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Assessment of Head Displacement and Disassembly Force with Increasing Assembly Load at the Modular Head/Trunnion Junction of a Total Hip Replacement Prosthesis

Introduction

The femoral components commonly used in total hip arthroplasty are modular. They require a secure connection between the head and trunnion, a factor that is influenced by the impaction force used by the surgeon at assembly. There is no standard protocol for the assembly of modular heads onto femoral stems. Manufacturing guidelines and surgical practice vary widely.

The aim of this study was to assess the effect of assembly force on the strength of the head-trunnion interface and to measure the initial displacement of the head on the trunnion with different assembly forces.

Materials and Methods

Twelve JRI™ Furlong HAC stems and head (size 28S) were used for this study. The stems were mounted in a custom rig on a materials test machine (Model 3367, Instron) and a pre-calibrated laser (optoNCDT 1302-20, Micro-Epsilon) sensor was used to measure the head displacement (Fig. 1).

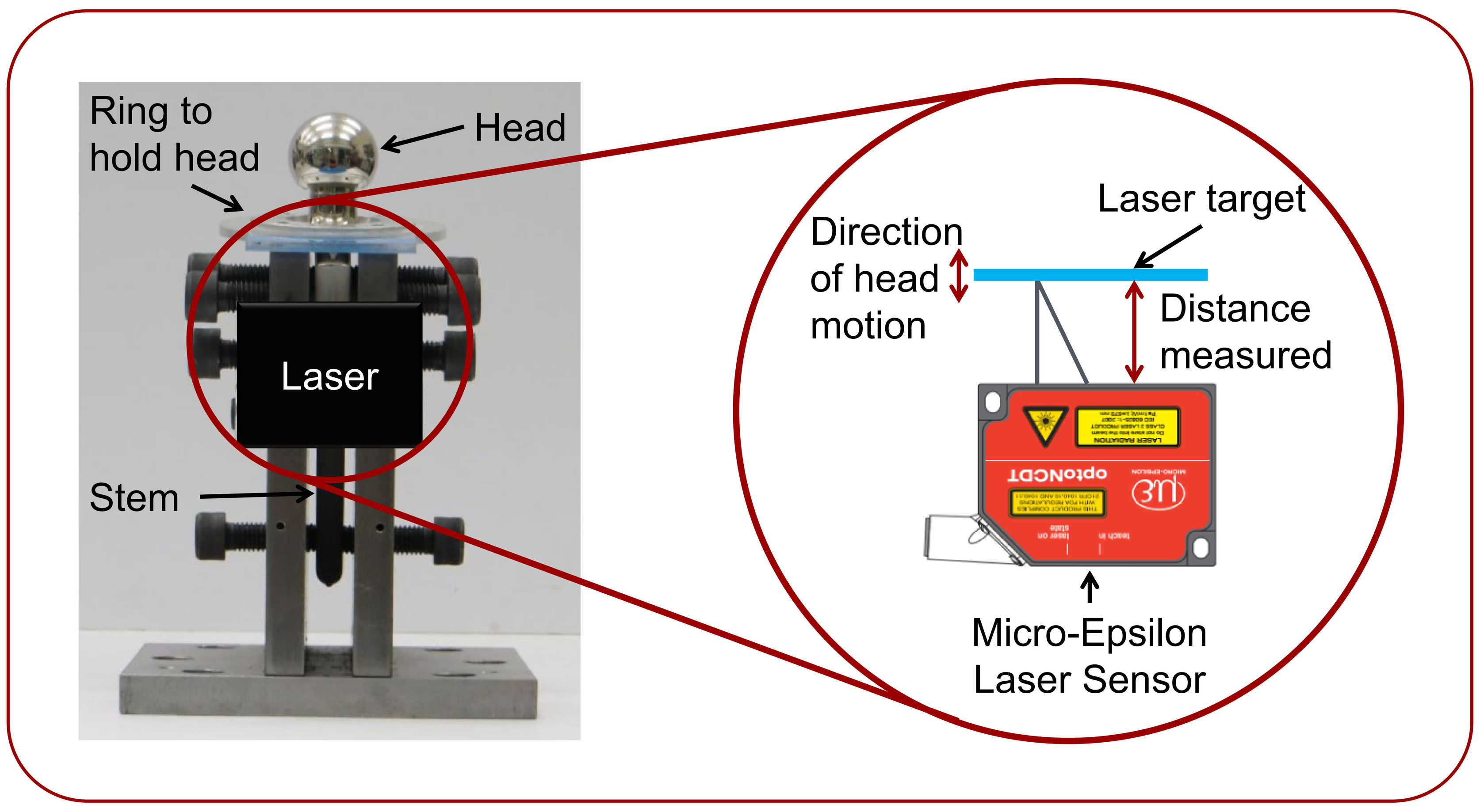

Fig. 1: Test Set-up

The heads were assembled on the stems with the Instron at a constant rate of 0.05 kN/s (ISO7206-10:2003). The implants were divided into three groups. Each group was assembled with a different peak assembly load: 2 kN, 4 kN and 6 kN. Levels of applied load and head displacement were recorded during assembly.

