all cases, the femoral component fracture occurred close to a femoral peg despite no signs on the pre-failure radiographs of any component malpositioning. Interestingly, the more recent implants included in the study have been modified with wider femoral fins, and we have seen no further component fractures.

Among the potential causes of femoral component failure, Han et al. have suggested that severe osteolysis in the distal femur resulted in weakened bone support of the medial side. This was thought to lead to fatigue fracture because of repeated cyclic stress on the femoral component [11]. Michos et al. suggested that poor bone ingrowth on the porous-coated surface of the femoral component could increase the local stress in uncemented implants and result in implant fracture [15]. Asharaf [3] and Panousis [17]

Fig. 2 Fracture of a finless titanium tibial component

Fig. 3 Fracture of a CrCoMo tibial component with bone loss

have shown that the older designed UKR femoral implants have a higher risk of breakage. They suggest that the risk of component fracture is less with newer designs that incorporate increased thickness of the prosthesis and/or reinforcement at the fixation pegs.

Compared with the femoral component fractures, both tibial failures in our study occurred later (mean 8.5 years). In both cases, evidence of polyethylene wear, metallosis and osteolysis was seen. Despite different metallic compositions (CoCrMo or titanium), both the tibial component fractures were localized to the posterior half of the implant suggesting stress concentration during knee flexion and extension resulted in fatigue failure. The role of malalignment in the tibial implant fractures could not be accurately assessed, as the HKA immediately after UKR implantation was available in only 1 patient. In neither case of tibial component fractures was an excessively thick polyethylene liner implanted.

In 2010, Small et al. demonstrated in an experimental model that the introduction of a metal tibial baseplate improved fixation and reduced distortion in UKR [24]. However, using a metal tibial component has implications for the thickness of the polyethylene used [5, 14]. As a result, several authors have recommended a minimum polyethylene thickness of 6 mm [2, 14, 19]. Simpson et al. demonstrated that a misaligned tibial tray could result in increased strain on the proximal tibia of approximately 40 % [22, 23]. Progression of knee osteoarthritis and laxity of the anterior cruciate ligament (ACL) increases the tendency of an incongruous implant to subluxate. This can cause highly localized further stresses in the tibial component and contribute to implant fracture. Furthermore, progressive wear of the polyethylene in UKR can lead to a secondary recurrence of the deformity with obvious increased stress on the implant components [24].

A high BMI (median 32.4) was a common feature of all patients with a broken implant suggesting a potential role for obesity in the failure of the components. However, the majority of authors do not include obesity as a contraindication for UKR [26]. In common with the available literature [3, 6, 9, 16, 17], we recorded a higher number of femoral than tibial component fractures all in fixed bearing implants. A possible explanation for this is that for several years, the majority of UKR have been performed both at our centre and in Italy generally using a fixed bearing all poly tibial component [7].

It is possible that the use of a mobile bearing may have prevented component fracture at least in the tibial implant. According to some authors, mobile-bearing knee prostheses may reduce contact stress in the polyethylene and decrease wear because of a fully congruent contact at each surface in all positions [1]. Furthermore, Goodfellow et al. suggested that a mobile-bearing design may reduce bone-prosthesis stress at the tibial surface [10]. However, in 2011, Pegg et al. published a series of polyethylene liner fractures in mobile-bearing UKR prosthesis [18].

Revision of the UKR following fracture of the metal components was achieved using a primary computer-assisted TKR recreating an anatomical implant alignment and joint line restoration [7]. In 3 femoral revisions, a primary CR TKR was used. A PS TKR was required to revise 1 femoral and 1 tibial component failure. Revision of the second UKR with the tibial component fracture required wide debridement and a tibial wedge and short stem.

The study does have some limitations including the small number of cases described, the inclusion of fractured femoral and tibial components from different manufacturers and it is retrospective. However, this is the largest single-centre series of implant fracture following UKR described in literature. The authors believe that this complication may be underappreciated and should always be taken into consideration when managing UKR failure.

