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Basic Science

Does Taper Size Have an Effect on Taper Damage in Retrieved Metal-on-Polyethylene Total Hip Devices?

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ABSTRACT

Background: Taper design has been identified as a possible contributor to fretting corrosion damage at modular connections in total hip arthroplasty systems, but variations in as-manufactured taper interfaces may confound this analysis. This study characterized taper damage in retrievals with 2 different taper sizes but comparable taper surface finishes and investigated if fretting and corrosion damage is related to taper size in the context of a multivariable analysis for metal-on-polyethylene bearings.
Methods: A total of 252 cobalt chromium femoral heads were identified in a collection of retrievals: 77 with taper A and 175 with taper B. Implantation time averaged 5.4 ± 6.0 years (range, 0-26 years). Explants were cleaned and analyzed using a 4-point semiquantitative method. Clinical and device factors related to head taper fretting corrosion damage were assessed using ordinal logistic regression with forward stepwise control. Components were then selected to create 2 balanced cohorts, matched on significant variables from the multivariable analysis.
Results: Increased head offset ($P < .001$), longer implantation time ($P = .002$), heavier patients ($P < .001$), and more flexible tapers ($P < .001$) were associated with increased taper fretting and corrosion damage. When damage scores were compared between the balanced groups, no significant differences were found.
Conclusion: These results suggest that fretting and corrosion damage is insensitive to differences in taper size. The final model derived explains almost half of the fretting corrosion damage observed and identifies contributing factors that are consistent with other in vitro and retrieval studies.

There is considerable interest within the orthopedic community in understanding the multifactorial process of modular component fretting corrosion in total hip arthroplasty (THA). Previous studies analyzing surgically retrieved hip devices have identified some patient and device factors associated with in vivo taper damage, including length of implantation, stem flexural rigidity, and head offset [1-5]. The increased incidence of taper-related complications in THA has also been attributed to the evolution of taper design [6]. Among implant manufacturers, narrower and shorter stem taper designs have been introduced to achieve increased range of joint

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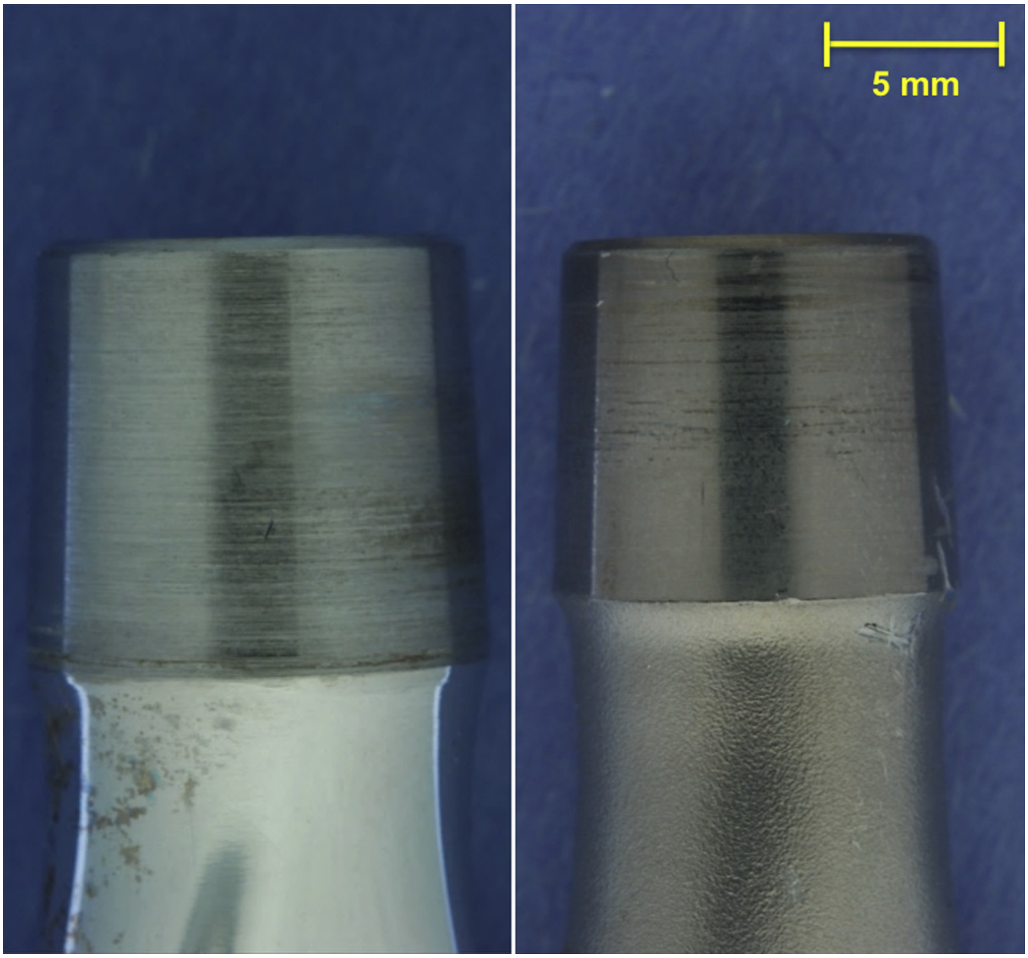