A pull-off test was then performed using the Instron at a constant rate of 0.008 mm/s (ISO7206-10:2003) and the disassembly force was recorded (Fig. 2).

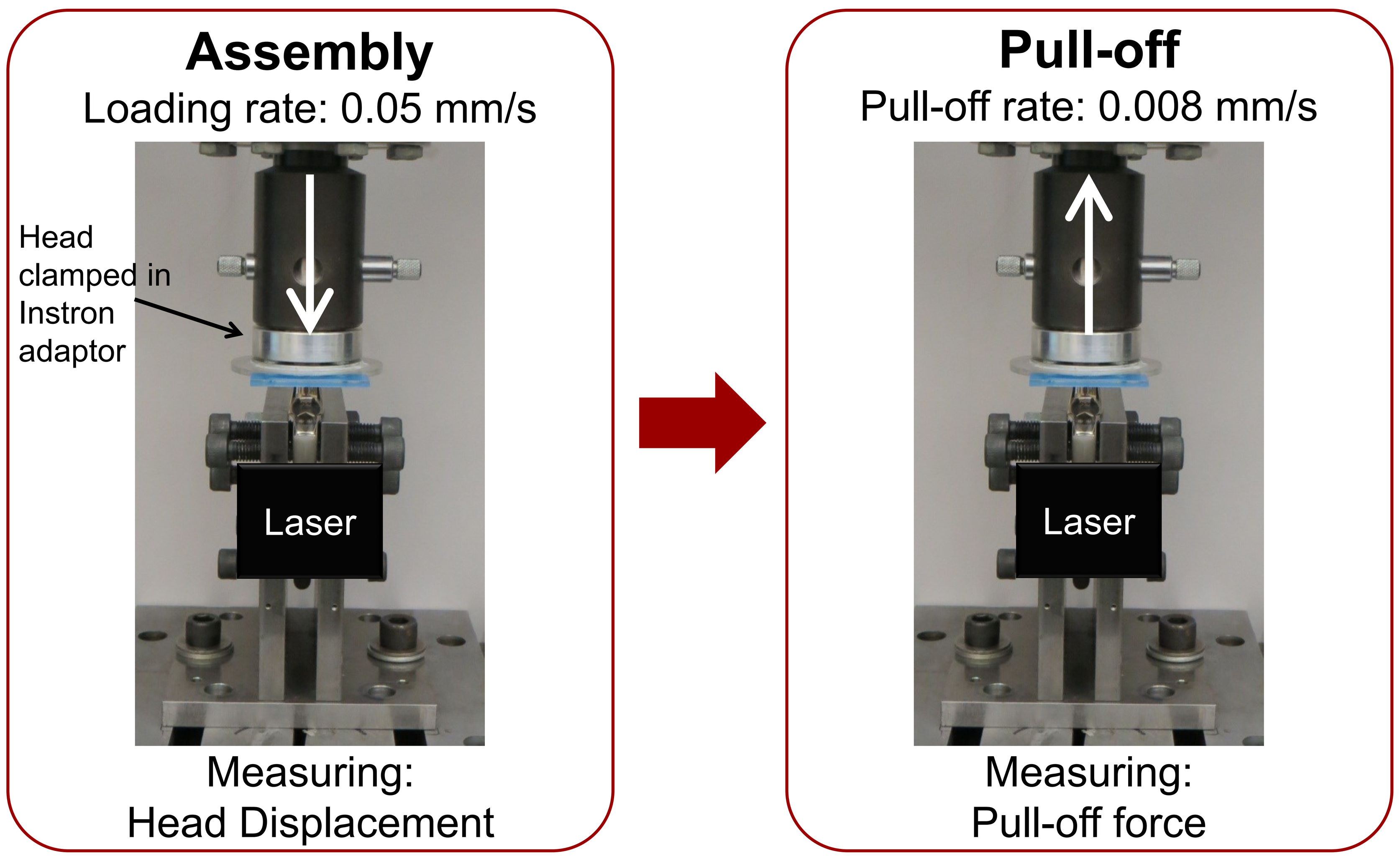

Fig. 2: Assembly and Pull-off Test

For statistical analyses, a Kruskal Wallis test was used to determine if any significant differences existed amongst the three groups of samples in terms of maximum head displacement and pull-off force. The Mann-Whitney U test was then used to compare pairs of groups to determine the significant differences between them.

