



Case report

Incarcerated fracture fragments of Longevity polyethylene liners after total hip arthroplasty

Michael A. Yee, MD ^{a,*}, Thomas J. O'Keefe, MD ^b, Suzanne Winter, MS, CCRC ^b

^a Department of Orthopaedic Surgery, University of Michigan, Ann Arbor, MI, USA

^b Department of Orthopaedic Surgery, St. Joseph Mercy Health System, Ann Arbor, MI, USA

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ABSTRACT

Highly cross-linked polyethylene liners are widely used in total hip arthroplasty because they experience lower wear rates than conventional polyethylene liners. However, the cross-linking process does decrease the resistance of polyethylene to fatigue failure and fracture. This report describes 2 cases of highly cross-linked polyethylene liner fracture occurring in association with hip dislocation and unsuccessful closed reduction consequent to blockage by an incarcerated liner fragment. These cases highlight the known polyethylene fracture risk factors of thin and unsupported polyethylene and large bearing sizes. They also reinforce the importance of a careful evaluation of postreduction radiographs for the presence of a concentric reduction and provide a possible explanation for postoperative hip instability, multiple dislocations, and incomplete seating of the femoral head on attempts at closed reduction. Copyright © 2016 The Authors. Published by Elsevier Inc. on behalf of American Association of Hip and Knee Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Since the late 1990s, highly cross-linked polyethylene (HXLPE) liners have been used in total hip arthroplasty (THA) to reduce wear rates and the incidence of associated osteolysis. Both in vitro and in vivo studies have confirmed that the cross-linking process successfully changes polyethylene (PE) characteristics to reduce wear [1–4]. Despite the advantage of HXLPE in terms of wear, it has been noted that cross-linking reduces fracture resistance. Several case reports have documented fractures about the rim of HXLPE liners [5–12]. Although most researchers agree that risk factors exposing implants to these types of fractures include acetabular component malposition [11], excessive femoral neck impingement on the PE liner [6], and the use of thin PE liners with large femoral heads [12,13], other researchers have concluded that cracks may occur in the absence of predisposing factors [8]. This case report describes 2

cases of HXLPE liner fractures occurring in association with hip dislocation with subsequent incomplete, nonconcentric reductions. These unsuccessful reductions were attributed to blockage by incarcerated liner rim fracture fragments.

Case histories

Case 1

An 80-year-old man underwent primary right THA with placement of a 54-mm trabecular metal modular acetabular shell (Zimmer, Warsaw, IN), a 3.5-mm lateralized Longevity cross-linked PE liner (Zimmer, Warsaw, IN) with 36-mm inside diameter, a Fitmore press fit stem (Zimmer, Warsaw, IN), B11 12/14 taper with +3.5-mm neck length, and a 36-mm cobalt-chrome femoral head (Fig. 1). The patient's recovery was uncomplicated and he returned to a high level of function until 5 months postoperatively, when he dislocated his right hip after a slip and fall from standing position (Fig. 2a). There had been no prior sensation of instability until this traumatic event. The hip was reduced in the emergency department, but the patient continued to have episodes of instability and experienced multiple subsequent dislocations. Postreduction radiographs consistently demonstrated a nonconcentric, incomplete reduction, which was not recognized until the patient

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* Corresponding author. 2912 Taubman Center, SPC 5328, 1500 E. Medical Center Dr., Ann Arbor, MI 48109, USA. Tel.: +1 734 930 7380.

E-mail address: yeemi@med.umich.edu

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Figure 1. Case 1: Initial postoperative right hip radiograph.

was evaluated by members of the orthopaedic team (Fig. 2b). On exploration of the hip joint, a fragment of the posterior lip of the HXLPE liner was found incarcerated between the femoral head and the acetabular cup liner which had been blocking successful reduction (Fig. 3). Cultures showed no sign of infection. The liner and femoral head were revised with a PE cobalt-chrome 32-mm bearing and 10°-augmented, oblique-face constrained liner (Zimmer, Warsaw, IN). The acetabular shell and femoral stem remained in good position and were not exchanged (Fig. 4). After revision, the patient experienced an uneventful recovery and has had excellent function to date. He is currently two and a half years

status after revision surgery, and his last follow-up examination was 1 year postoperatively. The patient presented in this case was informed that details of his operative and postoperative course would be submitted for publication, and he provided verbal consent.

