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# Gross Trunnion Failure After Primary Total Hip Arthroplasty

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ABSTRACT

Unfavorable outcomes from trunnion fretting and corrosion damage have been reported in the literature, gross failures of tapers in primary total hip arthroplasties have been less frequently reported. We report on 5 patients, who presented with gross trunnion failures of modular metal-on-polyethylene or ceramic-on-polyethylene bearings from 5 implant manufacturers, all necessitating revision surgery. None of these patients had an antecedent history of trauma, and the majority presented with pain or instability. No common factor was identified that may be predictive of these type of failures. Since there were 5 different stem designs, this suggests that it may be a rare generic phenomenon occurring with multiple designs. Currently, further investigations are necessary, including retrieval analysis, to identify risk factors that may predispose to such failures.



The Morse taper was originally developed to obtain reliable connections between two rotating machine components in the mid-eighteenth century [1]. It was based on the principle of a cone-in-cone which allowed stable fixation through compression of the walls of the bore (socket) as the trunnion is driven into it. Although it has been successfully used in various machines such as drill presses, milling machines, cutting tools, and power devices, one important application has been in lower extremity total joint arthroplasty for joining modular hip and knee components, in order to provide accurate alignment and secure frictional fixation. The purported benefits of modularity include adjustments in leg-length discrepancies, restoration of hip offsets, optimization of soft tissue tension, and easier exposure during revision surgeries. Under normal mechanical loading conditions, the interface between the mating surfaces of the modular taper junctions is mechanically stable to prevent dissociation or other unwarranted effects such as fretting damage, wear, loosening, or fracture.

Although the intimate conical connection between the trunnion and the bore allows firm contact and prevents construct disassembly, small gaps may be present between the mating surfaces due to manufacturing tolerances in the male and female cone geometries. These microscopic gaps or crevices may allow ingress of fluid and micro-movement (fretting) during cyclical mechanical loading leading to disruption of the protective passive surface oxide layer and increasing the susceptibility of the metal surfaces to mechanically assisted crevice corrosion (MACC) [2]. Multiple factors including taper design, metal-alloy mismatch, malpositioning, taper design incongruencies, as well as patient and surgical factors such as tissue interpositioning and/or failure to achieve initial engagement have been reportedly associated with the development of MACC [2–5]. These mechanical and corrosive mechanisms acting at the trunnion (male taper) and the bore (socket or female taper) are increasingly believed to result in the release of particulate debris and metal ions, which may lead to formation adverse local tissue reactions. In addition to these adverse tissue reactions, MACC can potentially lead to mechanical failures at the taper junction [5]. Although unfavorable outcomes from the release of metal ions from trunnion wear have been extensively reported in the orthopedic literature,[6–8] gross failures of tapers (for example substantial trunnion material loss, disassembly, or fractures) in primary total hip arthroplasties have been less frequently reported in only a few case reports [4,5,9].

Therefore, we have reviewed the clinico-radiographic factors that were associated with adverse prosthetic mechanical consequences of gross material trunnion failure or fracture, in a case series of patients who had undergone modular primary total hip arthroplasties. Specifically, we have described the: (1) patient demographics; (2) clinical presentation; (3) radiographic factors; (4) implant details; (5) intraoperative details; and (6) complications.

## Methods

A case series of 5 patients, involving 5 different stem designs from 5 different institutions were reviewed. Gross trunnion failures (GTFs) are defined as trunnions that, upon revision, exhibited gross loss of volume and/or material or a fracture. Operative reports, office charts, electronic health records, implant records, and radiographic images were analyzed to identify the demographics, description of trunnion failure, and other patient-reported details. Various demographic factors such as age,

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gender, body mass index, comorbidities, presenting symptoms, pre-operative diagnoses, and duration of follow-up were analyzed. When available, radiographs as well as intra-operative photographs and implant analysis reports were also reviewed to classify patients according to the type of morphological trunnion failure. Implant details including stem types, offsets used, femoral head diameters, taper types, neck lengths, and acetabular shell details including shell diameters were obtained from the implant records and tabulated. Intra-operative details including the presence of metallosis, pseudotumors, and adverse local soft tissue lesions were recorded. All implants were examined visually for gross wear, material loss, and deformation within the taper or for the presence of fracture. In addition, peri-operative and post-operative details of the revision surgery, including the occurrence of post-operative complications were documented. Serum metal ion levels (e.g. cobalt, chromium, and/or titanium) were evaluated when these were performed prior to revision surgery.

All radiographic measurements were obtained after calibration using the femoral head size documented from intra-operative records. Cup inclination and anteversion, femoral offset, and stem alignment were measured from pre-operative radiographs using digital software when available. The acetabular inclination was measured by determining the angle subtended between the line drawn across the inferior points of the ischial tuberosities and the line drawn through the superior and inferior points of the ellipse of the face of the acetabular shell projected on a supine antero-posterior radiograph. The acetabular anteversion was calculated using the formula as described by Pradhan [10] The femoral offset was measured from the radiographs by measuring the perpendicular distance between the anatomic axis of the femur and the center of the femoral head. Radiographs were also reviewed for the presence and location of femoral or acetabular osteolysis.

Approval of the respective institutional review boards were obtained prior to the study. All data collected were integrated into an Excel spreadsheet (Excel, Microsoft Corporation, Redmond, Washington) for tabulation and further analysis.

