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Case report

Notching of the Neck After Acetabular Constraint Necessitating Femoral Component Revision

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ABSTRACT

A 75-year-old woman who had previously undergone a left revision total hip arthroplasty with the use of a constrained acetabular liner presented with recurrent dislocation of the hip. Intraoperatively, there was metallic staining of the hip capsule and significant notching of the femoral neck, consistent with impingement of the intact locking ring, necessitating stem revision. Constrained acetabular liners have high failure rates due to intraprosthetic impingement, but to our knowledge, failure due to notching of the femoral component and metallosis from repeated impingement has not been described. Surgeons should be aware of this potential mode of failure.

Introduction

Instability remains one of the most common complications after total hip arthroplasty (THA) with dislocation rates ranging from 0.8% to 3.2% after primary THA and as high as 25% after revision THA [1]. Etiologies include poor component position, gluteus medius muscle deficiency, trochanteric nonunion, soft-tissue imbalance, impingement, and neuromuscular disorders [1]. For those patients with recurrent hip instability in the setting of cognitive or abductor deficiencies, constrained acetabular liners may provide added stability [2]. The increased femoral head coverage that these liners provide comes at the cost of a decreased arc of motion and intraprosthetic impingement, which transmits forces to the liner-implant and implant-bone interface [3]. Repeated impingement ultimately results in four modes of failure: 1) failure of cup fixation to the pelvis, 2) dissociation between constrained liner and metal shell, 3) biomaterial failure, and 4) dislocation of femoral head [4]. Biomaterial failure includes catastrophic wear, fracture of the constrained liner, or breakage of the metallic locking ring. Reported failure rates for constrained liners are as high as 25%, with failure of the locking ring being the most common cause [4]. While there are reports of notching of the femoral neck due to impingement with ceramic or metal liners after primary THA with the use of metal-on-metal, [5–13] ceramic-on-ceramic, [14,15] and dual-mobility components, [16–22] to our knowledge, there are no such cases reported with the use of constrained liners.

We report the occurrence of significant notching of the femoral neck as a result of impingement between the femoral stem and a constrained acetabular locking ring. This situation represents a potential cause of implant failure and metal particle generation of which arthroplasty surgeons should be aware when performing revision surgery for instability involving constraint. The patient was informed that data concerning the case would be submitted for publication and provided consent.

Case history

A 75-year-old woman with a history of hypertension, hyperlipidemia, anxiety, and depression presented to the emergency

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department in July 2019 with acute left hip pain after feeling a "pop" when bending over in her garden. Her leg was shortened, and she was unable to tolerate any passive hip range of motion but otherwise had a normal neurovascular examination. Four years earlier, in February 2015, the patient had undergone a primary THA using a DePuy Synthes Pinnacle cup and Summit press-fit tapered stem (DePuy Orthopedics, Inc., Warsaw, IN) elsewhere, which was complicated by multiple dislocations, ultimately requiring revision THA with a DePuy Synthes ALTRX 10° lipped constrained acetabular liner in June 2015. She had no further dislocations until January 1, 2016, when she initially presented to our institution with a posterior dislocation of her femoral component (Fig. 1). Given her constrained implant, no attempt at closed reduction was performed, and she was taken to the operating room the following day for a second revision surgery. Intraoperatively, there was approximately 1 mm of notching noted in the posterior neck of the femoral component consistent with intra-articular impingement with the prior 10° lipped constrained liner. The femoral component was well-fixed, so it was retained, despite the minor damage to the neck. The acetabular component was also well-fixed with an intact locking mechanism, so it was retained despite increased anteversion, measuring 43° using the Woo and Morrey method (Fig. 1) [23]. Instead, the surgeon decided to use a neutral liner and increase femoral offset, selecting a 32 mm cobalt chrome femoral head with a +9 mm offset, which resulted in an acceptable impingement-free range of motion during intraoperative testing. She had no further dislocations until her second presentation to our hospital in July 2019.