Results

The pull-off/disassembly forces increased significantly with assembly load; the statistical different between the three groups was p = 0.007 (Kruskal Wallis) (Fig. 3).

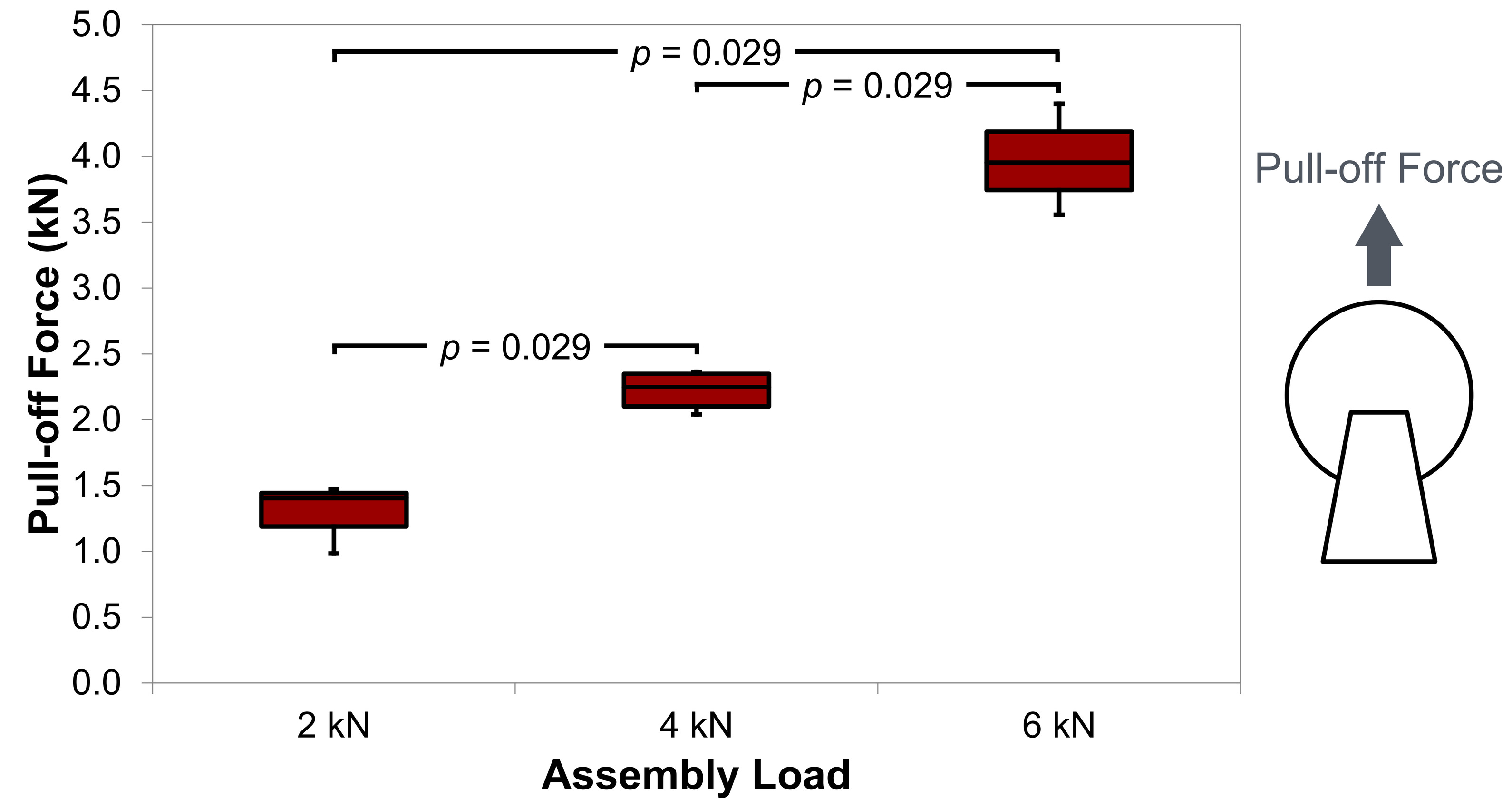

Fig. 3 – Pull-off force (kN) for each assembly load group (Mann-Whitney U).

