



Three Cases of Femoral Stem Failure in Rotating Hinge Revision Total Knee Arthroplasty: Causes and Surgical Considerations

Nemandra A Sandiford, FRCS, Jonathan RA Phillips, FRCS*,
Diane L Back, FRCS[†], Andrew D Toms, FRCS*

Complex Arthroplasty Unit, St George's Hospital, London,

**Exeter Knee Reconstruction Unit, Princess Elizabeth Orthopaedic Centre, Royal Devon and Exeter Hospital, Exeter,*

[†]Knee Reconstruction Unit, Guys and St Thomas Hospital, London, UK

Catastrophic failure of stemmed components in arthroplasty is an uncommon but a serious complication. Stem fractures and techniques for addressing these have been described following hip arthroplasty but much less so following total knee arthroplasty (TKA). We review three cases of catastrophic failure of the stem in rotating hinge revision TKA prostheses. We discuss the possible mechanism of failure and review the current literature addressing this topic. Metaphyseal support needs to be optimized in order to minimize load transfer to the stem and to the junction (and the risk of fracture) if a modular component is used. When constrained components are used, radiographs need to be carefully assessed for signs of proximal loosening. Nonmodular stems are also an option in this situation.

Keywords: *Fracture, Stem, Arthroplasty, Knee, Revision*

The number of revision total knee arthroplasty (TKA) procedures performed annually is steadily increasing.¹⁻³ This number is likely to continue to increase.⁴ Stemmed prostheses are frequently used in the revision setting in order to provide stable adjunctive diaphyseal fixation in cases with suboptimal bone stock.⁵⁻¹⁰ The introduction of modular stems enables the operating surgeon to customize the size, length and offset of stems; however, it does add a junction—and potential weak point—at its attachment to the condylar part of the prosthesis.⁵

Stems transfer load to the intact diaphyseal bone and provide an effective means of bypassing bony deficiencies in the metaphysis. Constrained prostheses are often used to optimize stability if there is compromise of the collateral ligaments in the revision setting. Stresses at

the bone implant interface are increased with the use of constrained components and ultimately greater forces are transferred to the modular stem.⁵ First generation stems were nonmodular; however, modularity has become an increasingly attractive option as the surgeon has the ability to optimize the fit and fill of the medullary canal (so called off-the-shelf customisation). One potential issue with modular stems is that stress concentration can occur at the modular junction, which can potentially lead to fracture of the stem and catastrophic failure of the prosthesis.⁵ This phenomenon is relatively uncommon with knee prostheses.

Definitive management of such cases involves making an accurate diagnosis of the cause of stem fracture, ruling out the presence of infection and revision of the failed component. Revision TKA in this setting can be technically challenging, particularly removal of the retained segment of a cemented stem. Two of three cases presented in their study were not associated with component loosening. A mechanism for this was not explained. Lim et al.⁵ described five cases of failure of constrained TKA designs at

Received October 25, 2016; Accepted August 1, 2017

Correspondence to: Nemandra A Sandiford, FRCS

Complex Arthroplasty Unit, St George's Hospital, Blackshaw Rd, London SW17 0QT, UK

Tel: +44-77-9306-0641, E-mail: nemsandiford@hotmail.com

Copyright © 2018 by The Korean Orthopaedic Association

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Clinics in Orthopedic Surgery • pISSN 2005-291X eISSN 2005-4408

the stem condylar junction. This is the largest series published to our knowledge, but no suggestions were made on detection of potential early signs which may be used to predict the risk of stem fracture, methods to minimize this intraoperatively and specific issues which should be considered during preoperative planning and the operative procedure.

We present three cases of failure of modular rotating hinge (MRH) revision prostheses (Stryker, Mahwah, NJ, USA) secondary to fracture of the femoral stem with a well-fixed, asymptomatic tibial component. We discuss their presentation and management as well as issues which need to be considered during preoperative planning and technical challenges that can be encountered.

CASE REPORTS

All patients gave verbal informed consent to be included in this case report. None of the patients presented in this report was treated by any of the authors.