Case 2

A 26-year-old woman with rheumatoid arthritis underwent primary right THA with placement of a 50-mm trabecular metal modular acetabular shell (Zimmer, Warsaw, IN), a 3.5-mm lateralized Longevity cross-linked PE liner (Zimmer, Warsaw, IN) with 36-mm inside diameter, a size 12 Trabecular Metal press fit stem (Zimmer, Warsaw, IN) with a +3.5-mm neck length, and 36-mm cobalt-chrome femoral head (Fig. 5). Acetabular version at the time of surgery was felt to be within acceptable limits, but subsequent radiographs demonstrated a vertical inclination of 55°. The patient had a fall from standing onto the right hip 8 months after surgery. There was no fracture or dislocation at that time, but she had feelings of instability in the months following the fall. At 11 months, the patient suffered a spontaneous dislocation with minimal internal rotation, flexion, and adduction while sitting on a stool (Fig. 6a). Her hip was reduced in the emergency department, but radiograph imaging showed that the femoral head was not completely seated within the acetabular liner (Fig. 6b). On exploration, the patient was found to have a fragment of an unsupported section of the PE liner incarcerated between the liner and the femoral head. The fragment included that segment of the liner from the posterosuperior rim between 2 successive indentations in the PE rim that facilitate the achievement of proper liner rotation before final seating. The fracture plane occurred at the contact point between the liner and the edge of the rim of the metal shell (Fig. 7). The entire component was revised to a more desirable abduction angle of 45° and 20° of anteversion and secured with 3 dome screws (Fig. 8). The PE liner and femoral head selections were 36 mm in diameter. After revision, the patient experienced an uneventful recovery and has had excellent function to date. She is currently 2 years status after revision surgery, and her last

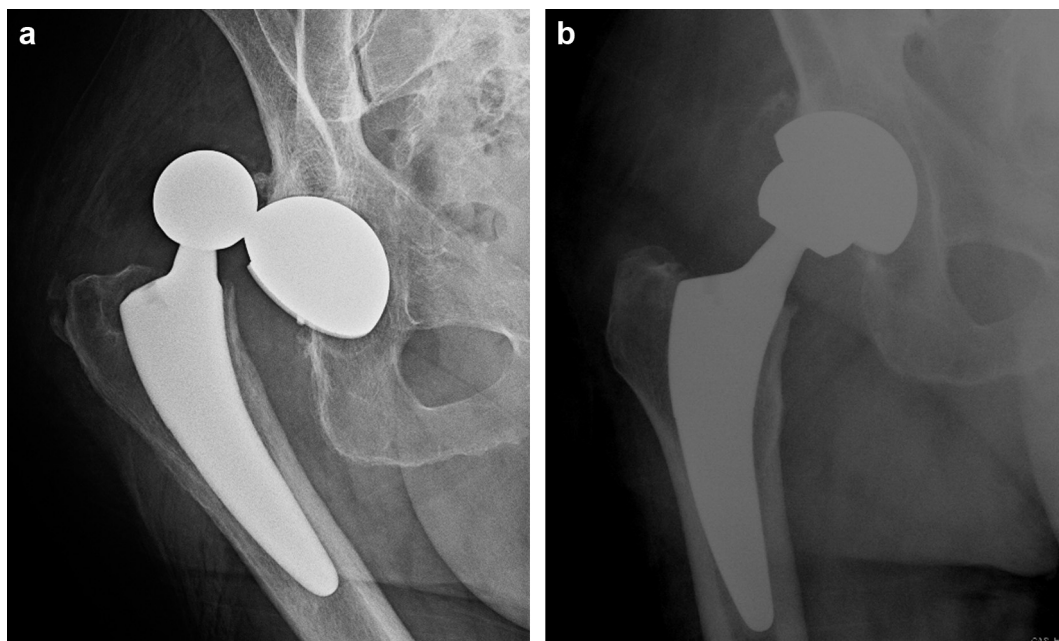


Figure 2. Case 1: Anteroposterior hip radiographs. (a) Dislocation of the right hip. (b) Interval relocation of the femoral head within the acetabular cup. The head is subtly eccentric and proud in comparison to the initial postoperative radiograph.

