



Fracture of Fully-coated Femoral Stem after Primary Total Hip Arthroplasty for Nonunion of Intertrochanteric Fracture: A Case Report

Young Soo Chun, MD, Hyung Suk Juh, MD, Yoon Je Cho, MD*, Kee Hyung Rhyu, MD

*Department of Orthopaedic Surgery, Kyung Hee University Hospital at Gangdong, Seoul, Korea,
Department of Orthopaedic Surgery, Kyung Hee University Hospital, Seoul, Korea**

Femoral stem fracture is an uncommon reason for the failure of total hip arthroplasty, with only 16 cases of fully coated stem fractures reported to date. Here we report a case in which a fully coated primary femoral stem fracture occurred after conversion to total hip arthroplasty for the non-union of an intertrochanteric fracture of the femur. Metallurgic evaluation of the etiology and mechanism revealed that the fracture was initiated by fatigue-related failure and completed by ductile failure on the posterior side of the fracture. Considering the recent trend of treating an intertrochanteric fracture with hip arthroplasty, possible stem failure should be considered, since most patients will have at least one of the known risk factors for stem fracture.

Key Words: Fracture, Cementless, Stem, Total hip arthroplasty

Implant fracture is an uncommon reason for the failure of total hip arthroplasty (THA). Most stem fractures occur in cemented prostheses due to loosening of the proximal cement, which leads to cantilever bending forces on the stem¹⁻⁶⁾. By contrast, there are only 16 reported cases of the fracture of a fully coated cementless stem made of cobalt-chrome, involving four different stems from three manufacturers⁷⁻¹¹⁾. Almost all

of those stems were long, had a small diameter, and were used in revision surgery. Here we report the case of a fully coated primary femoral stem made of cobalt-chrome and of conventional length that fractured in a patient following conversion THA for non-union of intertrochanteric fracture of femur. The details of this case are presented, together with the result of a metallurgic investigation of the prosthesis and a literature review.

CASE REPORT

A 77-year-old female with a body mass index (BMI) of 33.3 kg/m² presented after falling on her left hip. An intertrochanteric fracture of the left femur was diagnosed, which was treated by open reduction and internal fixation with compression hip screws in other hospital. Fourteen months after the index operation, she visited our clinic because of severe left hip pain. She could not stand or walk without a walker. Plain radiographs revealed loss of fixation and possible nonunion (Fig. 1A). After close observation for 4

Submitted: May 21, 2015 1st revision: June 24, 2015
2nd revision: August 4, 2015 Final acceptance: August 4, 2015
Address reprint request to

Kee Hyung Rhyu, MD

Department of Orthopaedic Surgery, Kyung Hee University
Hospital at Gangdong, 892 Dongnam-ro, Gangdong-gu, Seoul
05278, Korea

TEL: +82-2-440-6156 FAX: +82-2-440-7498

E-mail: khrhyu@gmail.com

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.

months, the patient underwent conversion THA with a fully coated femoral stem (Versys beaded fullcoat; Zimmer, Warsaw, IN, USA). The stem had a diameter of 14 mm and a length of 150 mm (Fig. 1B). Migration of greater trochanteric fragment with breakage of circlage cables was noted on the radiograph taken at 6 weeks after the operation. Despite greater trochanteric non-union, she did not complain of left hip pain and was able to walk with a cane. Four years after the operation, she presented to the emergency department of our hospital for left hip pain after having fallen from a chair. Plain radiographs demonstrated a transverse fracture in the femoral stem and the breakage of multiple cerclage cables (Fig. 2A, B). Although the level of bone defect was 2.5 cm distal to collar of stem, fractured level was different from the level of bone defect. It was 8 cm distal to collar of the stem. The femoral component was

revised using a modular femoral stem 18 mm in diameter and 140 mm distal with 55 mm proximal parts in length (Revitan; Zimmer). The remaining trochanteric fragments were reduced and fixed with a reversed anatomical plate for the right distal femur (Fig. 2C) together with a mixed auto- and allogeneic bone graft. Autograft was harvested at the iliac tubercle at the ipsilateral side. Mobilization with toe touch using walker was started 1 week after the operation. Use of walker or two crutches was recommended until 3 months after the operation. Full weight bearing was allowed 6 month after revision. At the most recent follow-up (1 year post-operatively) the patient was able to walk with a cane and without noticeable hip pain.

