

# Influence Of Ceramic Head Size And Damping Of Impactation On The Fixation Strength Of The Taper Connection In Total Hip Arthroplasty

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**INTRODUCTION:** The taper connection used in total hip arthroplasty (THA) offers advantages, including precise anatomical reconstruction of the leg length and offset, improved range of motion without impingement, and the possibility of head exchange in revision cases. A crucial parameter for taper strength is the load applied by the orthopaedic surgeon during the implantation. Low impactation force can cause insufficient taper connection leading to fretting and corrosion and an adverse local tissue reaction that may result in implant failure [1-5]. To get a comprehensive overview over the applied impactation forces and resulting taper connection strength, several factors must be considered in experimental testing. These factors include the precise location of force measurement sensor, damping effects through soft tissue, and the size of the ball head. Therefore, we evaluated the force above and below the taper as well as the stability of the taper connection of ceramic heads depending on changing compliance of the base plate and the re-usage of ceramic ball heads.

**METHODS:** 15 ceramic ball heads (diameter 36mm, n=9 and diameter 28mm, n=6) were impacted on 15 new titanium tapers. The taper were fixed to a base plate which was mounted upon materials with different mechanical properties. These materials were solid aluminium, representing the quasi-rigid base and commercially available PE-foam (6R8, Ottobock SE & Co. KGaA) and PEVA-foam (Lunatec CAD 35, nora systems GmbH). The taper connection was assembled using a drop rig, equipped with a hammer with a weight of 2.29 kg and an impactor equipped with a Polyamid (PA12) tip, which was positioned on the head (Figure 1a). The drop height of 10 cm resulted in 2.25 J impactation energy in accordance with the ASTM F2009 standard. Each head-taper combination underwent three impactations. The peak force was evaluated with a sensor inside the impactor and below the titanium taper. The pull-off tests were performed quasi-statically using a uni-axial testing machine (Z050, ZwickRoell GmbH & Co. KG) (Figure 1b). No significant difference caused by reusage of the titanium taper was found (Kruskal-Wallis-Test ( $p > 0.45$ )). Therefore, further evaluation estimated that each trial was independent from one another. The Kruskal-Wallis-Test with Post-Hoc-Tests and Bonferroni Correction was used to evaluate the influence of the base materials and the head size.

**RESULTS SECTION:** The soft base plates (PEVA-foam) showed significant lower forces inside the impactor for 36 mm heads (aluminium 4600N vs. PE 3140 N,  $p < 0.001$ ; vs. PEVA 3553 N,  $p = 0.005$ ), below the taper (aluminium 4500 N vs. PE 1250 N,  $p < 0.001$ ; vs. PEVA 1410 N,  $p < 0.001$ ) and in the pull-off-test (aluminium 2267 N vs. PE 1250 N,  $p < 0.001$ ; vs. PEVA 765 N,  $p < 0.001$ ). Neither for quasi rigid nor for soft base a smaller head size led to significant difference of the forces below the taper (aluminium 36 mm: 4500 N vs. 28 mm: 4197 N,  $p > 0.05$ ; PEVA 36 mm: 1250 N vs. 28 mm: 1588 N,  $p > 0.05$ ) or pull-off-forces (aluminium 36 mm: 2267 N vs. 28 mm: 2036 N,  $p > 0.05$ ; PEVA 36 mm: 790 N vs. 28 mm: 956 N,  $p > 0.05$ ).

**DISCUSSION:** Recent studies examining the fixation strength of the taper connection used quasi-rigid bases, which do not consider damping by soft tissue [2,6]. Our present data are in line with studies with anatomic specimens that confirm the influence of the soft tissue on the transduced force [7]. In our tests, no significant influence for different head sizes could be found. Sensor position below the taper was expected to represent acting forces more accurately than a sensor placed above the taper. The base material had a higher influence on the measured forces below the taper. Additionally, a sensor right below the titanium taper seems to be a more reliable indicator of the fixation strength of the taper connection than a sensor placed above the taper.

**SIGNIFICANCE/CLINICAL RELEVANCE:** Systems with softer base need higher impactation forces to produce stronger taper stability. The use of damping and placement of the force sensor should be a notable consideration in future studies investigating taper stability.

## REFERENCES:

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## IMAGES AND TABLES:

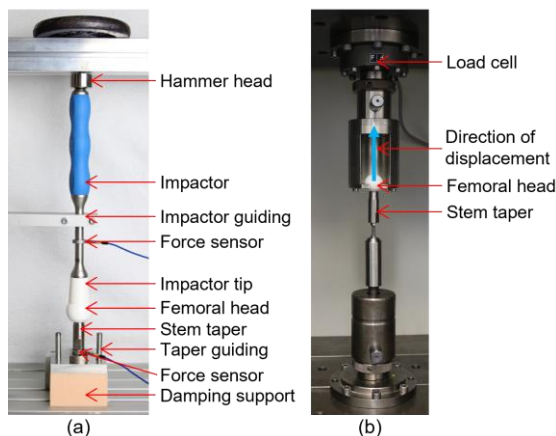


Figure 1: Impactation setup (a) and setup for quasi static disassembly (b)

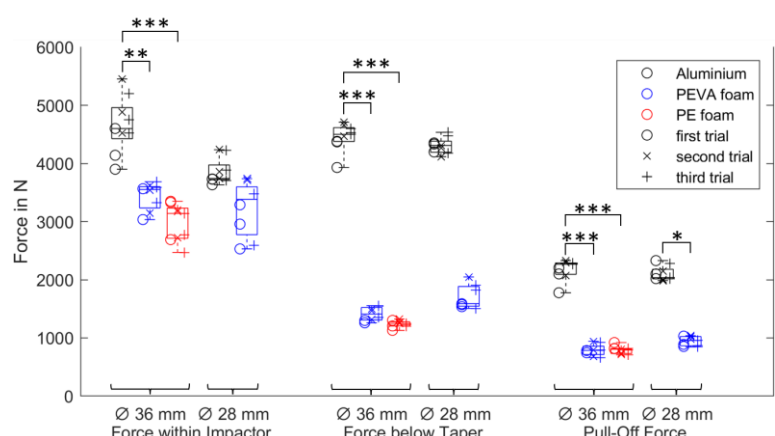


Figure 2: Whisker and scatter plot of forces measured within the impactor, below the taper and during pull-off testing; \*\*\* $p < 0.001$ ; \*\* $p < 0.005$ ; \* $p < 0.05$ .