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Case Report Open Access

Revision of Dual Mobility Implants Due to Impingement and Femoral Neck Notching: A Case Series

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Abstract

Impingement of femoral stems against metal dual mobility (DM) acetabular components after total hip arthroplasty (THA) can lead to notching of the femoral neck. The consequences may include debilitating pain, mechanical symptoms, release of metal debris, aseptic cup loosening, joint instability, dislocations, and the theoretical risk of femoral implant fracture. We report a primary case of a 35-year-old female who experienced impingement and femoral notching following DM THA and subsequently underwent revision due to these complications. This case is part of a series of 4 patients with similar complications. Following revision, all patients experienced symptom relief. Further studies are needed to determine the incidence of this issue, identify risk factors, and evaluate the outcomes of revision versus nonsurgical management for both symptomatic and asymptomatic cases.

Introduction

Dual mobility implants (DM) have become increasingly popular for both primary and revision total hip arthroplasty (THA) and have demonstrated excellent short and mid-term outcomes compared to standard bearing implants in reducing dislocation rates, especially in high-risk patients[1-5]. In modular DM implants, the acetabular cup is often comprised of an outer titanium shell, which serves as a rigid, durable housing for a modular cobalt-chromium liner that provides the articulating surface for the polyethylene (PE) bearing. The PE bearing, also referred to as the insert or mobile liner, offers a second articulation by accommodating the femoral head. This dual articulation mechanism, where the femoral head moves within the PE bearing and the bearing itself moves within the acetabular cup, provides a greater range of motion and increased jump distance before dislocation occurs[6]. Despite these advantages, there have been increasing reports of impingement of the cobalt-chromium acetabular liner against the titanium femoral stems[6-14].

Impingement can be a primary driver for revision surgery, as it can lead to various complications including pain, dislocation, aseptic cup loosening, and joint instability[6,8-11,15-18]. Additionally, impingement can cause femoral neck notching, which may also necessitate revision surgery. Notching can result in significant pain, mechanical symptoms, and metallosis, characterized by the release of metal debris and elevated metal ion levels that may lead to systemic toxicity and pseudotumor formation[6,8-11,15-18,20].

This study aims to describe the clinical presentation and outcomes of four patients who underwent revision THA (rTHA) due to implant impingement and femoral neck notching. By presenting a series of

cases, we seek to demonstrate the effectiveness of rTHA in alleviating symptoms related to these complications. All patients provided consent for their data to be included in this publication. The investigation received approval from an institutional review board (IRB #i20-00053) and was conducted in accordance with the ethical standards of the Declaration of Helsinki.

Case Histories

Case 1

A 35-year-old female underwent left primary THA due to avascular necrosis with a Modular Dual Mobility implant (MDM X3, Stryker Orthopedics, Mahwah, NJ) via posterior approach with assisted computer navigation. Postoperatively, she experienced severe continuous groin pain with radiation throughout the length of the iliotibial band. An easily noticeable squeaking noise was present with movement. On exam she ambulated with an antalgic gait and had tenderness over the groin. On exam she had normal 5/5 abductor function and a functional range of motion (ROM) with full extension, 0-120 degrees of flexion, 30 degrees of internal and 40 degrees of external rotation, 40 degrees of abduction, and 30 degrees of adduction with pain during extension and external rotation.

Anterior-posterior (AP) radiographs of the left hip were obtained and showed subtle notching over the superior aspect of the femoral neck and slight acetabular cup overhang inferiorly and superiorly with possible aseptic loosening of the acetabular cup (Figure 1a). Measurements of the acetabular component revealed 37 degrees of inclination and 29 degrees of anteversion and were measured using imaging software on AP pelvis radiographs (Figure 2). There was no gross pseudotumor visualized on MRI. Serum ion levels showed mildly elevated cobalt (0.5 ug/L, normal 0.1-0.4 ug/L) but normal chromium (0.2 ug/L, normal ≤ 1.4 ug/L).

