Catastrophic Failure of the Acetabular Polyethylene Liner in Ceramic-on-Polyethylene Total Hip Arthroplasty

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What to Learn from this Article? Unusual and Rare Complication of THR with its Management.

Abstract

Introduction: Catastrophic polyethylene failure is a rare complication of ceramic-on-polyethylene total hip arthroplasty due to the favorable tribological characteristics of ceramic. Failure of the polyethylene liner can be disastrous, increasing periprosthetic osteolysis, metallosis, and risk of dislocation. Complications associated with ceramic-on-polyethylene articulations have been studied extensively, however, only few reports have described its catastrophic wear. We report such a case of complete wear of the acetabular liner in a ceramic-on-polyethylene prosthesis in a 57-year adult male.

Case Report: A 57-year adult male with a history of bilateral total hip arthroplasty presented to our institution with bilateral hip pain worst on the right. Range of motion was limited by pain on the right hip at the extremes of motion. Radiographs revealed severe osteolysis, heterotopic ossification, complete wear of the acetabular liner, bony impingement of the femoral greater trochanter on the acetabular rim and superior migration of the femoral head. All findings were confirmed intraoperatively. Revision of the acetabular components was performed, which successfully alleviated the patient's symptoms.

Conclusion: Failure of the ceramic-on-polyethylene liner in our patient is due to the use of a non-cross linked polyethylene liner, a highly active lifestyle, and poor follow up. Arthroplasty surgeons should be aware of this complication especially in highly active patients with a conventional polyethylene liner and chronic hip pain.

Keywords: Total hip arthroplasty; polyethylene wear; ceramic femoral head; metallosis; osteolysis.

Introduction

Wear of the acetabular polyethylene liner is an expected complication of total hip arthroplasty. Polyethylene wear contributes to both periprosthetic osteolysis and aseptic loosening after total hip arthroplasty. Failure of the polyethylene liner depends on patient, implant, and

surgery related factors [1]. When metal femoral heads are used, there is an increased risk of complete wear through of the polyethylene acetabular liner and metal shell, increasing the risk of wear induced osteolysis, which is one of the most important factors contributing to failure of total hip arthroplasty[2].











Reviewer's Photo Gallery



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the polyethylene liner and imprinted in to the metal with pain elicited in the extremes of motion. poor follow up.

Case Report

A 57-year-old African American male with a history of

In efforts to reduce polyethylene wear, the use of ceramic bilateral total hip arthroplasty, presented to our clinic with bearings has become an appealing option in total hip progressively worsening bilateral hip pain that is worst on the arthroplasty. Ceramic's higher resistance to scratching right. The patient underwent bilateral total hip arthroplasty compared to chromium cobalt (CoCr), and inert qualities in 1994 and 1995 with a Wright Technology Interseal in an aqueous environment contribute to the lower linear Ceramic-on-Non-Crosslinked Polyethylene Hip System and volumetric polyethylene wear rates seen in ceramic on (Wright Technologies; Arlington, TN) for a diagnosis of polyethylene bearings compared to CoCr on polyethylene avascular necrosis. The acetabular cup measured bearings[3]. Alumina and zirconia comprise the two main 54mm(O.D)/28mm(ID) and the ceramic head measured ceramic bearings available, with the former having lower 28mm. The patient underwent replacement of the acetabular polyethylene wear rates[4] due to phase transformation components and femoral head of his left total hip seen in zirconia causing increased surface roughness[5]. arthroplasty in 1999 at an outside facility due to implant Several studies have shown alumina ceramic heads to failure after an athletic injury. In 2004, he began complaining produce consistent polyethylene wear rates of 0.03mm/year of pain, which was localized to both his hips but worst on the [6-8], while other studies report variable outcomes in right. Despite this pain, he remained engaged in light athletic polyethylene wear reporting 0.01-0.34mm/year[5,9,10]. A activities 7 days a week and did not follow up with his wear rate of 0.2mm/year and higher has been shown to be physician for annual check-ups. 1 month prior to his predictive of failure[11]. Reports in the literature of presentation, the patient noticed pain radiating into his right catastrophic wear of the ceramic-polyethylene articulation groin. On physical examination there was no gross deformity have implicated acetabular inclination >450, use of gamma or swelling present, however, there was diffuse tenderness to sterilized polyethylene, increased activity level, age <50, and palpation over bilateral hips. In the right hip, range of motion backside wear as causes of failure [12,13]. We report a case was limited to 40° of flexion, 100 of internal rotation, and 25° of catastrophic polyethylene failure where the ceramic of abduction. In the left hip, range of motion was limited to femoral head completely wore through the polar region of 70° of flexion, 15° of internal rotation, and 30° of abduction