In the emergency department, radiographs demonstrated a superior dislocation of her femoral component with an intact constrained acetabular liner and locking ring (Fig. 2). Laboratory investigation revealed a normal white blood cell count and erythrocyte sedimentation rate, with an elevated C-reactive protein level of 2.3 mg/dL (range: <0.5 mg/dL). Metal ions were not obtained. The left hip was aspirated, and the synovial fluid analysis was notable for 2000 nucleated cells with 66% neutrophils and cultures devoid of any growth before the revision surgery. Intraoperatively, the abductors were intact, but the femoral head was found to be protruding through a rent in the gluteal musculature. The head was reduced, and the hip joint was exposed through a posterior approach. Extensive metallosis was noted throughout the hip capsule and surrounding the granulation tissue. The metal acetabular shell was stable, so it was not revised. The constrained liner was well fixed to the cup, and the locking ring was intact but showed wear consistent with impingement posteriorly. To prevent excessive torque on the shell when removing the liner, an osteotome and a 40-mm reamer were used to section the liner in situ, ultimately allowing it to be removed in a piecemeal fashion. Inspection of the femoral component revealed three focal areas of notching on the posterior neck (Fig. 3). The stem was also stable, but given the significant wear and notching, a decision was made to revise it. The stem was removed using an extended trochanteric osteotomy and revised with a Wagner SL monoblock tapered cylindrical stem (Zimmer Biomet, Inc., Warsaw, IN). A DePuy Synthes Pinnacle ALTRX lipped liner was placed at the 12 o'clock position, and a 32 mm femoral head with a −3.5 mm offset was used (Fig. 2). Because the revision stem was placed somewhat proud with less anteversion, the hip was determined to be stable through a functional range of motion without the impingement previously noted. Postoperatively, the patient was given posterior hip precautions and used a hip abduction brace when out of bed. She worked with physical therapy daily and was discharged to a skilled nursing facility on postoperative day seven without complication. At 1-year follow-up, the patient was no longer wearing her abduction brace and ambulating without an assisted device with no further complications or dislocations.

Discussion

While constrained liners can add stability via a locking ring to increase coverage of the femoral head, they also can cause intraprosthetic impingement with the neck of the femoral component [2]. Repeated impingement most commonly results in failure of locking ring, failure of cup fixation to the pelvis, or dislocation of the femoral head [4]. While there are reports of notching of the femoral neck due to impingement after primary THA, [5–22] to our knowledge, there are no such cases reported with the use of constrained liners.

There have been several cases of femoral component damage from impingement after primary THA with the use of metal-on-metal, [5–13] ceramic-on-ceramic, [14,15] and dual-mobility components [16–22]. Vielpeau et al [19] reported a 4% incidence of femoral neck notching with the use of an early cementless dual mobility implant. They concluded that notching resulted from impingement against the posterior prominence of the metal shell, and after modifying the shell to reduce its prominence, no further