The patient underwent revision surgery 3 years after the primary. Intra-operatively, there was tissue staining with black metal debris indicating impingement and obvious femoral neck notching on the superior aspect of the femoral stem neck; the notch depth was 0.3 mm (Figure 1b). The acetabular cup, PE head liner, and femoral head were revised. The notched femoral stem (Secur-Fit, Stryker Orthopaedics, Mahwah, New Jersey) was not revised due to the lack of literature reports on femoral stem fractures due to minor notching and the added comorbidity of revising well-fixed femoral components. Implants used during this procedure included a Smith & Nephew R3 Multi-Hole acetabular shell, size 50 mm; one 35 mm Reflection Spher screw; one 15 mm Reflection Spher screw; one 20 mm Reflection Spher screw (Smith & Nephew Orthopaedics); an acetabular liner with 32 mm inner diameter and 50 mm outer diameter (Smith & Nephew Orthopaedics); and a Stryker LFIT V40 femoral head, 32 mm diameter, +8 mm neck length. Measurements of the acetabular component using AP pelvis radiographs revealed 22.3 degrees of inclination and 27.8 degrees of anteversion.

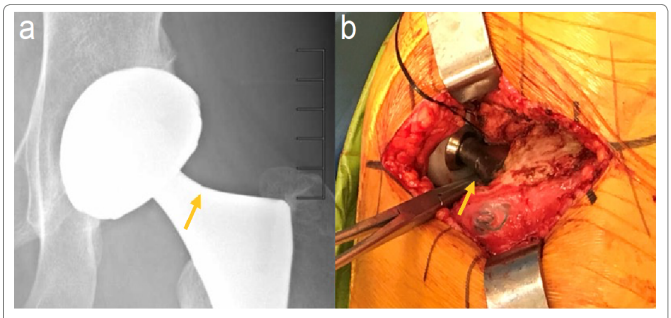

Figure 1. Case 1: Pre-revision anteroposterior radiograph showing neck stem notching (a). Notching on the superior aspect of the femoral neck seen intra-operatively (b).

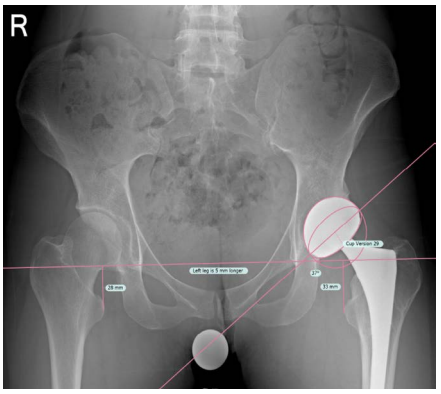

Figure 2. Case 1: Pre-revision anteroposterior radiograph with angular measurements of acetabular component position with 37 degrees of inclination and 29 degrees of anteversion.

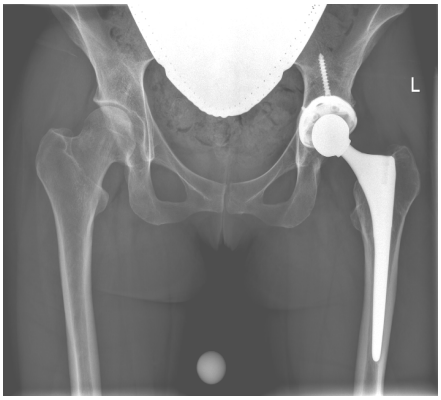

Figure 3. Case 1: Post-revision radiograph demonstrating correct implant positioning with no signs of impingement and a stable notch size.

Recovery was uneventful without any perioperative complications. At routine 3-months clinical follow-up, the patient had an improved gait, and mechanical symptoms of impingement and groin pain resolved. Radiographs showed appropriate implant positioning without evidence of impingement, and the size of the notch was stable with no stem fracture (Figure 3). To date, the patient has no further complications.