During assembly, almost no head displacement was seen until a sudden change in displacement of about 150 μm corresponding to a spike of 2.5 kN in the loading profile (Fig. 4). A more gradual change in displacement was then observed up to the peak assembly force. This was not seen with the 2 kN group.

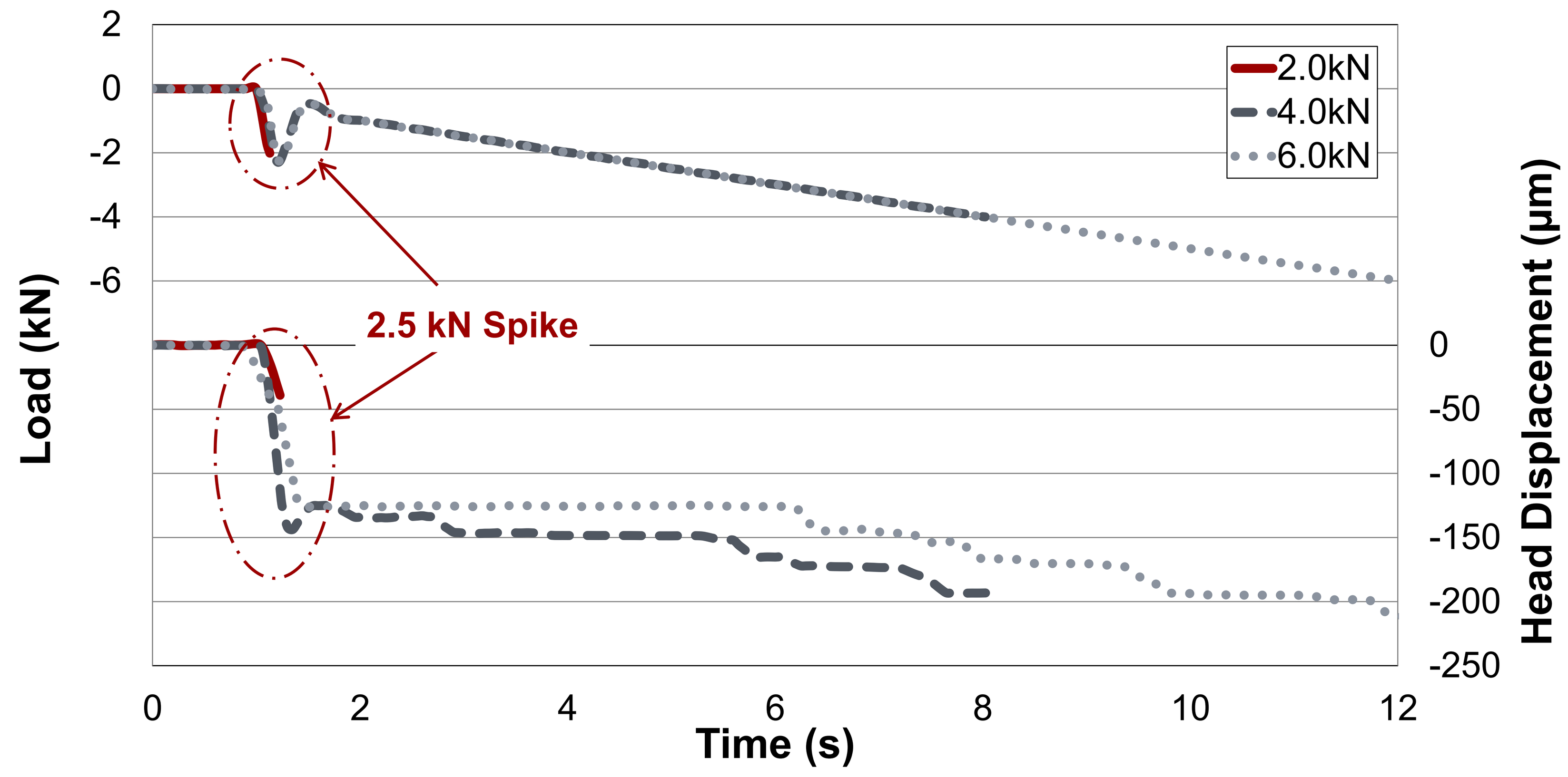

Fig. 4 – Load and head displacement for each assembly load group

The maximum head displacement on the trunnion was significantly different between the 2 kN group and the other two groups. No difference was observed between the 4 kN and 6 kN groups (p = 0.89) (Fig. 5).

