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Case report

Failure of Emperion modular femoral stem with implant analysis

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ABSTRACT

Modularity in total hip arthroplasty provides multiple benefits to the surgeon in restoring the appropriate alignment and position to a previously damaged hip joint. The vast majority of modern implants incorporate modularity into their design with some implants having multiple modular interfaces. There is the potential for failure at modular junctions because of fretting and crevice corrosion in combination with mechanical loading. This case report details the failure of an Emperion (Smith and Nephew, Memphis, TN) femoral stem in a 67-year-old male patient 6 years after total hip replacement. Analysis of the implant revealed mechanically assisted crevice corrosion that likely accelerated fatigue crack initiation in the hip stem. The benefits of modularity come with the potential drawback of a combination of fretting and crevice corrosion at the modular junction, which may accelerate fatigue, crack initiation and ultimately reduce the hip longevity.

Introduction

Modularity in total hip arthroplasty provides the surgeon with a great deal of freedom to account for complex native anatomy and easily change stem version, length, and offset. Multiple types of primary and revision modular stems have been developed. The Emperion (Smith and Nephew, Memphis, TN) femoral stem was introduced in 2006 and has a cylindrical stem that is attached by a taper connection to a sleeve with the sleeve first placed in metaphyseal bone followed by stem impaction. The sleeve and stem provide distal and proximal fixation, adjustment for proximal and distal sizing mismatch, and manipulation of stem version [1].

Device fracture can occur near the proximal end of the sleeve because of fatigue. This has been demonstrated in the laboratory setting with the S-ROM stem (DePuy Synthes, Warsaw, IN) [2], and a total of 9 fatigue failures near the proximal end of the sleeve connection have been reported in the clinical setting with this implant [3-5]. There has been one case report documenting Emperion (Smith and Nephew, Memphis, TN) stem fracture [6]. To our knowledge, there has been no previously reported microscopic and metallurgical analysis of this device after retrieval for fracture.

This case report provides the clinical history of a patient who had failure of a modular femoral stem after total hip replacement with metallurgic and microscopic analysis performed on the retrieval to determine the mode of failure.

Case history

The patient is a 67-year-old morbidly obese (body mass index, 43) male with no other significant medical history who underwent left total hip replacement in 2008. He had an uneventful postoperative course with no immediate complications, resolution of pain, and return to work. He had no hip pain before device failure and states he had been very happy with his hip replacement. Seventy-four months after initial hip replacement, he was in a restaurant and got up from a seated position when he felt a pop in his left hip. He returned to a seated position and stated that the hip was not initially painful. He then attempted to stand once again and was unable to bear weight with instability in the hip and severe pain. He presented to our facility and underwent comprehensive evaluation to include examination, radiographs, and exclusion of infection. On examination, he was found to have external rotation of the left leg in relation to the right leg with fullness appreciated

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on palpation. He had significant pain with any motion of the hip. He remained neurovascularly intact to the left leg. Radiographic evaluation was consistent with failure of the femoral stem because of fracture (Fig. 1). The options were discussed with the patient, and a revision of his femoral component was recommended. The patient was admitted and informed consent was obtained before surgery. At the time of surgery, the soft tissues were found to be healthy with no evidence of metal transfer or infection. A high-speed router and flexible osteotomes were used to disrupt the proximal bone-implant interface that was exposed at the level of the stem fracture. The stem was inset into the sleeve with nothing to grab for stem removal and no instrumentation available to drill and tap into the implant. The stem was well fixed distally after the proximal interface had been exposed, and multiple attempts to disengage the stem from the sleeve proximally were unsuccessful. An extended trochanteric osteotomy was performed to remove the stem, and it was verified to have excellent fixation with no evidence of distal loosening. There was bone noted within the distal spline that was cortical in nature. A high-speed burr was used to remove this remaining section of bone after the stem was removed. A liner exchange was performed to remove any potential metal debris from the polyethylene, and a revision modular Wagner-type femoral stem (DePuy Synthes, Warsaw, IN) was placed. Repair of the extended trochanteric osteotomy was performed with the use of a claw cable plate.

He was made touchdown weight-bearing for a period of 6 weeks to allow initial healing of the femoral stem and osteotomy site with the use of a walker and was then transitioned to a cane. He was able to walk without an assistive device by 8 weeks postoperatively. His course has been uneventful with resolution of pain and full return of function when last seen 6 months postoperatively (Fig. 2). He has been able to return to work and exercises routinely with no limitations.