acetabular shell resulting in aseptic loosening, severe Infection work up was negative revealing a slightly elevated osteolysis, and periarticular metallosis. We suggest that this ESR of 16 mm/hr (N 0-15) but normal CRP of 0.5 mg/dl (N 0 failure is mainly due to the use of a non-crosslinked to 0.7), hip joint aspiration reveled a cell count of 212 white polyethylene liner, the patient's highly active lifestyle, and blood cells (WBC) cells/cu mm and 63% polymorphonuclear cells. Radiographs of bilateral hips revealed severe osteolysis, heterotopic ossification, wear of the acetabular liner, bony impingement of the femoral







Figure 2: a) Retrieved Components from the Right Hip Illustrating Complete Wear through the Acetabular Liner and Metallosis on the Ceramic Bearing. b) Intraoperative Illustration of Severe Metallosis Periartcularly due to Long Term Wear of the Acetabular Cup by the Ceramic Bearing. c) Retrieved Ceramic Head Showing Metallosis and Loss of Surface Smoothness.

greater trochanter on the acetabular rim and superior HSS scoring system (Table 1 and 2). The articular surface of arthroplasty revision.

of the polyethylene liner into the acetabular cup [Fig 2A], on-metal contact. acetabular trabecular metal cup (Zimmer; Warsaw, IN) was publication. press fit, in the position of maximum bony contact, with the support of multiple screws. A cemented highly crosslinked polyethylene liner was cemented into the acetabular cup at 45° of inclination and 20° of anteversion. The ceramic bearing was replaced with a VerSys Hip System 36mm femoral head with a 12/14 taper (Zimmer; Warsaw, IN). Revision of the left hip was performed a few months following the right hip revision, moderate proximal femur osteolysis was present with moderate polyethylene liner wear. On both the left and the right hip it was decided to retain the femoral stem after it was inspected intra operatively and found to be stable and in proper version.

Analysis of the severely worn right hip components revealed >50% wear on the articular surface of the polyethylene insert and ceramic bearing according to the

migration of the femoral head [Fig 1]. Acetabular cup the ceramic femoral head showed an area of ceramic-onabduction angles were 21° and 50° in the right and left hip metal contact, severe metal transfer, and a severe loss of respectively. Femoral offset was 5.6cm (right) and 4.0cm surface smoothness [Fig 2C]. The unworn areas of the (left). Due to the severe wear and pain in both hips with ceramic head had an average surface roughness (Ra) of 1nm failure to respond to conservative non-surgical treatment, to 2nm while the worn areas had Ra of 2500nm to 3500nm. the patient was indicated for staged bilateral total hip With regards to the cemented titanium acetabular cup, the non-articular surface showed abundant bony ingrowth with On the right, intraoperative findings revealed complete good interdigitation, and no in vivo damage. The articular wear of the ceramic femoral head through the polar aspect surface showed an area of central wear caused by the ceramic-

causing severe metallic wear and indentation in the cup Post-operative weight bearing status was foot flat weight with severe metallosis and tissue destruction in the bearing for a period of 6 weeks with weight bearing periarticular region [Fig 2B]. Extensive heterotopic progressively increased during a period of 6 weeks to full ossification in the abductor muscles was also noted. Severe weight bearing at 3 months. At last follow up (12 months), the osteolysis and bone loss was present behind the acetabular patient was ambulating with no assistive devices without any cup, especially at the medial and superior posterior walls as complaints or pain. Postoperative radiographs showed no well as part of the posterior column. Cancellous bone was signs of loosening, misalignment, fracture or increased used to repair contained areas of gross osteolysis. A new osteolysis [Fig 3]. The patient agreed to have his case used for