Case 2

A similar pattern of notching was found in a 51-year-old male who presented with a four-year history of hip pain and mild mechanical symptoms. He had a left primary THA with a modular DM component and a ceramic femoral head (MDM X3, Accolade II, Stryker Orthopaedics, Mahwah, NJ). On examination, a click was heard with hip flexion and abduction. AP radiographs showed subtle notching over the superior aspect of the femoral neck, a relatively horizontal orientation of the acetabular cup and an incomplete fibrous interface behind the acetabular component (Figure 4a). An MRI with metal artifact reduction showed a small pocket of fluid in the hip capsule. Ion levels revealed elevated cobalt (2.9 ug/L, normal 0-0.9 u/L), and normal levels of chromium and titanium.

Intraoperatively, superior femoral neck notching was observed with metal staining limited to the synovial lining, and no pseudotumor formation or osteolysis was detected (Figure 4b). The DM metal liner was well seated with no evidence of corrosion affecting the acetabular modular junction. The acetabular cup was revised to correct its orientation and address the issues highlighted by the radiographic findings. The Ti6Al4V alloy titanium femoral stem (Accolade II, Stryker Orthopaedics, Mahwah, NJ) was not revised. At 3 months follow-up after revision surgery, the patient's symptoms had resolved and metal-ion levels normalized (chromium 0.5 ug/L, normal 0.1-2.1 ug/L; cobalt 0.0 ug/L, normal 0-0.9 ug/L). To date, the patient has no further complications.

Case 3

Similarly, a 75-year-old female with a history of spine fusion that underwent primary left THA via the posterior approach with a DM implant (G7; Zimmer Biomet, Warsaw, Indiana) due to primary osteoarthritis presented with pain and mechanical symptoms. Radiographs showed 41 degrees of acetabular cup abduction and 31 degrees of anteversion, and posterior femoral stem notching of 1 mm in depth (Figure 5). Cup orientation was measured using Traumacad software on AP pelvis radiographs. Notching was first seen 1.4 years after surgery. Metal ions levels were not available; however, no pseudotumor was identified on preoperative MRI.

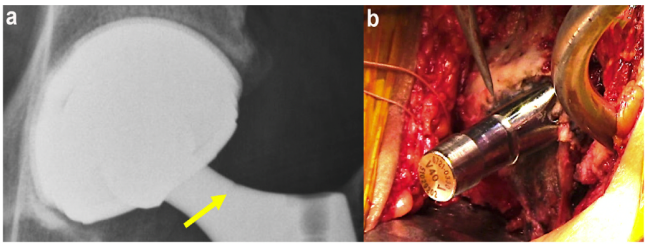

Figure 4. Case 2: Pre-revision anteroposterior radiograph showing neck stem notching (a). Notching on the superior aspect of the femoral neck seen intra-operatively (b).

Figure 5. Case 3: Pre-revision anteroposterior radiograph of patient with posterior femoral stem notching of 1mm in depth.

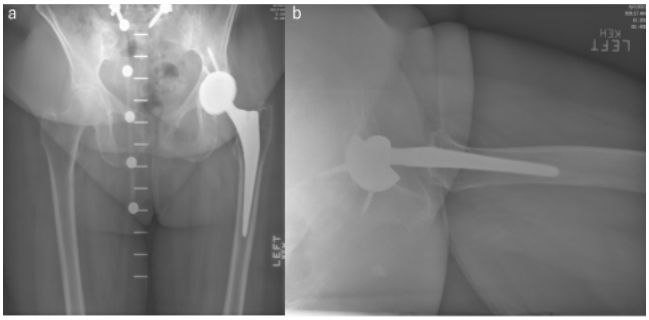

Figure 6. Case 3: Post-revision anteroposterior (a) and lateral (b) radiographs with no signs of impingement.

During the revision procedure the mobile PE liner, femoral head were revised. The patient underwent exchange from a -3mm to a +4mm neck. The notched femoral stem (Polarstem, Smith & Nephew, Memphis, TN, USA) and acetabular cup were retained. Cup position remained unchanged postoperatively. At 9 months follow-up after surgery, the patient reported improvement in her symptoms and radiographs showed no signs of impingement (Figure 6a & b). At most recent follow-up 4.6 years after revision, the patient has no further complications.

