THREE-DIMENSIONAL MODELING OF THE HIP KINEMATICS UNDER MICRO-SEPARATION REGIME AFTER TOTAL HIP REPLACEMENT: APPLICATION TO THE SQUEAKING

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Introduction: Recently, specific noise has been reported by many authors [1,2] as they found up to 15% of noisy hips when using ceramic-on-ceramic prostheses. This noise seems to be related to the hip kinematics and more precisely to the joint laxity [3]. Specific hip simulators (Leeds II) including a micro-separation of 500 μm allow to get clinically relevant wear rates and patterns wear [4]. However, to our knowledge there is no tribological modeling of ceramic-on-ceramic hip prostheses under micro-separation regime. The goal of the study was to model the hip kinematics under micro-separation regime in order to develop a computational simulator for total hip prosthesis including a joint laxity, which would allow to study the vibratory phenomenon and its link to prosthesis designs.

Materials and Methods: A three-dimensional model of the Leeds II hip simulator [4] has been developed on ADAMS® software.

A specific device allowed a controlled micro-separation (less than 500 microns) during the swing phase of the walking cycle. The increase of the load during the stance phase induced a relocation of the head in the cup. Values of the medial-lateral separation obtained with the model were compared to experimental data measured with 5 mm precision using a specific device (LVTD). Theoretical wear path of the model was compared to the literature data. The frequencies of the vibratory phenomena were determined, using the Fourier transformation.

Results: There was a strong correlation between the theoretical values and the experimental values of the medial-lateral separation during the walking cycle (0.92).

Edge-Loading contact occurred during 57% of the cycle according to the model and 47% according to the experimental data. Velocity and acceleration were increased during the relocation phase with a chaotic aspect that could generate vibration. The contact force according to the model had also a chaotic aspect during the micro-separation phase suggesting a chattering movement.

Discussion: A three-dimensional model of the kinematics of the hip after total replacement has been developed and validated with an excellent precision. It has highlighted possible explanations for the squeaking. In fact, relationship between kinematics and squeaking was suggested but has never been proved before. However, other factors could generate noise such as the lubrication conditions which have never been modeled under micro-separation regime.

References: