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Original Article

Metal-on-Metal Compared With Metal-on-Polyethylene: The Effect on Trunnion Corrosion in Total Hip Arthroplasty

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ABSTRACT

Background: Trunnion tribocorrosion in total hip arthroplasties is concerning, but retrieval studies often are subjective or lack comparison groups. Quantitative comparisons of clinically relevant implants are required. The purpose of this investigation was to evaluate material loss in metal-on-metal (MoM) and metal-on-polyethylene (MoP) total hip articulations while controlling for trunnion design and head size.
Methods: The 166 retrieved femoral heads from 2 manufacturers were analyzed. Four cohorts based on head size, trunnion design, manufacturer, and articulation type (MoM vs MoP) were created. Corrosion was measured by a coordinate measurement machine, and material loss was assessed (MATLAB).
Results: Retrieved femoral heads from MoP articulations had 5 times less trunnion material loss than MoM articulations, on average, for both manufacturers. There was no difference in material loss between large modular head (>40 mm) and 36-mm MoM hip trunnion. Implants with a material loss above the detectable limit demonstrated a correlation with time in vivo only in MoP articulations.
Conclusion: Retrieved femoral heads from MoP bearing couples had a lower magnitude of material loss than MoM couples, independent of head diameter. A time in vivo effect was only seen in MoP bearings.

Total hip arthroplasty (THA) is a successful procedure that has excellent patient outcomes [1]. With improved material and technology advancements, increased longevity and survivorship has occurred. Increased concern is now being expressed regarding the potential for corrosion at the head-neck junction; a phenomenon called trunnionosis or taperosis [2]. Material loss has been described both in metal-on-metal (MoM) [3] and in metal-on-polyethylene (MoP) articulations in THA [4,5].

A variety of mechanisms has been described for trunnionosis, including biochemical and mechanical factors. Mechanical factors resulting in fretting, disruption of the protective oxidative layer, and subsequent corrosion has been described [6]. Hip prosthesis characteristics that may increase the risk of material loss include head length [7], diameter [8], trunnion flexibility [9], trunnion design [10], trunnion surface finish [11], head-trunnion mating surface [12,13], and head and trunnion materials [14].

Although a number of factors have been suggested, literature does not provide evidence to direct clinical practice or further research. Cohorts in current literature are often limited to a single set of devices or are dependent on subjective measures of material loss. Although contributing important information, the lack of quantifiable measures in a series of retrieved implants of clinically relevant cohorts limits the ability to build on current literature in a meaningful way.

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Group	Number	Head Size	Mean Duration (range)	Surgeon-reported Reason for Revision
S&N MoP	88	28 mm: 67 32 mm: 21	6.9 years (1-15.6)	Wear/Lysis: 55 Instability: 13 Fracture: 11 Infection: 8 Pain: 1
S&N MoM	7	40 mm:1 42 mm:1 46 mm: 3 58 mm: 2	5.1 years (4.2-6.1)	Metal Reaction: 6 Unspecified: 1
DePuy MoP	29	36 mm: 29	2 years (0.06 – 8.8)	Infection: 10 Loosening: 6 Dislocation: 5 Instability: 4 Pain: 2 Fracture: 1 Subsidence: 1
DePuy MoM	42	36 mm: 42	6.4 years (0.25-11.6)	Metal Reaction: 27 Infection: 6 Loose: 4 Lysis: 2 Pain: 1 Dislocation: 1 Fracture: 1

Fig. 1. Four cohorts of study devices are shown with relevant summary data. MoM, metal-on-metal; MoP, metal-on-polyethylene.

The purpose of this study is to quantify and subsequently compare the material loss in MoP- to MoM-retrieved total hips secondary to tribocorrosion. The effect of head diameter on trunnion corrosion will also be examined. Finally, how time in vivo affects material loss will also be examined to provide guidance in monitoring THA patients.

Materials and Methods

Two institutional review board–approved retrieval databases were queried for devices of 4 designs from 2 manufacturers. The global inclusion criteria for the study were established as (1) known in vivo duration, (2) known reason for retrieval, (3) known bearing couple, and (4) the modular head was available for metrology. The 4 cohorts included (1) Smith & Nephew (S&N; Memphis, TN) MoP heads with a head diameter of either 28 or 32 mm, (2) all S&N Birmingham Hip Modular MoM heads with a head diameter of 40-58 mm, (3) all DePuy (Warsaw, IN) Articul/eze MoM heads with a diameter of 36 mm using the Pinnacle system, and (4) all DePuy Articul/eze MoP heads with a diameter of 36 mm using the Articul/eze system. All S&N and DePuy trunnion were of a 12-mm/14-mm design.

Retrievals were disinfected via soaking in 70% ethanol or 10% neutral-buffered formalin for 72 hours. Following disinfection and a fresh water rinse, the bores of the heads were gently cleaned by a single, experienced surgeon evaluator using a soft, nylon bristle brush.

Taper material loss measurement was performed according to a validated technique that takes advantage of the short distance of taper engagement relative to the overall depth of the female taper bore [15–17].

All taper measurements were performed by a single research engineer with knowledge of the original machining specifications for the tapers and the expected locus and distance of taper lock-up.

Bores were measured using a Zeiss Contura G2 Coordinate Measurement Machine (CMM) running Calypso software (Oberkochen, Germany). Heads were mounted using a nonmarring fixture that secured the heads at 4 points around the equator. A 3-mm ruby stylus was controlled using a custom measurement script in which at least 72 axial scans were taken along the complete length of the bore with measurements every 0.1 mm along the scan.

Point clouds were analyzed using MATLAB (MathWorks, Natick, MA). Data are presented to the user in a graphical form relating

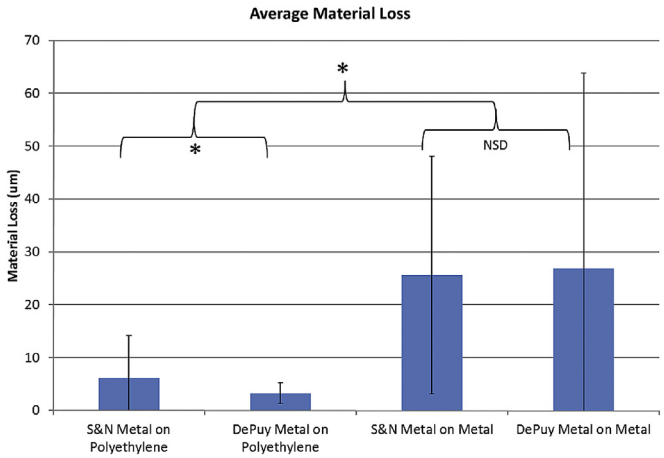

Fig. 2. Average material loss for each cohort shows that MoP devices have less loss than MoM devices. Although one cohort of MoP devices has less loss than the other, both groups have average values close to the detection limit of the measurement system. *Statistically significant difference. NSD, no statistical difference.