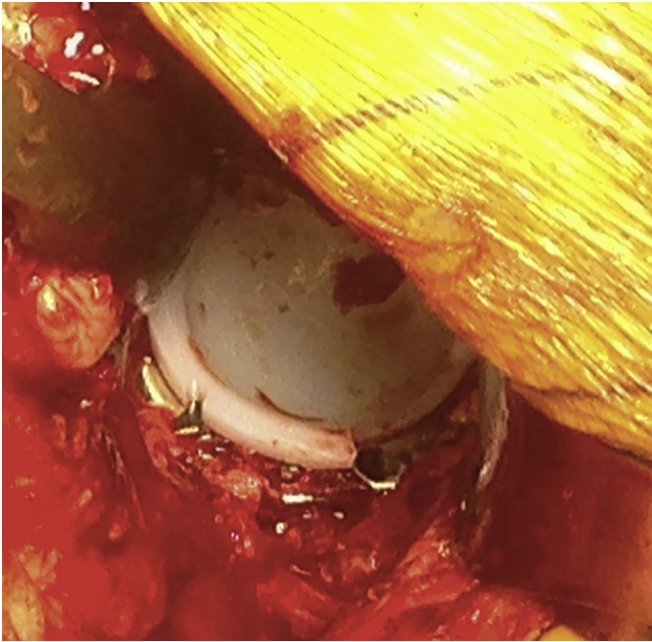


Figure 3. Case 1: Intraoperative picture during right THA revision showing a poster-superior defect in the acetabular liner. The fracture fragment has been removed from its position interposed between the head and cup.

follow-up examination was 17 months postoperatively. The patient presented in this case was informed that details of her operative and postoperative course would be submitted for publication, and she provided verbal consent.

Discussion

Osteolysis secondary to debris from PE wear has traditionally been a common cause of loosening and failure in THA. Both in vitro and in vivo studies have shown that HXLPE liners have significantly

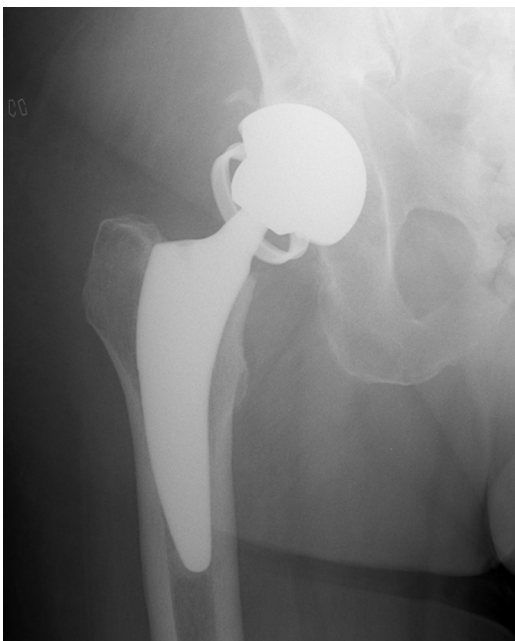


Figure 4. Case 1: Postoperative right hip radiograph after revision to a constrained liner.

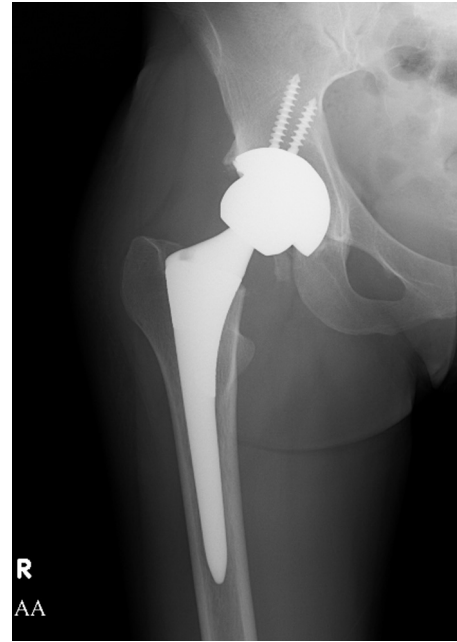


Figure 5. Case 2: Initial postoperative right hip radiograph.