Case 1

A 73-year-old female patient underwent a primary TKA in 2005 due to symptomatic osteoarthritis. She underwent a two-stage revision due to infection to an MRH prosthesis (Stryker) 5 years later. She presented with a swollen, painful knee after experiencing a fall indoors in March 2015. Radiographs revealed a fracture of the femoral stem at the stem condyle junction. She had been experiencing increasing pain in this knee for several months prior to falling. Her body mass index (BMI) was 28 kg/m². She underwent a revision procedure during which the femoral component and femoral stem were found to be grossly

loose. The distal femoral bone stock was deficient and the femoral condyles were fractured and displaced. The tibial component was well-fixed. The distal femur was resected and reconstruction was performed with a global modular replacement system tumor prosthesis (Stryker). Radiographs revealed a fracture of the femoral stem at the stem condyle junction (Fig. 1).

Case 2

A 79-year-old male patient had a primary TKA performed in 2000 due to symptomatic osteoarthritis. He underwent a two-stage revision in 2008 due to infection. An MRH prosthesis (Stryker) was used. He suddenly felt a “give” in his knee whilst walking indoors in 2014, without any antecedent trauma. He presented to hospital where radiographs showed distal femoral osteolysis with fracture of both femoral condyles, radiolucent lines in the metaphyseal cement mantle and a fracture of the femoral stem at the metaphyseal/diaphyseal junction (Fig. 2). This was at the level of the junction of the stem and condylar parts of the prosthesis. The patient was very active. His BMI was 31.3 kg/m². He had an ipsilateral cemented total hip arthroplasty *in situ* which had also been previously revised as a result of a fracture of the femoral prosthesis. The femoral component was revised to a distal femoral replacement. The tibial component was found to be well-fixed and was preserved. The proximal part of the fractured stem was found to be grossly loose. This finding, along with the loose cement mantle and poor bone stock, facilitated easy removal of this part of the stem.

Case 3

A 76-year-old female patient underwent a left TKA in

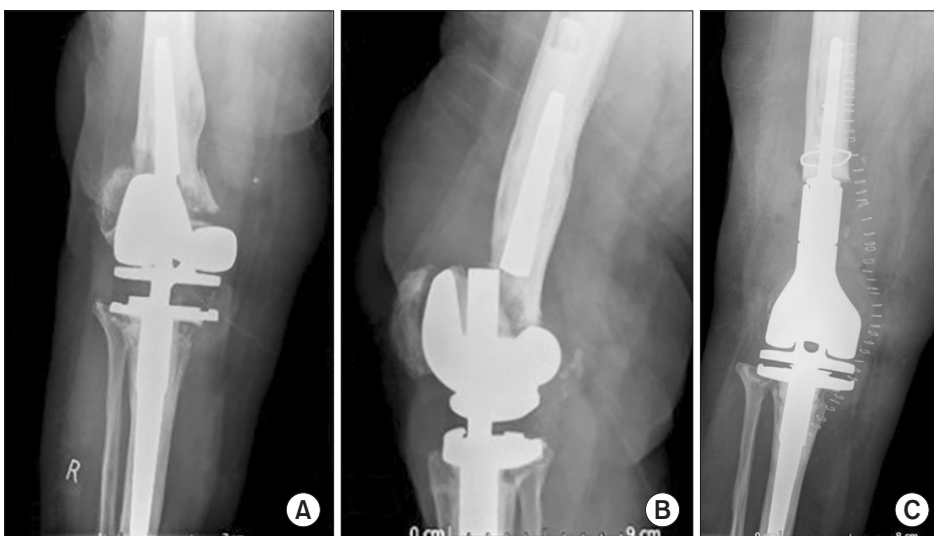


Fig. 1. Radiographs of case 1 illustrating a fracture of the femoral stem at the stem condyle junction. (A) Anteroposterior view. (B) Lateral view. (C) Post-revision radiograph.

