INFLUENCE OF THE RESTING PERIOD ON THE *IN VIVO* FRICTION IN HIP JOINT REPLACEMENT

Philipp Damm, Alwina Bender, Georg Bergmann
Julius Wolff Institute, Charité – Universitätsmedizin Berlin, Germany

Introduction

Friction between head and cup is one of the most important factors for the endurance of total hip joint replacement (THR). With 26% to 48% of all cases [CJRR], polyethylene wear and aseptic loosening are the most frequent reasons for revisions of THR. To determine friction in THR *in vitro*, simulator studies were performed which mostly determined the friction during continuous movements. However, during daily activities movement often interrupted by short resting periods. Aim of our study was to determine realistic friction data *in vivo* after a short resting period.

Methods

An instrumented total hip joint was developed to measure *in vivo* forces (F) and friction moments (M) [Damm 2010]. The measurement system is powered inductively; 3D forces and moments are transmitted by radio telemetry and reported in %BW (% bodyweight) and %BWm. Measurements were taken 12 months post operatively (pOP) in 4 subjects; during the first 4 steps of walking after an average resting time of 8s. Load patterns of 6-17 trials were averaged per subject [Bender and Bergmann 2011]. Furthermore the joint load of an average subject was calculated from the intra-individually averaged loads. A 3D approach was chosen for the calculation of the coefficient of friction (μ) from the force vector $\underline{F}_{res}$ and the vector of the friction moment $\underline{M}_{res}$.

$$\mu = |\underline{M}_{res}| / (|\underline{L}| * |\underline{F}_{res}|). \qquad (1)$$

$\underline{L}$ connects the point of force application at the head and the movement axis and is perpendicular to this axis and to the frictional force.

Results

In figure 1 the load pattern of F_{res}, M_{res} and μ for an average patient are shown. During walking F_{res} had 2 maxima at contralateral toe off (CTO) and contralateral heel strike (CHS). With 236±0.5%BW at CTO and 238±4.3%BW at CHS, F_{res} was nearly constant during the first 4 steps. In contrast whole F_{res} the pattern of M_{res} was higher during the 1st step (marked green) than during the following ones. On average its values were increased by 50% at CTO, 21% at CHS and 21% for the maximum of M_{res}. As a consequence the pattern of μ was also increased during the 1st step, on average by 50% at CTO and 23% at CHS. The highest value of μ always occurred when flexion of the joint started and was 20% higher during the 1st step.

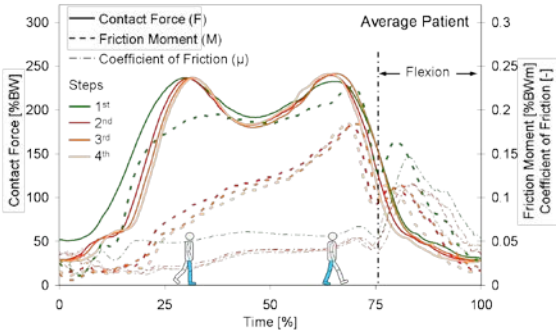

Figure 1 *Pattern of F_{res}, M and μ of an average patient after a mean resting period of 8s; data during the first 4 steps*

Discussion

This study is the first one reporting forces and friction in hip implants under real *in vivo* conditions. It showed that after a resting period M_{res} and μ are increased during the 1st step. M_{res} was up to 50% higher during the 1st step after a short resting period of 8s. This is probably caused by the fact that the synovia is squeezed out from the joint during resting. Possible consequences are higher shear stresses at the gliding surfaces and also increased mechanical stresses at the cup fixation. Hence increased wear and a risk of friction induced cup loosening can not be excluded. Additional investigations will show if these first findings can be generalized.

Acknowledgment

Support of the project by German Research Society (SFB 760; Be 804/19-1) and Deutsche Arthrose-Hilfe e.V..

References

Bender and Bergmann, Comp. Meth. Biomech. Biomed. Eng., 2011
CJRR, Report of the Can. Inst. of Health Inf., 2008
Damm *et al.*, Med. Eng. Phys 32, 2010