decreased wear rates compared to conventional PE liners [1–4]. The enhanced resistance to wear exhibited by HXLPE liners is attributed to their resistance to plastic deformation. However, improvement in wear rate is associated with a reduction in tensile strength, ductility, and toughness of HXLPE liners, ultimately lessening the liner's fracture resistance [14]. An analysis of voluntarily reported Longevity (Zimmer, Warsaw, IN) liner fractures to the U.S. Food and Drug Administration through April 2013 shows that 74 events had been reported since the liner was approved in 1999 [13]. Of these cases, most occurred in patients with small acetabular shells (<54 mm) and large-diameter femoral heads (>36 mm) [13]. This combination of a small shell and a large head requires the use of a thin liner, and liners with <7-mm thickness at the weight-bearing surface and <4.8-mm thickness at the rim are more likely to fracture than thicker liners.

There are several case reports of fractured HXLPE liners in the literature. The earliest report included 4 Longevity (Zimmer, Warsaw, IN) liners from 2 patients that demonstrated cracking and rim failure at the grooves that articulate with the shell locking mechanism [11]. The authors concluded that the use of a thin acetabular liner, relative vertical cup alignment, large femoral head implantation, and the inherent properties of the HXLPE predispose the liner to failure [11]. Other case reports documenting fractured HXLPE liners provide similar conclusions in regard to predisposing factors to such events [9,12]. Hara et al. [10] noted that fractures likely initiate at the rim-dome junction and propagate superficially to the articular surface. Duffy et al. [6] reported a case of rim failure due to excessive femoral neck-liner impingement secondary to the use of a Marathon (DePuy Synthes, Warsaw, IN) extended lip liner. In this case, impingement was not demonstrated on revision if a neutral liner was used [6]. Similarly, Furmanski et al. [7] studied 4 different HXLPE extended lip liners and found that all liners had fractures despite being well positioned. Thus, the impingement stress experienced by an extended lip liner during normal mechanical loading events appears to be sufficient to fracture the HXLPE liner. This is especially evident at the thin areas occurring at the shell-liner locking grooves. Another report of 9 retrieved HXLPE liners found that 6 had shallow initiated cracks, even in 3 liners that

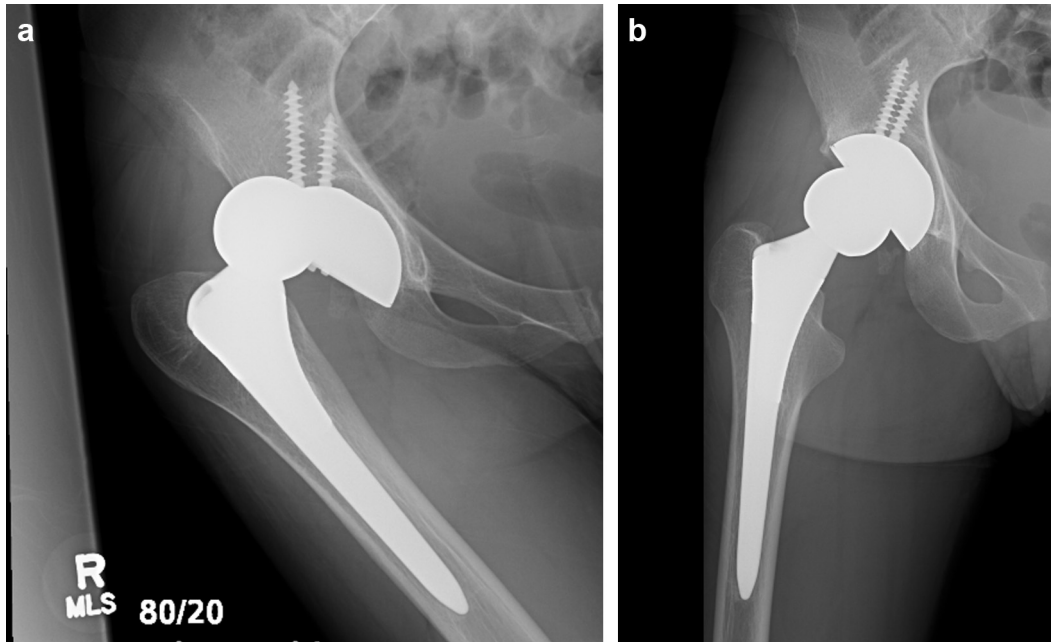


Figure 6. Case 2: Anteroposterior hip radiographs. (a) Dislocation of the right hip. (b) Interval relocation of the femoral head within the acetabular cup. The head is concentrically reduced but proud of the initial postoperative position.

were retrieved after only 1 month in vivo [8]. Therefore, these small cracks may have occurred during manufacturing, surgical implantation, or initial postoperative loading.