Figure 1. Left hip anteroposterior radiograph on presentation demonstrating failure of the femoral implant at the stem-sleeve junction.

Figure 2. Left hip anteroposterior radiograph 6 months after revision left hip arthroplasty with the use of extended trochanteric osteotomy and revision modular femoral stem.

Discussion

The hip stem in the present study experienced final overload failure suddenly as the patient rose from the seated position with no preceding pain or dysfunction. The fatigue crack that eventually led to this overload failure was initiated on the lateral side just below the proximal stem-sleeve taper interface (Fig. 3a). The interior lateral wall of the sleeve taper component above the distal stem fracture surface (Fig. 3b) and the interior taper sleeve (Fig. 3c) showed evidence of fretting and crevice corrosion on the opposing tapered surfaces to the area of fatigue crack initiation. In a previous retrieval analysis of 78 S-ROM stems (DePuy Synthes, Warsaw, IN), 88% had experienced corrosion and 65% showed fretting at the stem-sleeve interface [3]. Seven (9%) of the devices had experienced stem fracture near the proximal end of the stem-sleeve interface at an average of 111 months after implantation in a similar manner to this case in which failure occurred 74 months after the initial hip replacement. The findings of the failed S-ROM stems (DePuy Synthes, Warsaw, IN) are similar to the results of our analysis with a significant amount of corrosion identified at the taper surface (Fig. 3c).

We suspect the process leading to the catastrophic failure of the implant occurred over an extended period of time despite the patient being asymptomatic. Implant analysis revealed substantial corrosion noted on the lateral side of the fracture surface (lower portions of Fig. 3d and e), which may have accelerated fatigue crack initiation on the lateral side of the hip stem. The crack spread with continued fatigue loading but was temporarily arrested at each of