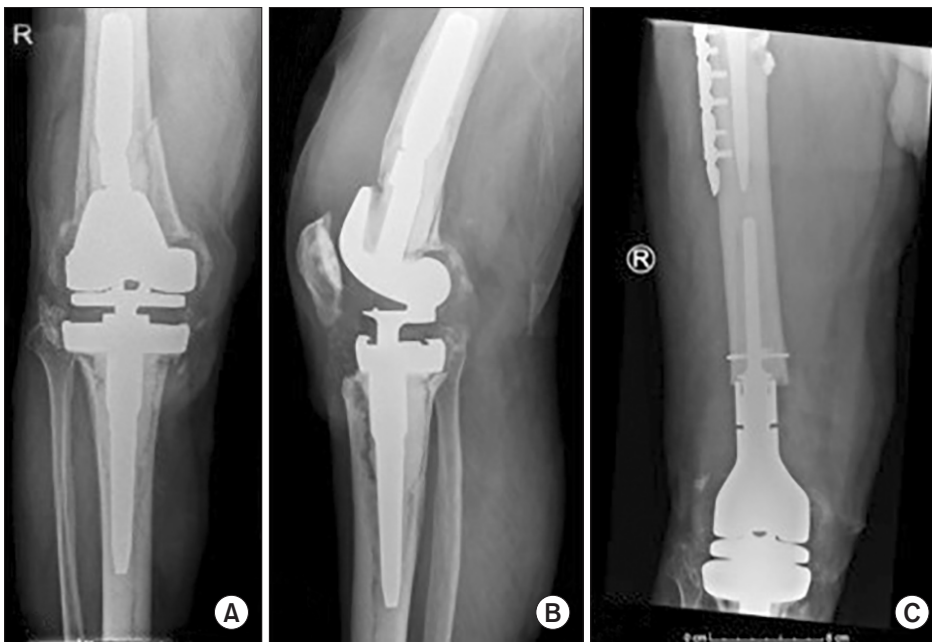


Fig. 2. Radiographs of case 2 illustrating a fracture of the femoral stem at the junction of the unsupported condylar component and the well-fixed stem. (A) Anteroposterior view. (B) Lateral projection. (C) Reconstruction with a distal femoral replacement.



Fig. 3. Radiographs of case 3. (A) The femoral stem is fractured at the point where its diameter changes. (B) There are radiolucent lines around the proximal part of the tibial stem but this was asymptomatic and the tibial component was well fixed at the time of surgery. The femoral component was revised with a longer stemmed component.

2005 as a result of symptomatic osteoarthritis. She underwent a two-stage revision to an MRH prosthesis (Stryker) in 2008 due to infection. At the time of revision, a medial tibial condyle defect was filled using a fresh frozen femoral head allograft. She had no postoperative complications. Three years later, she presented with a 4-month history of progressive left knee pain. There was no antecedent trauma. Orthogonal radiographs demonstrated a fracture of the femoral stem at the junction of the metaphysis and diaphysis (Fig. 3). The tibial component was well-fixed. An isolated femoral component revision was performed using a longer cemented stem. The proximal part of the femoral stem was well-fixed in the existing cement mantle. This was removed with the cement mantle using cement splitting chisels. In all cases, the latest revision procedure as well as the postoperative course of the patients included were uncomplicated. They were mobilising with one stick

at the time of the latest follow-up.

DISCUSSION

The cases presented in this paper have several features in common. They were all relatively active individuals with medial rotation hinge (MRH) prostheses *in situ*. These all failed by fracture at the stem condylar junction with no preceding trauma. Infection was ruled out in all cases. Radiologically there were signs of loosening of the distal part of the stem as well as poor metaphyseal femoral bone stock. Failure of the prosthesis occurred in the region of the stem corresponding to the junction of the well-fixed and loose regions of the stem, where metaphyseal support was lost. The tibial components were well-fixed in all cases and therefore not revised. Radiolucent lines were visible around the proximal third of the tibial stem in case 2 (Fig.

2), but these were nonprogressive and not associated with clinical symptoms. This is possibly explained by the forces acting through each side of the joint. The tibia experiences mainly axial loading while the femoral component experiences flexion extension, varus valgus and axial stresses.

Constrained prostheses transmit significantly greater forces to the stem.⁵⁾ In normal situations, these stresses pass *via* the femoral component into the femoral condylar bone. In the setting of deficiency of the condyles, such loads are transferred to the stem. Added to this is the fact that the stem component junction occurs at this level.