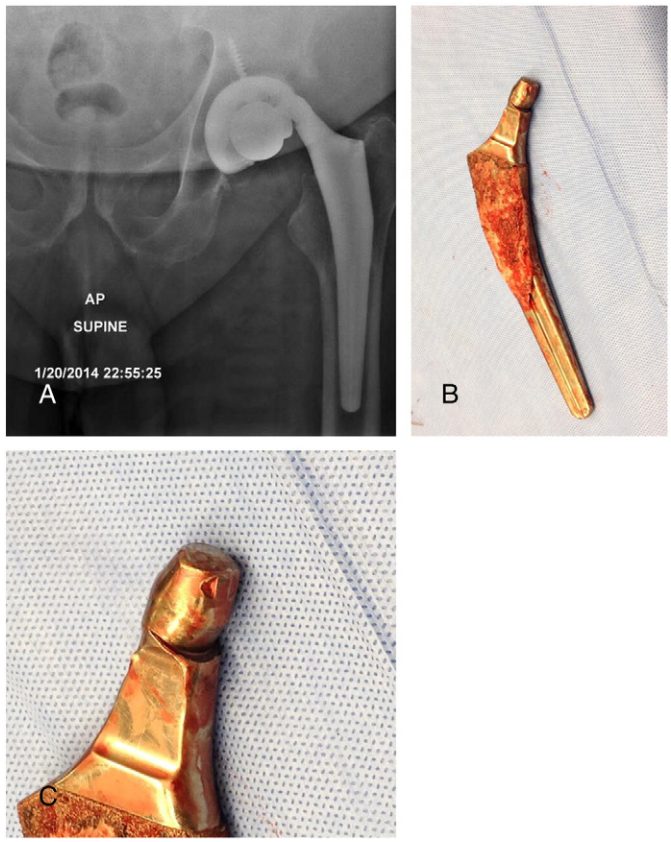


**Fig. 1.** (A), (B), and (C) Initial radiographic images on presentation (patient 1) showing dissociation of the trunnion from the femoral head, and explanted femoral stem demonstrating gross trunnion failure.

## Results

*Each Case will be Individually Described:*

*Case 1*

A 67 year-old man, received a left primary cementless total hip arthroplasty in February, 2006 for a pre-operative diagnosis of primary osteoarthritis. His past medical history included obesity with a body mass index (BMI) of 40 kg/m$^2$. The femoral implant used was a cementless 16 ML extended offset taper stem (Zimmer Orthopaedics, Warsaw, Indiana), while the acetabular component used during the index procedure was a cementless Trilogy cup (Zimmer Orthopaedics, Warsaw, Indiana) of size 60 millimeters. The femoral head component was a 32 millimeters cobalt-chromium skirted head with a +4 millimeters neck length. The liner used was a Longevity (Zimmer Orthopaedics, Warsaw, Indiana) highly cross-linked polyethylene bearing. Immediate post-operative radiographs showed that the components were in satisfactory position (acetabular angle of 45 degrees and an anteversion angle of 20 degrees) and his post-operative course was uneventful. By three months, he had returned to his usual activities.

However, 8 years later, he presented to the office complaining of marked acute onset of non-radiating left hip and groin pain while getting in to his car. He was unable to bear any weight thereafter. Radiographs revealed disassociation of the trunnion from the femoral head component and it was indicated for exploration/revision surgery (See Fig. 1A). Metal ion levels performed prior to revision surgery were found and revealed a cobalt ion level of 0.5 ng/L and chromium of 2.9 ng/L. Intra-operatively, the trunnion was found to be malformed with wear of the antero-superior and postero-superior surface and grooving of the inferior surface (See Fig. 1B and C). Minimal peripheral osteolysis was found around the acetabulum and proximal femur on exploration. In addition, there was substantial black débris suggestive of metallosis in the periprosthetic tissues. The proximal femoral lysis created some erosion and thinning of the medial calcar, as well as the superior acetabulum in the periphery. During revision, the acetabular shell was retained while the liner and the femoral stem were replaced with a revision stem ceramic head, and a highly crosslinked polyethylene liner. His post-operative course was uneventful and he has returned to his usual activities including playing golf 4–5 times a week at 5 months follow-up.

*Case 2*

A 60 year-old man, who had a BMI of 30 kg/m$^2$, underwent a left primary cementless total hip arthroplasty in July of 2007 for a pre-operative diagnosis of primary osteoarthritis. His past medical history included well-controlled hypertension. The femoral implant used was a standard offset cementless Accolade TMZF tapered wedge stem (Stryker Orthopaedics, Mahwah, New Jersey), while the acetabular component used during the index procedure was a cementless Trident PSL acetabular cup (Stryker Orthopaedics, Mahwah, New Jersey) of size 60 millimeters. The femoral head component was a 40 millimeters cobalt-chromium standard non-skirted head with a +4 millimeters neck length on a V40 taper. The liner used was an X3 highly cross-linked polyethylene bearing (Stryker Orthopaedics, Mahwah, New Jersey). Immediate post-operative radiographs showed that the components were in satisfactory position with an acetabular angle of 45 degrees and an anteversion angle of 12 degrees. His post-operative course was uneventful and he had returned to his usual activities by 4 months.

However, 7 years later, he presented to the office complaining of marked acute onset of left hip pain, instability, and clicking while getting off a toilet seat. He had a severe antalgic gait thereafter and