SAME OFFSET, DIFFERENT STABILITY: HOW HEAD LENGTH AFFECTS TAPER JUNCTION MICROMOTIONS IN TOTAL HIP ARTHROPLASTY

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Introduction

Modular neck systems allow intraoperative adjustment to adapt the implant length to patient's anatomy or to replace only the damaged element of a hip prosthesis. Morse taper principle is frequently adopted to combine prosthetic components: after the application of the assembly force, the trunnion (male portion) locks the artificial joint through the compression of the taper (female portion) [1]. Nevertheless, modular prostheses present issues related to the establishment of relative micromotions between coupled elements, which can lead to implant failure due to cytotoxic metal debris onset. Micromotions can be influenced by surgeon-related factors including the selection of prosthetic components [2]. Although equal implant offsets can be achieved by assembling tapers and trunnions of different sizes, intraoperative adjustments are often limited to the head length. However, different studies reported that implant failure can be correlated with the head length variation due to presence of a lever arm between the head centre and the taper engagement area [2-3].
In this work, the head length impact on the head-neck junction stability was investigated through an *in silico* comparison between couplings with the same Offset.

Methods

Three head-neck junctions with different head lengths (S = 14.7 mm, M = 18.7 mm, and L = 22.7 mm) were designed compensating the lever arm introduction with a variation of the neck length (Fig. 1). The models consisted of a Ø 32 mm zirconia-toughened alumina (ZTA) head and a titanium alloy stem (Ti6Al4V), which was considered cylindrical for the whole neck. No angular mismatch between the two components was considered (perfect fit configuration).

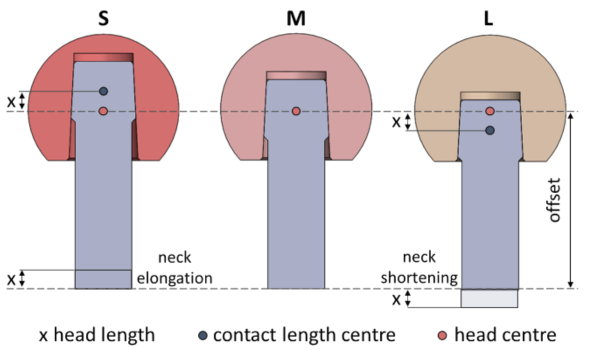

Figure 1: FE models of the head-neck taper junction with different head length (S, M, and L, x = 4 mm) but same offset.

A finite element (FE) model (Abaqus, Dassault Systèmes, France) of each configuration was implemented by simulating the insertion of the taper on the trunnion using a 4 kN applied force [3]. The head axial movement and the contact pressure were verified by analytical calculations proposed in [4]. Following the assembly phase, multibody (MB) derived loads (Adams View, MSC Software, USA) were imposed as boundary conditions in a FE simulation to estimate the taper junction micromotions as the relative slip (CSLIP) between the contacting surfaces during a normal walking cycle.

Results

The maximum micromotion was observed in the distal-medial area of the trunnion contact surface for all configurations. The L-size head model was the most critical case, showing a relative slip equal to 4.1 µm at 50% of the gait cycle (i.e., start of the swing phase). At the same time step, S-size model exhibited the lowest value of micromotions, reaching 1.7 µm (Fig. 2).

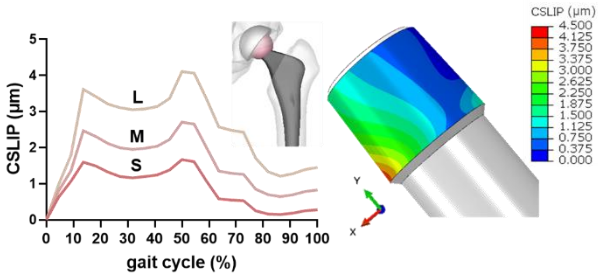

Figure 2: (Left) Maximum CSLIP in S, M, and L configurations during a walking cycle. (Right) CSLIP distribution at 0.55 s in the L-size implant.

Discussion

This study assessed the head-neck joint stability in implants with different head lengths. The proposed approach allows the simulation of specific geometry in different load conditions: this methodology can be useful to reduce the risk of implant failures, supporting clinical decision-making processes.

References

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