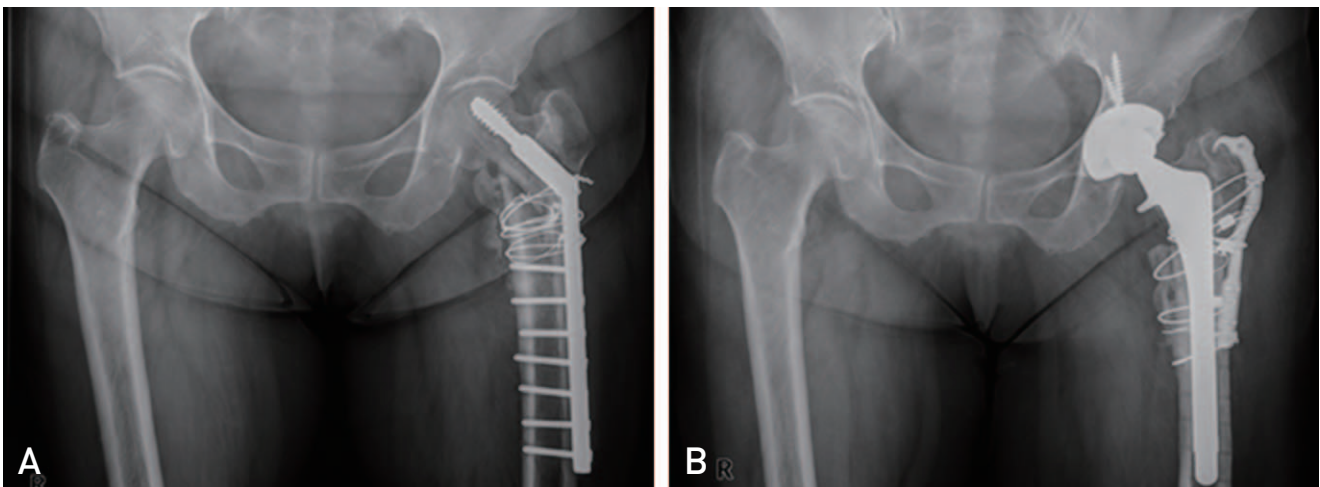


Fig. 1. (A) Anteroposterior radiograph shows possible non-union of the intertrochanteric fracture and loss of fixation. (B) Four months later, conversion total hip arthroplasty was performed using a fully coated femoral stem.

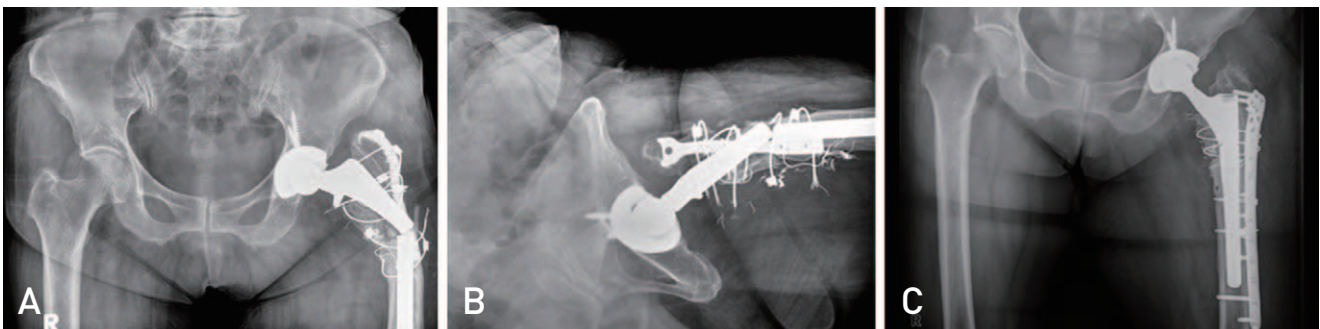


Fig. 2. (A) Anteroposterior and (B) cross-table lateral radiograph of the hip taken in the emergency department 4 years after the conversion total hip arthroplasty show stem fracture at a level lower than the initially deficient area on the medial aspect of the proximal femur. (C) Revision surgery was performed using a distal fixing modular stem with a larger diameter and bone grafts.