Case 4

A 64-year-old female with a history of Ehlers-Danlos syndrome presented complaining of pain, mechanical symptoms, instability, and recurrent dislocations 6.8 years after undergoing revision left THA with a cementless DM implant and uncemented stem (ADM X3; Stryker Orthopedics, Mahwah, NJ) via the posterior approach due to osteoarthritis. Radiographs showed 8 degrees of acetabular cup inclination and notching of the posterior aspect of the femoral neck (Figure 7a & b). MRI showed no pseudotumor formation.

All components were replaced during the revision surgery. Implants used during the procedure included a Biomet G7 acetabular cup (Zimmer Biomet, Warsaw, IN), size 50 mm, secured with one screw; an MDM liner, size D, with ArCom polyethylene, 28 mm x 40 mm; a Biomet Arcos femoral stem with an STS distal segment, 13 mm x 150 mm; a broached proximal segment, size B, with high offset (60 mm); a Biomet Biolox Delta ceramic femoral head, 28 mm diameter, +3 mm neck length; a 38 mm trochanteric bolt; and a large trochanteric claw secured with two Biomet cables. There were no complications postoperatively and the patient reported improvement of her symptoms at 2 months follow-up where radiographs showed no signs of impingement (Figure 8a & b). Approximately 1 year after the revision, the trochanteric claw was removed due to left-sided bursitis at the time of her right primary THA. At most recent follow-up, 2 years post-revision, she continued to do well with no further complications.

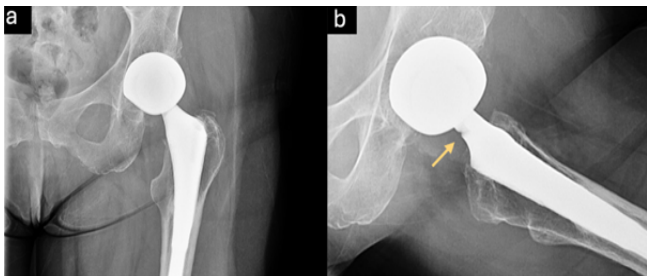

Figure 7. Case 4: Pre-revision anteroposterior (a) and lateral (b) radiographs with posterior femoral notching.

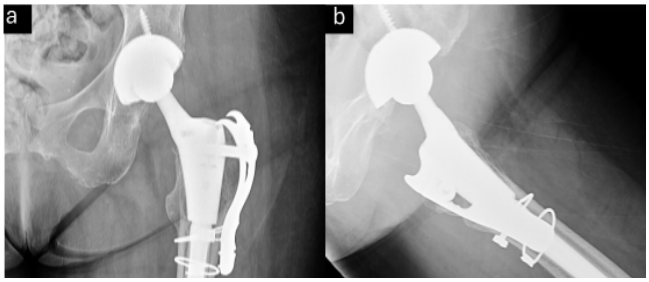

Figure 8. Case 4: Post-revision anteroposterior (a) and lateral (b) radiographs with no signs of impingement.

Discussion

Dual mobility implants are advocated to help decrease instability following primary THA. Despite the proven efficacy in preventing dislocation[1-5], especially in high-risk patients[6], these bearings are not free of complications. They can incur implant impingement, polyethylene wear, intraprosthetic dislocation (IPD), incomplete acetabular liner seating, and acetabular taper corrosion[7,21-23]. Impingement with femoral neck notching has a reported incidence of 3.5% to 4%[10,19], and can cause debilitating pain, mechanical symptoms, and metallosis leading to rTHA. However, not all cases of implant impingement and femoral neck notching require revision surgery[18,19]. The long-term outcomes of these unrevised cases have yet to be determined. Previous studies have shown that contributing factors include implant positioning, spinopelvic deformities, and implant design[19].