Conclusion

The incidence of fracture of metallic components in UKR at our centre during the study period was 4.9 %. This is likely to be an overestimate of the true incidence because of our centres extensive experience in partial knee replacement [3, 6, 11, 17, 18]. Femoral component fracture occurred as an early complication in older designs with minimal bone loss and presented a more straightforward revision procedure. The site of femoral component fracture varied depending on implant design but was always seen close to a femoral peg. Metal tibial component fractures occurred later and involved the posterior half of the component. Tibial component failure was seen in association with osteolysis or metallosis in all cases and required more demanding revision procedures. The authors recommend consideration of metal implant fracture at periodic follow-up of UKR especially in obese patients.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Argenson JN, Connor JJ (1992) Polyethylene wear in meniscal knee replacement: a 1–9 years retrieval analysis of the Oxford knee. J Bone Joint Surg Br 74:228–232
2. Argenson JN, Parratte S (2006) The unicompartmental knee: design and technical considerations in minimizing wear. Clin Orthop Relat Res 452:137–142
3. Ashraf T, Newman JH, Evans RL, Ackroyd CE (2002) Lateral unicompartmental knee replacement survivorship and clinical experience over 21 years. J Bone Joint Surg Br 84(8):1126–1130
4. Bellamy N (2002) WOMAC: a 20-year experiential review of a patient-centered self-reported health status questionnaire. J Rheumatol 29:2473–2476
5. Buechel FF, Rosa RA, Pappas MG (1989) A metal-backed, rotating-bearing patellar prosthesis to lower contact stress: an 11-year clinical study. Clin Orthop Relat Res 248:34–49
6. Cameron HU, Welsh RP (1990) Fracture of the femoral component in unicompartmental total knee arthroplasty. J Arthroplasty 5(4):315–317
7. Confalonieri N, Manzotti A, Chemello C, Cerveri P (2010) Computer-assisted revision of failed unicompartmental knee arthroplasty. Orthopedics 33(10 Suppl):52–57
8. Engh GA, Ammeen DJ (1999) Bone loss with revision total knee arthroplasty: defect classification and alternatives for reconstruction. AAOS Instr Course Lect 48:167–175
9. Furnes O, Espehaug B, Lie SA, Vollset SE, Engesaeter LB, Havelin LI (2007) Failure mechanisms after unicompartmental and tricompartmental primary knee replacement with cement. J Bone Joint Surg Am 89(3):519–525
10. Goodfellow JW, O'Connor J (1986) Clinical results of the Oxford knee: Surface arthroplasty of the tibiofemoral joint with a meniscal bearing prosthesis. Clin Orthop Relat Res 205:21–42
11. Han CD, Han CW, Yang IH (2009) Femoral component fracture due to osteolysis after cemented mobile-bearing total knee arthroplasty. J Arthroplasty 24(2):323.e7–323.e12
12. Insall JN, Dorr LD, Scott RD, Scott WN (1998) Rationale of the knee society clinical rating system. Clin Orthop Relat Res 248:13–14
13. Lewold S, Robertsson O, Knutson K, Lidgren L (1998) Revision of unicompartmental knee arthroplasty: outcome in 1,135 cases from the Swedish Knee Arthroplasty study. Acta Orthop Scand 69(5):469–474
14. Lingaraj K, Morris H, Bartlett J (2011) Polyethylene thickness in unicompartmental knee arthroplasty. Knee 18(3):165–167
15. Michos J, Rallis J, Fassoulas A (2006) Fracture of femoral component in a resurfacing total knee arthroplasty. J Arthroplasty 21(7):1068–1071
16. Moreland JR (1986) Fracture of a unicompartmental knee replacement femoral component. Clin Orthop Relat Res 206:166–168
17. Panousis K, Murnaghan C, Koettig P, Grigoris P (2004) Fracture of the femoral component of a Brigham unicompartmental knee: a case report. Knee Surg Sports Traumatol Arthrosc 12(4):307–310
18. Pegg E, Pandit H, Gill HS, Keys GW, Svard GC, Connor JJ, Murray DW (2011) Examination of ten fractured Oxford unicompartmental knee bearings. J Bone Joint Surg Br 93(12): 1610–1616
19. Ridgeway SR, McAuley JP, Ammeen DJ, Engh GA (2002) The effect of alignment of the knee on the outcome of unicompartmental knee replacement. J Bone Joint Surg Br 84(3):351–355
20. Sandborn PM, Cook SD, Kester MA, Haddad RJ Jr (1987) Fatigue failure of the femoral component of a unicompartmental knee. Clin Orthop Relat Res 222:249–254
21. Saragaglia D, Estour G, Nemer C, Colle PE (2009) Revision of 33 unicompartmental knee prostheses using total knee arthroplasty: strategy and results. Int Orthop 33(4):969–974
22. Simpson DJ, Gray H, D'Lima D, Murray DW, Gill HS (2008) The effect of bearing congruency, thickness and alignment on the stresses in unicompartmental knee replacements. Clin Biomech 23(9):1148–1157
23. Simpson DJ, Price AJ, Gulati A, Murray DW, Gill HS (2009) Elevated proximal tibial strains following unicompartmental knee replacement-a possible cause of pain. Med Eng Phys 31(7):52–57
24. Small SR, Berend ME, Ritter MA, Buckley CA, Rogge RD (2011) Metal backing significantly decreases tibial strains in a medial unicompartmental knee arthroplasty model. J Arthroplasty 26(5):777–782
25. Springer BD, Scott RD, Thornhill TS (2006) Conversion of failed unicompartmental knee arthroplasty to TKA. Clin Orthop Relat Res 446:214–220
26. Tabor OB Jr, Tabor OB, Bernard M, Wan JY (2005) Unicompartmental knee arthroplasty: long-term success in middle age and obese patients. J Surg Orthop Adv 14(2):59–63