Despite the acknowledgment of liner fractures in other case reports, our report is the first documentation of fractures with associated incarcerated fragments blocking successful concentric reductions of the femoral head. In the only other case report that describes liner fractures after a specific dislocation event, the dislocation was anterior [5]. The fragment was from the anterosuperior rim, and the hip was successfully reduced but unstable [5]. In our case 2, a significant traumatic event was followed by the development of a sensation of instability culminating in a dislocation which was spontaneous. It is likely that in this case, a fracture occurred with the initial event that ultimately leads to further fatigue and crack propagation with enlargement of the

cleavage plane between the segmental indentations of the liner. We believe that it is likely that, in this instance, dislocation occurred with the fragment remaining tethered on one end and that, with relocation, the fragment was pulled into the acetabular component by the returning femoral head where complete dissociation occurred.

The liners used in these cases accommodated the largest femoral head diameter for the shell selected. Consequently, the liners, each with a dome thickness of 6.8 mm and rim thickness of 3.2 mm, were the thinnest liners available for the implant. The liner

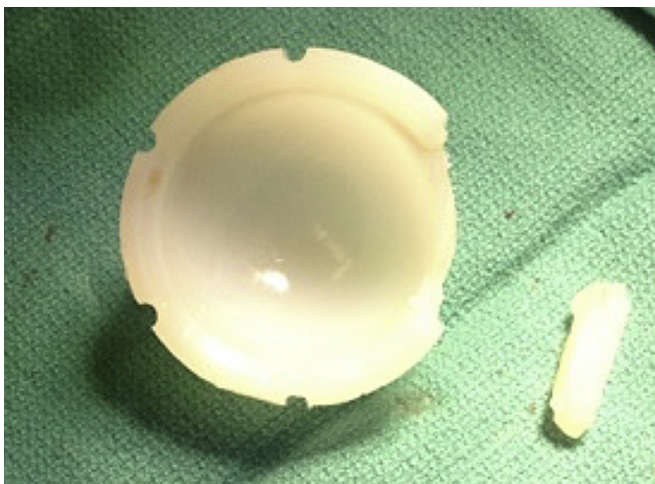


Figure 7. Case 2: Highly cross-linked polyethylene acetabular liner with posterior rim fracture fragment. Intraoperatively, the fragment was found incarcerated between the liner and the femoral head.



Figure 8. Case 2: Postoperative right hip radiograph after acetabular revision with correction of the abduction angle and liner replacement.

thickness was insufficient to prevent PE failure in our patients which further supports the suggestion made by previous researchers that hips with large femoral heads and thin liners are predisposed to such events. Acetabular liner fracture is a known complication that may occur at higher rates with the use of large femoral heads and thin HXLPE liners with unsupported rims especially in the circumstance of vertical acetabular positioning. Since the time of revision in case 2, the frequency and widespread nature of rim fracture associated with this liner design has been generally recognized. The authors have since abandoned the use of components whose design includes an unsupported PE liner. These cases highlight the importance of a careful review of postreduction films for complete and concentric seating of the femoral head within the acetabular cup. It is important to consider the possibility of an incarcerated liner fracture fragment in poorly reduced prosthetic hips and hips that experience multiple dislocations and subjective instability, especially in those with large femoral head components and thin acetabular liners.

Summary

Fracture of highly cross-linked PE acetabular liners is a known but rare complication associated with THA. In this case report, the authors present an exceptionally uncommon clinical entity in which the liner fracture fragment becomes incarcerated between the femoral head and the remaining liner after attempts at closed reduction. This report supports the conclusions of the authors of previous reports that suggest that the use of large femoral heads and thin acetabular liners increases the risk of liner fracture. However, this is the first report to document the incarceration of a liner fracture fragment and an incomplete seating of the femoral head after attempted closed reduction resulting in hip instability and recurrent dislocation. Importantly, clinicians must closely review postreduction radiographs to assess for concentric seating of the femoral head within the acetabular component, as non-concentric reductions may indicate liner fragment incarceration and the need for revision arthroplasty.

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