A literature review querying PubMed and Google Scholar using the combination of "dual mobility," "impingement," and "notching" identified several studies that reported similar cases of impingement with femoral component notching[8-14]. Cummings et al.[24] studied the prevalence and associated risk factors for femoral notching related to impingement of the femoral stem against the acetabular component in 37 patients with DM implants. They reported a 5% prevalence of femoral notching that was best appreciated on Dunn's acetabular x-ray views, not commonly obtained following THA. This may account for the underreported incidence of femoral notching. In the same study, notching was associated with increased mean acetabular anteversion (32.5 degrees with notch, 19.6 degrees without; $p = 0.03$); 2 out of 5 patients with anteversion greater than 30 degrees had notching, while no patients with less anteversion had notching ($p = 0.01$).

Additionally, in a study by Harwin et al.[6], 1 case out of 249 patients who received a modular DM implant for primary THA had impingement of an anteverted cup, resulting in trunnion notching, requiring revision of the acetabular cup and stem. Epinette et al.[11] also reported

Table 1: Patient and revision details

Patient	Age	Sex	Location of femoral neck notching	Indications for revision	Components revised
1	35	F	Superior	Impingement, femoral neck notching, pain, mechanical symptoms, aseptic loosening of the acetabular cup, elevated metal ion levels, theoretical risks of ongoing impingement and femoral stem notching	Acetabular cup, mobile PE liner, femoral head
2	51	M	Superior	Impingement, femoral neck notching, pain, mechanical symptoms, aseptic loosening of the acetabular cup, elevated metal ion levels, theoretical risks of ongoing impingement and femoral stem notching	Acetabular cup
3	75	F	Posterior	Impingement, femoral neck notching, pain, mechanical symptoms, theoretical risks of ongoing impingement and femoral stem notching	Mobile PE liner, femoral head
4	64	F	Posterior	Impingement, femoral neck notching, pain, mechanical symptoms, theoretical risks of ongoing impingement and femoral stem notching, instability, recurrent dislocation	Acetabular cup, mobile PE liner, femoral head, femoral stem

additional instances of femoral notching, including 2 cases among 321 patients younger than 55 years implanted with DM components. Angular measurements of the component position were not reported in their series, but excessive acetabular anteversion was noted in both cases. Similar to our patients, these studies reported an association between the cup angular position and femoral stem notching, suggesting functional component position may influence the location of impingement and subsequent notching. For instance, preoperative radiographs of our cases identified a posterior impingement with a femoral neck notch and acetabular anteversion ≥ 30 degrees in one case, a posterior and superior femoral neck notch with acetabular inclination 45 degrees in one case, and one case superior femoral neck notching with 37 degrees of inclination and 29 degrees of anteversion. It seems that the increased anteversion of the acetabular component to minimize posterior dislocation risk may contribute to the risk of impingement and subsequent notching of the femoral stem. However, beyond this, there may be a higher risk of impingement among patients selected for DM related to the indication for their use, for example, in those with reduced spinopelvic mobility from degenerative disease or prior lumbar arthrodesis as well as patients with higher native range of motion.

In addition to these biomechanical factors, the primary diagnosis leading to THA may influence postoperative impingement risk and patterns. For instance, Case 1 involved a patient with avascular necrosis, a condition often associated with preserved joint mobility prior to surgery. In contrast, Case 3 had primary osteoarthritis, typically marked by restricted preoperative ROM. These diagnostic differences can affect the range of motion patients demand from their prostheses postoperatively, potentially altering both the likelihood and anatomical presentation of implant impingement. Although our case series was not designed to assess this relationship, it is a variable that warrants further attention in future studies.

There is insufficient evidence in the literature to determine the superiority of rTHA vs. nonsurgical care for patients with femoral neck notching due to implant impingement. However, the presence of notching with impingement does raise questions about the long-term implications. Acetabular cup loosening is an associated sequela of femoral neck impingement[25], and two of our patients underwent acetabular shell revision due to compromised fixation (Table 1). Other reasons for revision surgery included poorly tolerated pain and mechanical symptoms (n = 4), instability (n = 1), recurrent dislocations (n = 1) and the theoretical risk from ongoing impingement and femoral stem notching (n = 4).