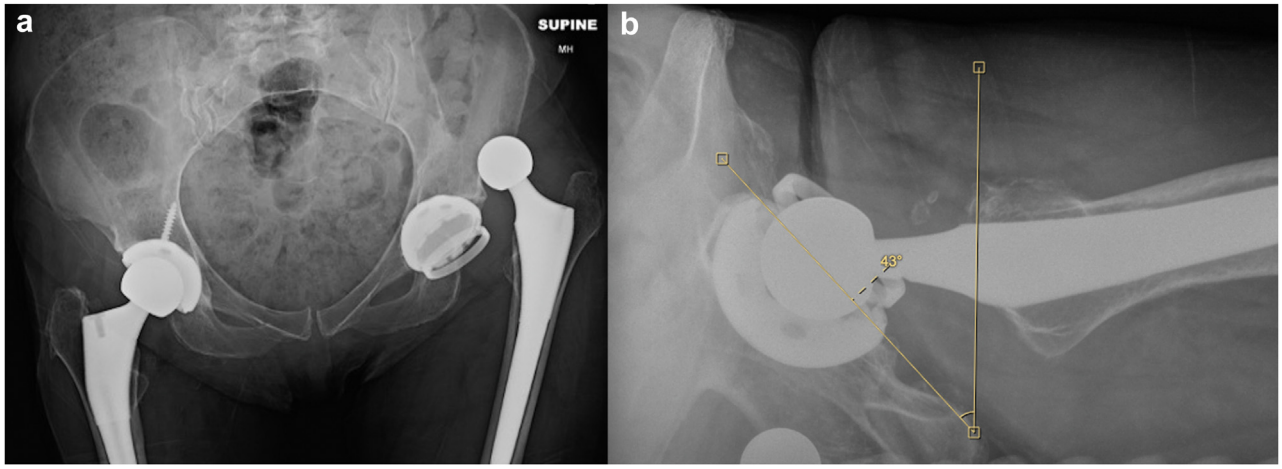

Figure 1. (a) Anteroposterior radiograph of the pelvis at initial presentation showing a posterior dislocation of the femoral component. (b) Cross-table lateral radiograph of the left hip after the patient's first revision surgery. Acetabular component anteversion was measured using the Woo and Morrey Method as the angle formed when a tangential line to the opening of the acetabulum and a line drawn perpendicular to the horizontal edge of the radiograph intersect.

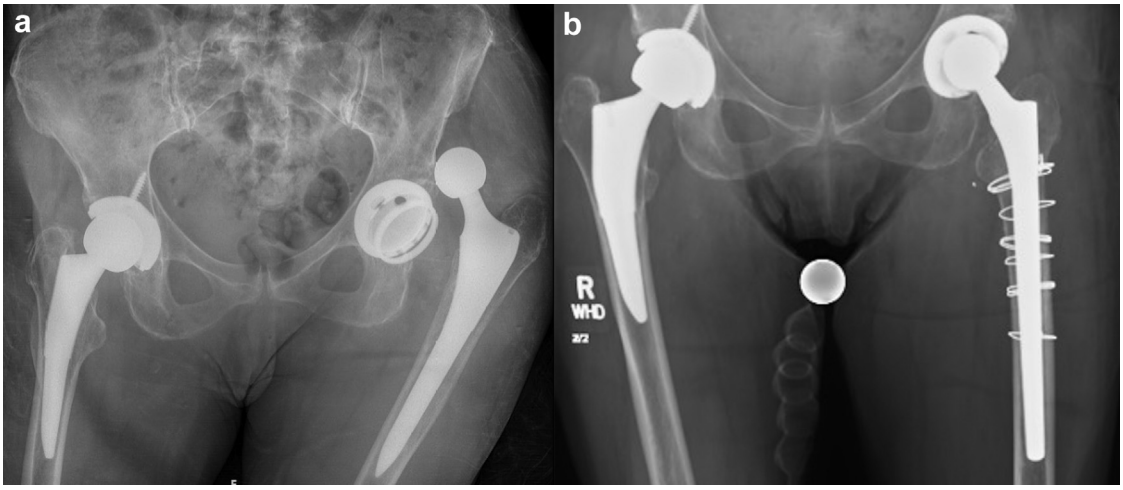

Figure 2. (a) Anteroposterior radiograph of the pelvis at second presentation showing superior dislocation of the femoral component with intact constrained liner and locking ring. (b) Final postoperative radiograph after revision left total hip arthroplasty, involving femoral component revision with head and liner exchange.

cases of notching occurred. Similarly, Matzko et al [22] described a case of femoral notching from impingement against a dual mobility acetabular bearing. They determined that increasing acetabular anteversion greater than 25-30 degrees may be a risk factor for femoral neck notching with dual mobility or other hard acetabular bearings. Donaldson et al [13] described a case where excess acetabular component anteversion lead to twin notches on the femoral neck in a metal-on-metal primary THA. The authors determined that one notch was from the initial area of impingement of the neck against the metal liner, and the second notch was due to a separate area of impingement from head-subluxation. Our patient's stem also displayed twin notches in the posterior neck at the time of her second revision. These twin notches were approximately 9 mm from the initial notch seen during her first revision surgery (Fig. 3), indicating that there was ongoing impingement of the neck against the constrained liner after increasing her offset with a +9-mm femoral head. Contributing factors likely included excessive anteversion of the femoral and acetabular components which resulted in increased impingement. The safe zone for acetabular orientation using a posterior approach is between 15° ± 10° of anteversion and 40° ± 10° degrees of abduction [24]. Component position out of this safe zone may increase dislocation risk. Our patient's acetabular anteversion was 43°; however, the decision was made not to revise the cup during her first revision given that it was well-fixed and stable through a functional range of motion during intraoperative testing after increasing her offset. While increasing femoral offset has been shown to improve hip range of motion [25], repeated impingement continued to occur, resulting in notching of the femoral neck and her subsequent dislocation.