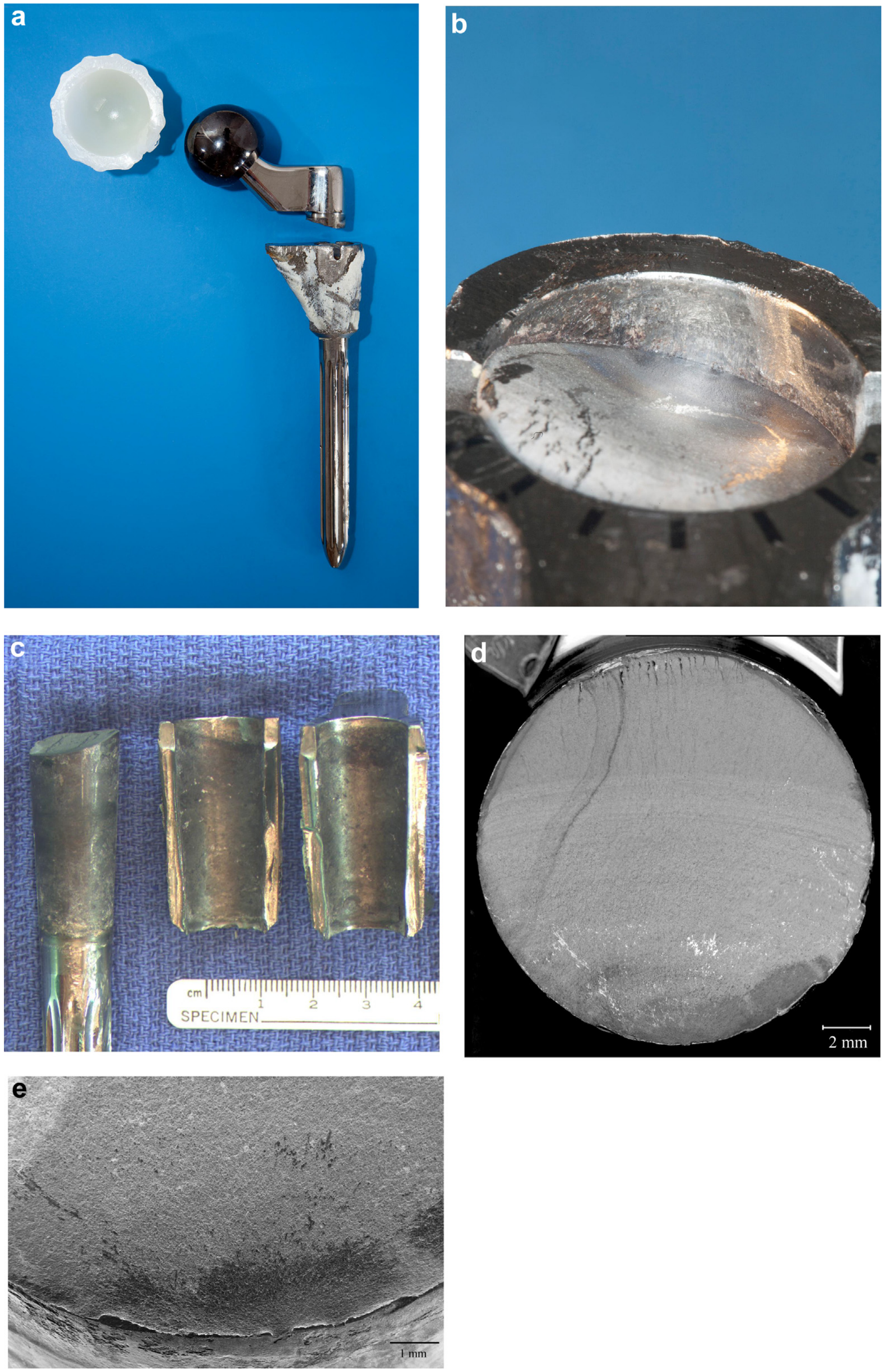

Figure 3. (a) Photograph of modular hip retrieval components. (b) Photograph of interior taper sleeve with distal stem fracture surface. (c) Photograph of the exterior lateral distal stem, interior lateral distal sleeve, and interior medial distal sleeve components. (d) Two-dimensional stitched X-Y light microscopy image of entire proximal stem fracture surface. (e) Scanning electron microscopic image of proximal fracture surface showing chevron marks indicating the fatigue crack initiation point emanating from the lateral surface.

the conchoidal markings (Fig. 3d). The propagating fatigue crack continued to reduce the area of remaining intact segment of the stem until it could no longer support the physiological loading cycles, eventually leading to overload failure. Fatigue cracks are known to initiate on the tension side of a hip implant, which is the lateral side, under normal physiologic loading.

In this case, the patient was morbidly obese with increased cyclical loads being placed on the implant in comparison to an average weight person. We suspect this contributed to device failure in a relatively short time after implantation. An increase in body weight places significantly increased forces across the hip joint, including any modular junctions. There have been several case reports of modular implant failures of the Profemur Z stem (Wright Medical Technology, Arlington, TN) in morbidly obese patients. Weight, activity level, and stem design were all suspected contributory factors to failure in these cases [7,8]. Review of the device literature for the S-ROM (DePuy Synthes, Warsaw, IN) and Emperion (Smith and Nephew, Memphis, TN) stems advises caution with hip replacement in the morbidly obese with no specific contraindication to the use of this implant design in these patients.

The distal stem was well fixed at the time of revision surgery, which would make extraction difficult without the use of an extended trochanteric osteotomy. The modularity of this stem could have potentially allowed for removal of the stem with maintenance of the sleeve and placement of a new stem. However, we would not recommend this as there was significant corrosion with concern for damage when placing a new stem if the sleeve was a contributing factor in the initial implantation, and lastly, the patient failed this device type in a relatively short time period with concern for repeat failure with the same type of implant. It also would be technically difficult to accomplish as the stem was not protruding in any manner to obtain a grasp of it and would require drilling and tapping or other similar process such as entering the knee and tapping the stem out in a retrograde fashion.

Summary

Modularity in femoral hip stems provides the surgeon with more options and freedom for implantation in comparison to monoblock femoral stems. The use of modular femoral stems can create other issues with known device failure at modular interfaces. In this instance, the failure mechanism was attributed to crack initiation likely stemming from crevice and fretting corrosion on the lateral side of the hip stem within the taper sleeve. The patient was morbidly obese which may have also contributed to increased stress and early device failure. The fatigue crack propagated across the surface, and the hip stem eventually failed because of ductile overload near the medial side of the stem. No evidence of manufacturing or metallurgical irregularity was found on the hip stem or sleeve components. The fatigue fracture of this modular hip stem represents an unusually early failure that was likely accelerated by crevice corrosion within the taper sleeve with the patient's morbid obesity identified as a potential contributing factor. We recommend caution with the use of modular femoral stems in morbidly obese patients because of increased cyclical loading across implant junctions. We would recommend being prepared to proceed with extended trochanteric osteotomy for stem removal when presented with a similar clinical scenario.

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