What Effect Does the Strength of the Taper Connection Have on Taper Damage in Retrieved Total Hip Devices?

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Introduction: There is concern within the orthopedic community about mitigating fretting corrosion in modular components in total hip arthroplasty. Bench-top studies have reported that increasing the force with which the femoral head is impacted onto the femoral stem increases the stability of the interface, thus limiting the relative micromotion between the two components and reducing the propensity for mechanically assisted crevice corrosion [1,2]. However, little is known about the implications of these findings in the clinical setting. It has been reported that for as-manufactured implants, head impaction forces are correlated to the force that is required to extract the head from the taper [2]. Thus, we hypothesized that the force of extraction would be negatively correlated with taper corrosion damage in clinical explants.

Methods: Forty-nine (49) femoral stems with heads still assembled were included in this study: forty-six (46) were retrieved from revision surgery as a part of a multi-institutional retrieval program, and three (3) were obtained post mortem. Clinical information was available for forty-two (42) of the surgically retrieved components. Mean patient age at implantation for these devices was 58 years (range, 25 - 80 years) and implantation time averaged 8.8 ± 6.7 years (range, 0 - 24.0 years). The components were revised predominantly for loosening (26) and infection (7). Before testing, these components were cleaned by two 20-minute soaks in a 1:10 disinfecting solution (DisCide®, Palmero Health Care, Stratford, CT) followed by two 30-minute sonication periods in water. The necropsy-retrieved
components were carefully removed from the femurs, and rinsed briefly in a disinfecting solution for decontamination. Removal of the femoral heads was achieved using custom-designed fixtures in conjunction with a mechanical testing frame (MTS Systems Corporation, Eden Prairie, Minnesota). All specimens were loaded in accordance with ISO 7206 and the taper extraction force was noted as the peak load measured before break detection. The taper interfaces were then semi-quantitatively analyzed for fretting and corrosion damage using a previously described 4-point scoring method [3].

**Results:** The mean femoral head extraction force recorded was 3,613 N (range, 834 - 8244 N). Damage scores at the head taper and on the stem were positively correlated with each other (ρ=0.61, p<0.001; Spearman’s rho) as was the aggregate head and stem score with implantation time (ρ=0.33, p=0.04). No correlation between femoral head extraction force and taper damage scores was found when all components were analyzed together (p=0.21). However, grouping the components by implantation time (short term: 15 years, n=11) revealed an inverse relationship between head extraction force and taper damage for the intermediate term implants (head taper: ρ=-0.73, p=0.001; stem taper: ρ=-0.57, p=0.023; Figure 1). Additionally, a slight bimodal distribution was observed in the intermediate group, becoming more apparent in the long-term group (Figure 2).

![Figure 1: Correlation between femoral head extraction force and damage score at the head and stem tapers for the intermediate term devices (n=16).](image)
**Discussion:** These results suggest that a relationship between femoral head extraction force and taper damage exists, but that it is dependent on implantation time. For intermediate-term devices, the greater damage observed in tapers with lower extraction forces supports the theory that more firmly impacted components are less susceptible to fretting corrosion damage. In the short term however, this relationship is obscured by the presence of devices that were not in vivo long enough for significant corrosion to occur - irrespective of the taper interface integrity. Conversely, after long implantation times, it is possible that corrosion proceeds to such an extent that cold-welding occurs within the interface - resulting in very high pull off forces for heavily corroded components. Additional investigation is underway to elucidate the mechanism behind these observations and determine the applicability of trends derived from bench-top testing to in-vivo implant performance.

**Significance:** The force at which the femoral head is impacted has been shown in bench top studies to have an effect on the stability of the interface and the propensity for fretting corrosion. This study seeks to explore practical evidence of this phenomenon in vivo by using clinical explants.

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