Fig. 1. Comparison of the C-Taper (left) and V40 (right) designs at the same magnification.

motion while decreasing the risk of impingement and dislocation [7]. However, it has been hypothesized that these designs may experience more severe fretting corrosion because a smaller taper experiences greater stress for a given load [8]. Fretting corrosion is understood to be a synergistic mechanical and electrochemical phenomenon: increased localized stress may make the passive oxide film more likely to fracture, which compromises the corrosion resistance of the interface [9].

Understanding the effect of smaller tapers is complicated, as size is often not the only variable that can change between designs. In an experimental study that measured the taper angle of retrieved THA devices, commonly used taper options had angles of 4°, 5.6°, and 6° [10]. The surface finish of the taper may also vary, as some contemporary stem tapers have surface ridges in a grooved or threaded pattern [3,7,10-12]. It has been reported that during head impaction, deformation of these ridges limits the local stress concentration that results from a mismatch in cone geometry tolerances [12]. This provides a stress distribution that is particularly favorable for ceramic heads; however, these ridges have also been shown to leave imprints within metal heads via localized corrosion mechanisms [11,12].

The purpose of this study was to identify the effect that taper size has on taper damage while controlling for other variations in taper design. From a single manufacturer (Stryker Orthopaedics, Mahwah, NJ), we identified 2 different taper sizes that were fashioned with similar taper angles and comparable surface finishes. The C-Taper is based on the 12/14 Euro taper design, whereas, the V40 taper was designed with 8% less taper length and approximately 20% lower surface area (Fig. 1). Both taper designs have a similar taper angle of 5° 40' and a smooth surface finish (surface profile with a wavelength <100 μm and amplitude <4 μm) [13]. In this study, we sought to determine if there was a difference in taper fretting and corrosion damage between these 2 taper sizes. To test this, we analyzed a consecutive series of explanted components retrieved over a 9-year period by performing a review of the clinical records associated with the devices, combined with semi-quantitative evaluation of the modular taper interfaces. We assessed the difference in damage using a multifactorial approach, controlling for other design and clinical factors that might affect taper damage. Thus, the preliminary goal of this study was to identify which factors are associated with taper damage in these devices.

Methods

Clinical and Implant Information

Overall, 252 cobalt chromium (CoCr) femoral heads manufactured by Stryker Orthopaedics were identified as either C-Taper or V40 from a collection of devices within a multi-institutional retrieval program. The metal-on-polyethylene (MoPE) systems were collected under an institutional review board–approved, multi-institutional implant retrieval program. Of the retrieved heads, 77 were C-Tapers and 175 were V40