Figure 3: Post-operative Bilateral Hip Radiograph Showing Stable Components.

Polyethylene wear debris, and the resulting inflammatory col response leading to osteolysis and loosening, is the primary cor mode of failure limiting the longevity of total hip cro arthroplasty patients. In efforts to decrease polyethylene of wear debris, improvements have been made to pol polyethylene articulating surfaces (decreasing 0.2 polyethylene oxidation and increasing crosslinking) and cro femoral head bearing surfaces (ceramic-on-polyethylene, we ceramic-on-ceramic, and metal-on-metal). Compared to had CoCr, ceramic bearings are harder and more resistant to mo scratching, have superior surface characteristics and a ost more rounded surface profile with fewer sharp edges, and 0.1 are chemically inert in the aqueous environment of the rate body. Ceramic bearings have been shown to cause less wit polyethylene wear, osteolysis and loosening compared to cro CoCr. Despite their superior resistance to wear, lab studies high risk of failure over the course of the 18-year implantation have shown that a single scratch with an Ra of 10-20nm on increase polyethylene failure through third body wear . Our patient had an Ra of 1-2nm on unworn areas, making case.

articulation of the head with the metal acetabular cup periarticular area. Catastrophic failure of total hip 0.29% to 10.9%. Survival of primary ceramic-onpolyethylene arthroplasty has been promising at up to 10 years with survival rates of 95% to 98.1%. However, longvariable ranging from 70% to 89%. Reports of catastrophic failure of the ceramic-on-polyethylene arthroplasty, including our patient, fall into this latter time range with failure being attributed to patient, surgical, and implant related factors.

| ar rates than crosslinked polyethylene. Engh and | | | | | | | | | |
|----------------------------------------------------------|--|--|--|--|--|--|--|--|--|
| leagues performed a prospective randomized control trial | | | | | | | | | |
| nparing 10 year outcomes in non crosslinked and | | | | | | | | | |
| sslinked polyethylene liners and reported a survivorship | | | | | | | | | |
| 94.7% in non-crosslinked and 100% in crosslinked | | | | | | | | | |
| yethylene over 10 years. Average, penetration rates were | | | | | | | | | |
| 2mm/year for non-crosslinked liners and 0.06mm/year for | | | | | | | | | |
| sslinked liners. 91% of the non-crosslinked group had a | | | | | | | | | |
| ar rate of 0.1mm/year while 10% of the crosslinked group | | | | | | | | | |
| d a wear rate of 0.1mm/year. A polyethylene wear rate of | | | | | | | | | |
| re than 0.1mm/year has been correlated with a risk for | | | | | | | | | |
| eolysis with a 43% risk in hips with a wear rate of | | | | | | | | | |
| mm/year to 0.2mm/year, a 80% risk in hips with a wear | | | | | | | | | |
| e of 0.2mm/year to 0.3mm/year, and a 100% risk in hips | | | | | | | | | |
| h a wear rate >0.3mm/year. Given this, the use of a non- | | | | | | | | | |
| sslinked polyethylene liner in our patient placed him at | | | | | | | | | |