DM implant impingement and femoral notching can cause metal debris and elevate serum metal ion levels, leading to pseudotumor and adverse local tissue reaction (ALTR)[26-29]. Two of our patients had elevated ion levels, however, MRI showed no pseudotumor or ALTR in any of them. While the clinical significance of mild metal ion elevations is unclear, it remains a source of concern, and it may lead to systemic toxicity at high levels[20].

Another concern of the femoral neck notching is the possibility of femoral stem fracture. Nonetheless, none of the cases had a fracture in this report, and no study in our literature review reported this complication[16,18,21,30]. An earlier study showed that 0 out of 10 patients with femoral neck notching experienced fracture through the femoral notch, had further radiographic evidence of osteolysis, or had undergone further surgery after the index rTHA at a mean 2.7-year follow-up (range 1-7.6 years)[19]. In another case series[18], two patients with posterior femoral neck notching due to DM implant impingement remained asymptomatic, and the size of the notch remained stable with no stem fracture at 4.5 years follow up after rTHA. This suggests that mechanical femoral stem failure may not be a rapid consequence.

The management of impingement and femoral neck notching in patients with dual mobility implants presents a significant clinical challenge, especially in distinguishing when to surgically intervene in symptomatic versus asymptomatic cases. This case series has documented several instances where symptomatic patients benefited from surgical revision, underscoring the potential necessity for proactive interventions. However, the decision-making process for asymptomatic patients remains complex and poorly defined, primarily due to a lack of comprehensive data. Further study is essential to accurately determine the incidence of these complications, identify risk factors, and compare outcomes of rTHA with nonsurgical care. Such work could provide the foundation for evidence-based guidelines that clearly delineate when surgical intervention is preferable to conservative management.

Summary

The ability of DM constructs to lower dislocation rates has led to its increased use by surgeons, but there are still some concerns regarding this type of implant bearing and the need for long-term follow-up to determine outcomes. Some early to mid-term data shows associated complications such as implant impingement and femoral neck notching. This case series found four dual mobility cases that had implant impingement and femoral neck notching. They required rTHA due to debilitating pain, mechanical symptoms, release of metal debris, aseptic cup loosening, hip instability, dislocations, and the theoretical risk of ongoing impingement and increased femoral stem notching. All cases were diagnosed with AP and lateral radiographs and had verified evidence of notching

intraoperatively. We have shown that rTHA can alleviate pain and mechanical symptoms. Nonetheless, more data is needed to determine whether any asymptomatic or minimally-symptomatic implant impingement cases might benefit from revision surgery to prevent possible future catastrophic failure. Further studies are required to enumerate the incidence of this issue, identify risk factors, and define results of long term management with rTHA versus nonsurgical care.

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Conflict of Interest

The following authors have something to disclose.

Peter K. Sculco, MD: Enovis (paid consultant, IP royalties), Intelligjoint Surgical (stock or stock options, research support), Parvizi Surgical Innovation (stock or stock options), Zimmer (paid consultant, paid presenter or speaker)

Stephen Duncan, MD: Bone support (paid consultant, research support), Heraeus (paid consultant), Heron (paid consultant), Journal of Arthroplasty (editorial or governing board), Journal of Knee Surgery (editorial or governing board), Journal of the American Academy of Orthopaedic Surgeons (editorial or governing board), Kentucky Orthopaedic Society (board or committee member), Medtronic (research support), MiCare (stock or stock options), OrthAlign (paid consultant), ROM3 (stock or stock options), Smith & Nephew (IP royalties, paid consultant, research support), Stryker (research support), Zimmer (paid consultant, research support)

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Matthew Hepinstall, MD: American Association of Hip and Knee Surgeons (board or committee member), CAOS (board or committee member), Exactech, Inc (paid consultant, research support), ISTA (board or committee member), JointMedica (paid consultant), Stryker (paid consultant, paid presenter or speaker, research support)

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