1. Metallurgic Investigation

The failed femoral stem was sent to the Korean Testing & Research Institute (Seoul, Korea), certified for the testing of industrial products and standardization conformance. The fractured section of the stem was analyzed by stereoscopic microscopy (M-125; Leica, Wetzlar, Germany) and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS, 6490LV; JEOL, Tokyo, Japan) at high magnification to determine the elemental composition of the stem and fracture development. It was confirmed that the stem was made of cobalt chrome alloy by SEM-EDS. Grossly, the fracture line was transverse and there was no defect. The fractured plane showed signs of fatigue failure with “beach marks” in the crack starting from the lateral end and ductile failure on the other end of the fracture (Fig. 3A). Beach marks and stair-step morphology confirmed the crack was made by fatigue failure (Fig. 3B). As the crack propagated, ductile failure, confirmed by the dimple morphology, finally led to complete separation (Fig. 3C). The fracture propagated in circular fashion. The final separation occurred on the posterior aspect, 270° from the starting point, rather than on the medial aspect of the stem.

DISCUSSION

To date, only 16 cases in which a fracture occurred in a fully coated femoral stem have been reported. Most of those stems were long and the fractures developed after revision THA. In their 1995 report, Sotereanos et al.⁷⁾

described two anatomic medullary locking femoral stem (DePuy, Warsaw, IN, USA) fractures caused by osteolysis that led to inadequate proximal femoral bone stock. In 2005, Busch et al.⁸⁾ reported fractures in two solution stems (DePuy) and three Echelon revision femoral stems (Smith and Nephew, Memphis, TN, USA). Stem fractures have been attributed to femoral bone defect, BMI >30 kg/m², the small diameter of the femoral component, and extended trochanteric osteotomy during the initial revision procedure⁸⁾. In their 2012 report, Lu et al.⁹⁾ described fractures in four beaded fully coated long femoral stems (Zimmer). In 2009, Landa et al.¹⁰⁾ reported fractures in three Echelon revision femoral stems (Smith and Nephew) with nonunion of the greater trochanter and proximal femoral bone loss. The overall risk factors reported in these cases were inadequate proximal femoral bone stock, extended trochanteric osteotomy, BMI >30 kg/m², and the use of a stem with a diameter <13.5 mm⁷⁻¹⁰⁾. Our patient had three of these four risk factors, including poor posteromedial bony support at the proximal femur, high BMI (33.3 kg/m²) and greater trochanteric nonunion, which could be considered as equivalent to extended trochanteric osteotomy. Thus, she was at high risk of stem fracture. However, in contrast to the above-mentioned reports, the fracture occurred after primary THA in our patient. Because there were posteromedial and partly lateral bone loss at the proximal femur, we considered the bone defect as Paprosky IIB. Thus, we had to choose distally fixed, fully coated stem. Although it had a collar, it was not the matter of concern. This system (Versys beaded fullcoat) had two options in

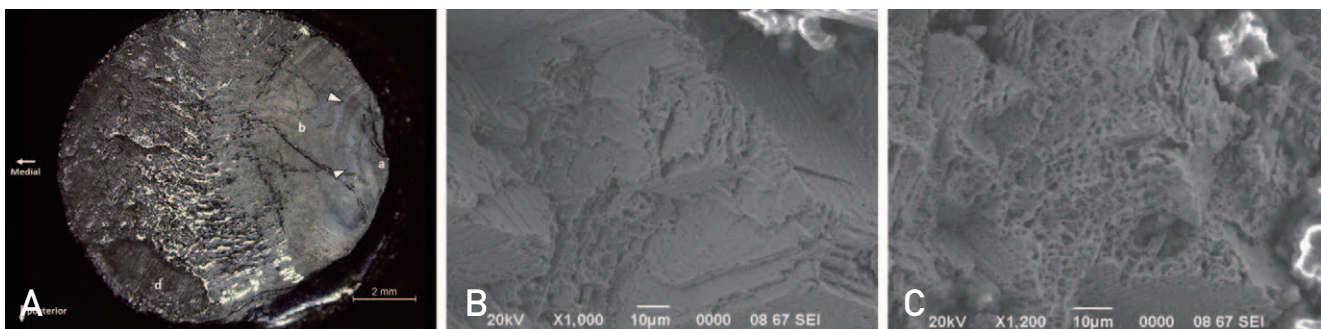


Fig. 3. (A) The fracture plane of the femoral stem ($\times 8$) shows fatigue failure starting from area 'a'. The beach marks (arrowheads) reveal the initiation of fatigue failure. Failure propagated through area 'c' to the area 'd' in counter-clockwise manner. Area 'd' shows ductile failure leading to final separation. (B) The stair-step morphology as seen on scanning electron microscopy (SEM, $\times 1,000$) and the beach mark area ('b' in Fig. 3A) confirm that the initiating mechanism was fatigue failure. (C) Dimple pattern as seen on SEM ($\times 1,200$) along the medial area ('c' in Fig. 3A) shows that the final separation was propagated by ductile failure.

