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Original Article

Factors Associated With Trunnionosis in the Metal-on-Metal Pinnacle Hip

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ABSTRACT

Background: Trunnionosis of the tapered head-stem junction of total hip arthroplasties, either through corrosion or mechanical wear, has been implicated in early implant failure. Retrieval analysis of large numbers of failed implants can help us better understand the factors that influence damage at this interface.
Methods: In this study, we examined 120 retrieved total hip arthroplasties of one bearing design, the 36-mm diameter metal-on-metal, DePuy Pinnacle, that had been paired with 3 different stems. We measured material loss of the bearing and head-trunnion taper surfaces and collected clinical and component data for each case. We then used multiple linear regression analysis to determine which factors influenced the rate of taper material loss.
Results: We found 4 significant variables: (1) longer time to revision ($P = .004$), (2) the use of a 12/14 taper for the head-trunnion junction ($P < .001$), (3) decreased bearing surface wear ($P = .003$), and (4) vertical femoral offset ($P = .05$). These together explained 29% of the variability in taper material loss.
Conclusion: Our most important finding is the effect of trunnion design. Of the 3 types studied, we found that S-ROM design was the most successful at minimizing trunnionosis.

Numerous reports have demonstrated that a significant amount of material can be lost from the taper junction of large diameter (≥36 mm) total hip arthroplasties as a result of fretting or corrosion [1-4]. This process is commonly referred to as trunnionosis; however, the mechanisms of this are poorly understood.

Retrieval studies investigating large numbers of failed components have the ability to identify the surgical, implant, and patient factors associated with high taper material loss [5]. For instance, previous studies have suggested that the paring of dissimilar alloys, that is, a titanium stem with a cobalt-chromium (Co/Cr) head, can increase the risk of galvanic corrosion at the taper junction [6].

A recent in vitro study has suggested that smoother and longer trunnions are associated with less mechanically assisted corrosion [7]. It is vital that retrieval studies confirm or refute these findings since in vitro studies did not predict the highly variable in vivo rates of bearing surface wear of metal-on-metal (MOM) hips.

The Pinnacle (DePuy) was one of the most commonly implanted MOM hips in the world and was typically paired with a Corail, Summit, or S-ROM stem. It has been demonstrated that the Corail and Summit have a similar trunnion surface topography that is rougher than that of the S-ROM [8], which is also longer.

Furthermore, an understanding of all other factors associated with increased taper material loss may assist clinical surveillance of implants through risk stratification and facilitate improved future

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designs. Therefore, in this study, we used multiple linear regression statistics to identify those factors that are associated with material loss at the head taper of a hip of a single design.

Methods

This was a retrieval study involving 120 MOM Pinnacle hips that had been consecutively received at our center. Analysis was performed on a total of 360 different surfaces, consisting of the cup bearing, head bearing, and head taper surface for each hip. All hips consisted of a 36-mm femoral head and had been retrieved from 50 male and 70 female patients with a median age of 62 years (26-75) and a median time to revision of 73.5 months (12-128). The median prerevision whole-blood cobalt and chromium metal ion levels were 6.9 (0.60-97.40) and 3.7 (0.50-90.00), respectively; the median Co/Cr ratio was 1.95 (0-10.20). The reasons for revision were unexplained pain confirmed as adverse reaction to metal debris post revision (n = 115), infection (n = 2), femoral loosening (n = 1), malposition (n = 1), and recurrent dislocations (n = 1).

The hips had been paired with 3 different stem designs: Corail (n = 61), Summit (n = 42), and S-ROM (n = 17); however, only 16 stems were retrieved. All 3 stem designs were made of a forged titanium alloy (TiAl6V4) and used a cementless fixation. The trunnions of the Corail and Summit stems had the same diameter (12/14), comparable angle (5.6°), flexural rigidity (162.25 Nm^2 and 160.54 Nm^2, respectively) and comparable length and surface topography. The trunnion of the S-ROM stem was, however, longer and smoother [8], had a smaller diameter (11/13), greater angle (6°), and lower flexural rigidity (108.98 Nm^2), Figure 1. The S-ROM stem also has a greater degree of modularity with the addition of an adjustable proximal sleeve.