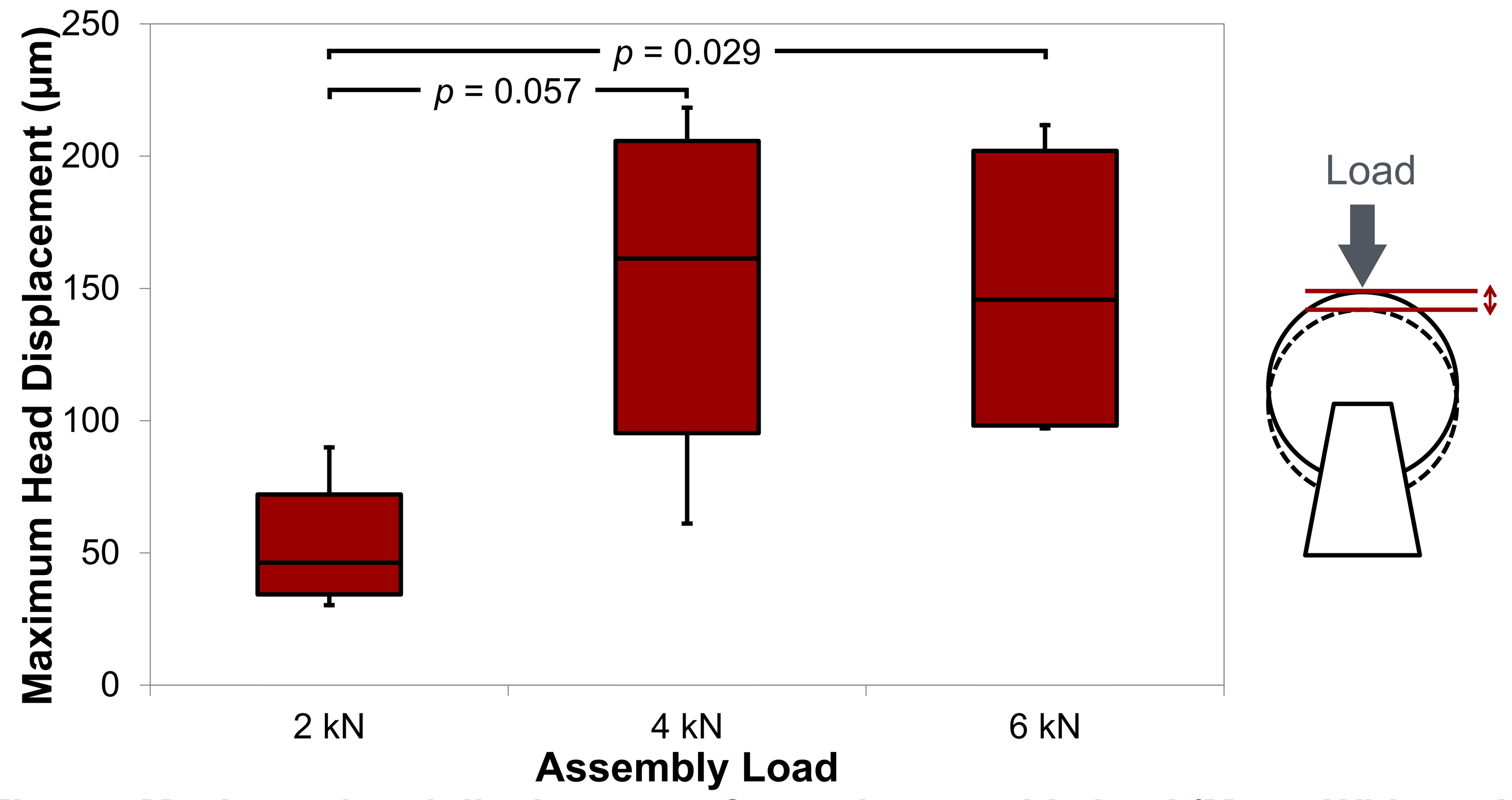

Fig. 5 – Maximum head displacement for each assembly load (Mann-Whitney U).

Discussion & Conclusions

The increase in assembly load resulted in a higher pull-off force. An assembly force of at least 2.5 kN was required to overcome the frictional forces needed to engage the head on the trunnion. Assembly loads below this threshold were insufficient to achieve full seating of the head and hence coupling between the two components. The results presented are applicable to JRI Furlong HAC stems, however similar patterns would be expected with comparable implant designs.

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References:
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2. Rehmer et al. *Clin Biomech* 2012; 27: 77-83

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