length; 150 and 200 mm. The one we choose was shorter stem that was 150 mm in length and 14 mm in diameter. Because the stem configuration was not long and slender as noted in other reports (200 mm in length and <12 mm in diameter) and the patient's viable proximal femoral bone, the possibility of stem failure was not considered at or after the operation. However, the metallurgic investigation revealed that this was indeed the case and provided an analysis of the fracture's development. We believe that the greater trochanteric non-union at the early postoperative period violated the intimate biologic contact between host bone and stem, eventually led to failure of bone ingrowth at the proximal part of stem.

To our knowledge, this is the first case report to include a metallurgic analysis of the failure mechanism in a cementless, fully coated stem used in a primary THA. The fracture was initiated by fatigue failure along the lateral aspect of stem and eventually resulted in ductile failure at its posterior aspect. Propagation of the fracture was not in the lateromedial direction as expected, but rather counter-clockwise. This might reflect the normal biomechanics of the hip, in which the physiological load on the femoral head is from lateral to medial and from anterior to posterior. Metallurgic analysis revealed that the minor fall eventually completed the final part of fracture, not initiated the whole process.

This case provides orthopedic surgeons with a warning that no stem of any size is immune to fatigue fracture. Considering the recent trend of treating an intertrochanteric fracture with hip arthroplasty, possible stem failure should be considered, since most patients will have at least one of the known risk factors for stem

fracture. Surgeon should pay great attention to restore viable proximal bone stock as much as possible to prevent this unwanted stem failure.

REFERENCES

1. Wroblewski BM. *Fractured stem in total hip replacement. A clinical review of 120 cases. Acta Orthop Scand.* 1982; 53:279-84.
2. Chao EY, Coventry MB. *Fracture of the femoral component after total hip replacement. An analysis of fifty-eight cases. J Bone Joint Surg Am.* 1981;63:1078-94.
3. Rostoker W, Chao EY, Galante JO. *Defects in failed stems of hip prostheses. J Biomed Mater Res.* 1978;12:635-51.
4. Woolson ST, Milbauer JP, Bobyn JD, Yue S, Maloney WJ. *Fatigue fracture of a forged cobalt-chromium-molybdenum femoral component inserted with cement. A report of ten cases. J Bone Joint Surg Am.* 1997;79:1842-8.
5. Sadoghi P, Pawelka W, Liebensteiner MC, Williams A, Leithner A, Labek G. *The incidence of implant fractures after total hip arthroplasty. Int Orthop.* 2014;38:39-46.
6. Barrack RL. *Early failure of modern cemented stems. J Arthroplasty.* 2000;15:1036-50.
7. Sotereanos NG, Engh CA, Glassman AH, Macalino GE, Engh CA Jr. *Cementless femoral components should be made from cobalt chrome. Clin Orthop Relat Res.* 1995; (313):146-53.
8. Busch CA, Charles MN, Haydon CM, et al. *Fractures of distally-fixed femoral stems after revision arthroplasty. J Bone Joint Surg Br.* 2005;87:1333-6.
9. Lu HC, Lin CL, Chang CW, Lai KA. *Fracture of VerSys fully bead-coated long femoral stems: report on four fractures in 41 hips. Kaohsiung J Med Sci.* 2012;28:345-9.
10. Landa J, Benke M, Dayan A, Pereira G, Di Cesare PE. *Fracture of fully coated echelon femoral stems in revision total hip arthroplasty. J Arthroplasty.* 2009;24:322.e13-8.
11. Gallart X, Claret G, Garcia S, Fernández-Valencia JA, Riba J. *Rupture of extensively porous coated stems - a case series of 2 patients. J Orthop Case Rep* 2014;4:36-9.