Performance of Biolox Delta Ceramic Bearings with Titanium Adapter Sleeves in Revision Hip Arthroplasty: A Retrieval Analysis

Mark Figgie Jr., BS, Marcella Elpers, BS, Douglas Padgett, MD.
Hospital for Special Surgery, New York, NY, USA.

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Introduction: Titanium adapter sleeves are being increasingly utilized in revision hip arthroplasty using the Biolox® option system, but currently little data exist on their clinical performance. The sleeves allow for a new ceramic head to be placed on an existing stem even when the trunnion is damaged. The titanium sleeve protects the new ceramic from fracture and micromotion at the trunnion by fitting into the taper region of the ceramic. However, this creates new surfaces consisting of ceramic-metal and metal-metal contact. Metal transfer is seen on ceramic heads, characterized by the appearance of metallic debris transferred onto the articular and taper regions. Fretting and corrosion have been observed as a result of contact motion between two metal surfaces, causing the deposition of soluble and particulate matter. This debris can then potentially lead to ALTR or periprosthetic osteolysis. The objective of this study was to evaluate a series of retrieved titanium adapter sleeves paired with ceramic femoral heads used in revision hip arthroplasty for metal transfer, fretting and corrosion at the various implant junctions.

Methods: Thirteen ceramic heads with titanium adapter sleeves were identified from our IRB approved implant retrieval program. Seven of the thirteen retrieved femoral heads had femoral stems available for analysis. Patient demographics were collected on all cases. The articular and taper regions of the ceramic heads were assessed for metal transfer using an established grading system. The metal transfer scores from this series were then compared against our previous series of Biolox® delta femoral heads that did not have corresponding titanium adapter sleeves (1). The femoral stem trunnion, when available, as well as the inner and outer surfaces of the titanium sleeve were graded for fretting and corrosion using the Goldberg scale (2). Scanning electron microscopy (SEM) was used to obtain high magnification images of the titanium sleeves and better assess the surface damage. Energy dispersive x-ray analysis (EDAX) was used to identify the material composition of the sleeves and any debris observed on the sleeve. Metal transfer, fretting and corrosion scores were compared by region using student t-tests, single factor ANOVAs, or the nonparametric equivalent when appropriate. Significance was set to p<0.05.

Results: The ceramic femoral heads in this study showed greater metal transfer at the apex of the articular surface than the superficial taper surface when compared to the previous study. Seven of the thirteen retrievals were revised for periprosthetic fracture, dislocation or implant loosening and tended to have greater metal transfer at the apex. The outer surface of the titanium sleeves which contact the ceramic were largely undamaged regardless of the damage to the inner surface of the metal sleeve or the metal transfer score of the ceramic taper surface. The corrosion score of the inner surface of the titanium sleeves was found to be significantly higher than those of the outer surface. Analysis of corrosion on SEM images of the titanium sleeves illustrated none of the common characteristics
associated with corrosion. EDAX analysis of the metal sleeves identified the black debris, characterized as corrosion on the Goldberg scale, as a biological carbon compound as opposed to corrosion products. **Discussion:** The titanium sleeve-trunnion interface is indicative of low levels of fretting and corrosion and the ceramic-sleeve interface has not been shown to be of concern for either. The low levels of fretting and corrosion may be due to the fact that twelve of the thirteen stems were titanium, making them similar alloy couples which have been shown to have lower levels of fretting and corrosion (3). When compared to fretting and corrosion scores of similar alloy couples from previous studies (3), the titanium sleeves showed lower Goldberg scores for both. The black debris initially thought to be corrosion products were later identified as a biological compound consisting of carbon. **Significance:** This study supports the use of the Biolox® option system in revision hip arthroplasty by demonstrating little damage to either the titanium adapter sleeve or the ceramic head.

![Diagram](image)

Figure 1 - Pictorial demonstration of articular and taper surface grading regions
Figure 2 - SEM image of fretting with a goldberg score of 2 illustrating flattened machine lines
Figure 3 – Pictorial illustration of a metal transfer grade of 4 on the taper surface of the ceramic head