an articulating femoral head surface can significantly Many of the reports of catastrophic polyethylene failure have also attributed the acetabular abduction angle of more than 45° to be a risk factor for polyethylene wear, which is surface roughness a less likely contributor to failure in this consistent with reports of a 5% to 8% increase in the linear wear rate when the abduction angle is raised from 45° to 55° . In catastrophic polyethylene failure the femoral head However, our patient had an abduction angle of 21°, which completely penetrates the polyethylene liner resulting in would not explain the severe wear seen in this case. Other mechanisms of wear related to abduction angle have been causing metallosis, osteolysis, and tissue damage in the proposed. Kligman and colleagues suggested that a difference of >18.3° of acetabular inclination between contralateral sides arthroplasty is a rare occurrence with reported rates of increased risk for polyethylene wear. This may explain one mechanism of wear in our patient, who had a 29[°] difference in abduction angles between contralateral sides.

The polar polyethylene wear pattern and degree of term survival rates from 10 to 20 years have been more volumetric wear observed in our patient was surprising [Fig 2A]. It is plausible that the continued participation in athletic activities despite the patient's chronic hip pain contributed to a "boring" mechanism of wear, which together with a 21° abduction angle would concentrate wear towards the center of the cup. Charnley and colleagues were the first to report The use of non-crosslinked polyethylene was a major risk that prosthetic femoral heads "bored" into polyethylene factor for catastrophic failure in this patient. Non- liners, creating for itself a cylindrical path. Multiple wear crosslinked polyethylene has been shown to have higher vectors most likely added another component to the degree of

| | Wear | Burnishing | Scratching | Abrasion | Delamination | Creep | Cracking | Pitting | | Wear | Burnishing | Scratching | Abrasion |
|----------------------|------|------------|------------|----------|--------------|-------|----------|---------|-----------|------|------------|------------|----------|
| Articular Surface | 3 | 2 | 3 | 3 | 0 | 2 | 0 | 0 | Articular | 2 | 2 | 2 | 2 |
| Non- Articular | 1 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | Surface | 3 | 3 | 3 | 3 |
| Surface | | | | | | | | | | | | | |

we

time.

Table 2: Ceramic Head Wear Graded with the HSS Scoring System . Scores are Defined as follows: 0=no wear, 1=less than 10%, 2=10%-50%, 3=greater than 50%.

| able | 1: A | cetal | oular | vvear | Grade | d with t | the Ha | 22 200 | oring 3 | system. | Scores | are |
|-------|------|--------|-------|-------|-------|----------|--------|--------|---------|---------|--------|------|
| Defin | ed a | is fol | lows: | 0=no | wear, | 1=less | than | 10%, | 2=10 | %-50%, | 3=gre | atei |
| han { | 50% | | | | | | | | | | | |



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volumetric wear in this patient. The multiple wear vectors *v* may have been caused by minor loosening and shifting of *4*. the acetabular liner, a change in the gait cycle due to pain or *w* muscle weakness, and progressive changes in *a* biomechanical conditions such as contact stress, sliding *5*. distance, and friction coefficient .

While it is rare to have failure of the ceramic-onpolyethylene articulation, arthroplasty surgeons should be aware of this complication especially in highly active patients, who have had a total hip arthroplasty with noncrosslinked polyethylene. This case also stresses the importance of routine follow up, including radiological studies, in total hip arthroplasty with more vigilant observation recommended in patients with longer than 10 year implantation time and among patients complaining of chronic hip pain.

Conclusion

Ceramic-on-polyethylene prosthetic wear is a rare complication with grave consequences such as metallosis, osteolysis, and local tissue damage. The use of noncrosslinked polyethylene increases the risk of wear and should be avoided in patients undergoing total hip arthroplasty. Close follow up of total hip arthroplasty patients with non-crosslinked polyethylene should be instituted to prevent complications associated with polyethylene wear.

Clinical Message

Though rare, ceramic-on-polyethylene wear presents a major challenge for the arthroplasty surgeon. Routine follow up for total hip arthroplasty patients is a basic part of patient care. It is essential to evaluate patients complaining of hip pain for component wear and early detection may help prevent associated complications.

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