At the time of her second presentation to our institution, treatment options included revision of her cup, her stem, or both components. We did not think she would benefit from another head and liner exchange given her recurrent instability in the

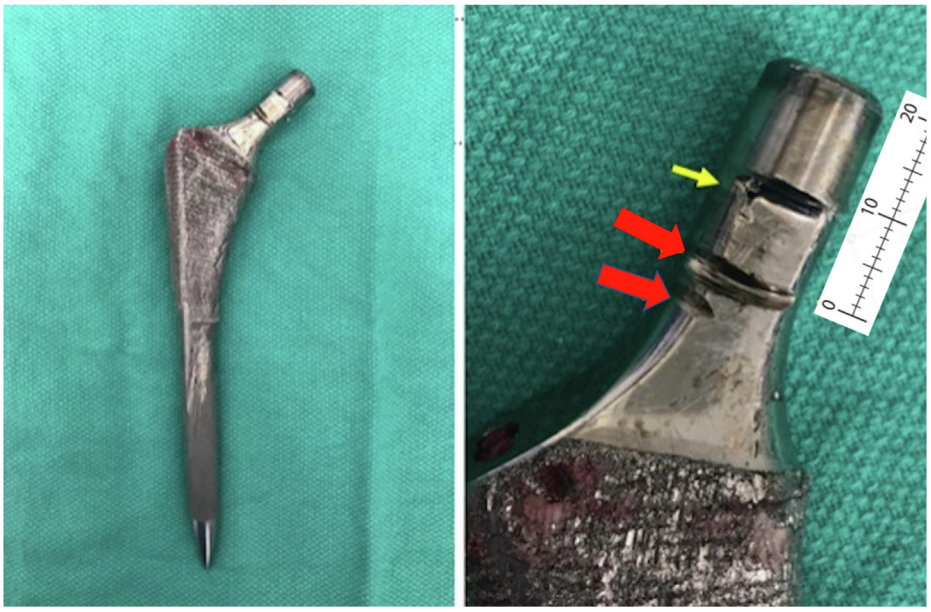

Figure 3. Notching of the femoral component neck in three distinct locations. The yellow arrow represents the first area of notching seen during the first revision. The red arrows demonstrate twin notching seen during the second revision, approximately 9 millimeters distal to the first notch.

setting of increased anteversion of both her femoral and acetabular components. Conversion to a dual-mobility cup would have been an alternative strategy to provide stability, but no compatible dual mobility cup was available at the time of her revision surgery. Ultimately, careful intraoperative inspection of each component for damage or loosening helped to determine the definitive treatment. Intraoperatively, both components were stable, but there was significant notching of the posterior femoral neck. While there are no reports of femoral implant fracture through an existing notch in the literature, we felt the damage was significant enough to necessitate revision of her femoral component. The new stem was placed with less anteversion which significantly improved her arc of motion. As a result, we decided not to revise the cup because it was stable with an intact locking mechanism, and we determined the hip to be stable through a functional range of motion after placement of a new lipped liner. This treatment strategy highlights the important role that component positioning has on intraprosthetic impingement and hip stability.

Summary

This case report demonstrates a rare occurrence of femoral neck notching with the use of a constrained acetabular liner. Excessive component anteversion may be a risk factor for notching, as it resulted in increased impingement of the posterior neck of the femoral component. We recognize that impingement is a well-documented mode of failure for constrained liners; however, failure typically occurs due to dislocation, locking ring damage, or acetabular component loosening. Femoral notching can also lead to increased metal particle production and extensive metallosis throughout the joint capsule and soft tissues. Although reports of femoral implant fracture through an existing notch have not been described in the literature, arthroplasty surgeons should be aware of this potential risk.

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Conflicts of interests

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Informed patient consent

The authors declare that informed patient consent was taken from all the patients.

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