Prerevision X-rays were obtained for each hip in order to measure the position of the implant; the median acetabular inclination was 45° (24-68), and the median horizontal and vertical femoral offsets were 43 mm (28-59) and 76 mm (52-98), respectively.

Visual Assessment of Corrosion

The severity of corrosion of each of the retrieved head taper surfaces was determined through macroscopic inspection and with the aid of a Leica M50 microscope (Leica Microsystems, Germany) at up to ×40 magnification. A well-published scoring system [1] was used to grade each taper with a score of between 1 (no corrosion) and 4 (severe corrosion); this method has previously been demonstrated as being both repeatable and reproducible [2]. Corrosion scoring was conducted by a single examiner experienced in retrieval analysis. We repeated this corrosion scoring for the 16-stem trunnions that were available in this study.

Measurement of Bearing Surface Material Loss

A Zeiss Prismo (Carl Zeiss Ltd, Rugby, United Kingdom) coordinate measuring machine was used to measure the volume of material loss at the cup and head bearing surfaces of the retrieved hips. A 2-mm ruby stylus was translated along 400 polar scan lines on each surface, using previously published protocols [9], to record up to 30,000 data points. The raw data were analyzed using an iterative least-square fitting method, and regions of material loss were mapped by comparing with the unworn geometry of the bearing surface. These wear maps were also used to determine if edge wear of the cup had occurred.

Measurement of Head Taper Material Loss

A Talyrond 365 (Taylor Hobson, Leicester, United Kingdom) roundness-measuring machine was used to measure the volume of material loss at the internal taper surface of each femoral head. Using previously published protocols [10], a 5-μm diamond stylus was used to take a series of 180 vertical traces along the axis of the taper surface. These traces were combined to create a rectangular surface from which worn and unworn regions were identified and volumetric material loss calculated. Due to insufficient numbers of retrieved stems available, we did not consider material loss at the stem trunnion in this study; however, it has previously been shown that material loss at the trunnion is negligible [10] as the CoCr head taper is preferentially worn over the softer titanium stem.

Factors Included in the Multiple Regression Analysis

We calculated the association between 10 variables and the extent of corrosion and annual material loss rate at the taper; this

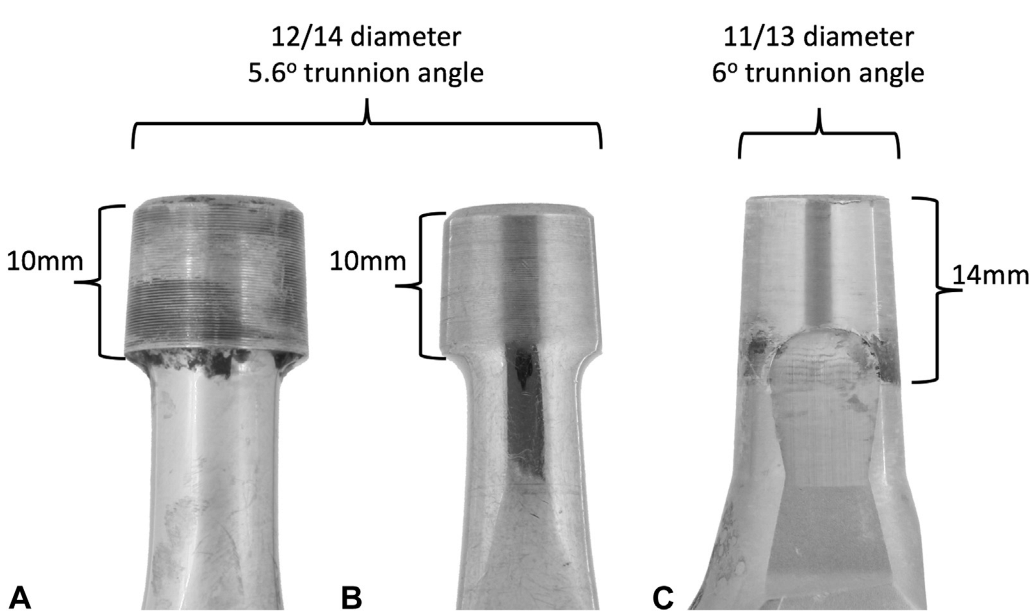

Fig. 1. Trunnion dimensions of the (A) Corail, (B) Summit, and (C) S-ROM stems.