Two of the fractured stems in this series were of relatively small diameter relative to the width of the medullary cavity (Figs. 1 and 2); however, this is not a significant issue with cemented stems. In the third, the diameter of the stem was more closely matched to the diameter of the medullary canal. The fractures, in all cases, occurred at the level where bone quality and support changed but also where there was a change in the quality of fixation of the stem itself and the diameter of the stem—an effective stress riser.

The fact that these stems failed with minimal or no trauma reflects the importance of the above factors. The only reliable management option in such cases is revision of the prosthesis. The first step in surgical planning is to rule out infection. The surgeon needs to consider the surrounding bone stock as well as the length of the stem and the quality of its fixation, as this will determine the optimal surgical approach, instruments required for component extraction including removal of the proximal, retained stem segment and options for definitive reconstruction. In two of the cases presented, the femoral bone was resected and replaced with a tumor prosthesis. In the third case, the retained stem was removed along with the cement mantle

using readily available cement extraction chisels. It was then revised to a longer cemented stem.

The presence of another prosthesis proximally and the need for additional procedures such as a bridging plate to prevent formation of a stress riser must also be carefully considered. At the time of revision, the surgeon needs to optimize fixation in each zone of the bone.⁷⁾ Devices such as metaphyseal sleeves^{2,3)} can be used to optimize load transfer in zone 2 from the condylar component to the femur while minimising stresses on the stem.

The cases presented in this paper are relatively uncommon. We believe it is important that patients who have revision prostheses *in situ* and early signs of metaphyseal bone loss should be closely followed up and there should be a low threshold for investigating new onset pain in this group. Highlighting such cases provides a source of useful information to surgeons involved in managing these often complex cases and joint registries for surveillance of such prostheses and also acts as a source of feedback to manufacturers involved in the design of revision knee prostheses.

When planning revision TKA procedures, the quality of available bone stock must be carefully assessed. Metaphyseal support needs to be optimized in order to minimize load transfer to the stem and to the junction if a modular component is used. When constrained components are used, radiographs need to be carefully assessed for signs of proximal loosening. Nonmodular stems are also an option in this situation.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Akrawi H, Magra M, Shetty A, Ng A. A modified technique to extract fractured femoral stem in revision total hip arthroplasty: a report of two cases. *Int J Surg Case Rep*. 2014;5(7):361-4.
2. Bugler KE, Maheshwari R, Ahmed I, Brenkel IJ, Walmsley PJ. Metaphyseal sleeves for revision total knee arthroplasty: good short-term outcomes. *J Arthroplasty*. 2015;30(11):1990-4.
3. Graichen H, Scior W, Strauch M. Direct, cementless, metaphyseal fixation in knee revision arthroplasty with sleeves—short-term results. *J Arthroplasty*. 2015;30(12):2256-9.
4. National Joint Registry. 10th Annual report 2013: national joint registry for England, Wales and Northern Ireland [Internet]. Hemel Hempstead: National Joint Registry; 2013 [cited 2018 Mar 2]. Available from: http://www.njr-centre.org.uk/njrcentre/Portals/0/Documents/England/Reports/10th_annual_report/NJR%2010th%20Annual%20Report%202013%20B.pdf.
5. Lim LA, Trousdale RT, Berry DJ, Hanssen AD. Failure of the stem-condyle junction of a modular femoral stem in revision total knee arthroplasty: a report of five cases. *J Arthroplasty*. 2001;16(1):128-32.
6. Moreland JR, Marder R, Anspach WE Jr. The window technique for the removal of broken femoral stems in total hip

- replacement. *Clin Orthop Relat Res.* 1986;(212):245-9.
7. Morgan-Jones R, Oussedik SI, Graichen H, Haddad FS. Zonal fixation in revision total knee arthroplasty. *Bone Joint J.* 2015;97(2):147-9.
 8. Mow CS, Wiedel JD. Structural allografting in revision total knee arthroplasty. *J Arthroplasty.* 1996;11(3):235-41.
 9. Mow CS, Wiedel JD. Noncemented revision total knee arthroplasty. *Clin Orthop Relat Res.* 1994;(309):110-5.
 10. Murray PB, Rand JA, Hanssen AD. Cemented long-stem revision total knee arthroplasty. *Clin Orthop Relat Res.* 1994;(309):116-23.