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Analysing 'Lift-off' Events During Knee Wear Testing

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Introduction

The lower conformity and bi-condylar nature of the knee makes condylar 'lift-off' (LO) an issue; fluoroscopy studies show condylar LO in many cases[1]. However a distinction must be drawn between 'condylar' LO, and 'local' LO (i.e. when specific areas of the articulating surface experience intermittent contact). It is possible to have local LO without condylar LO, and both may contribute to increased wear in different ways. Local LO has been studied in pin-on-disc (POD) tests and has been shown to have the potential to increase wear[2,3]; condylar LO has also been re-created for knee wear tests, again increasing wear[4]. However, *in-vitro* it is difficult to determine whether an increase in wear is due directly to condylar LO, or a resulting increase in local LO. Condylar LO will modify the kinematics of the knee, allowing greater mobility for the contra-lateral condyle, and increasing contact pressure; however an increased level of local LO *may* also occur, which may be increasing wear potential in other ways. *In-silico* models provide a means to explore and this interaction and visualise LO.

Materials and methods

Two LO metrics were defined (LO frequency/cycle and contact-time/cycle), and used in conjunction with existing computational knee wear simulations[5,6]. First, an *in-vitro* condylar LO study[4] was re-created *in-silico*. Results were compared with and without condylar LO. Next, these LO metrics were used to compare six different designs, under ISO force-driven control, to determine the extent to which local LO is dependent upon design geometry.

Results and Discussion

In the condylar LO simulation, it is apparent that local LO occurs in both cases (with and without the condylar LO); even in the case without condylar LO, certain areas of the insert experience up to five separate LO events per cycle; only slightly less than the case with condylar LO (Fig.1). This suggests that a condylar LO test is not an ideal differentiator for analysing the effect of 'local' LO event frequency; rather, resulting differences in wear rate may be due to changes in contact pressure or area, or altered kinematics due to the uni-condylar loading.

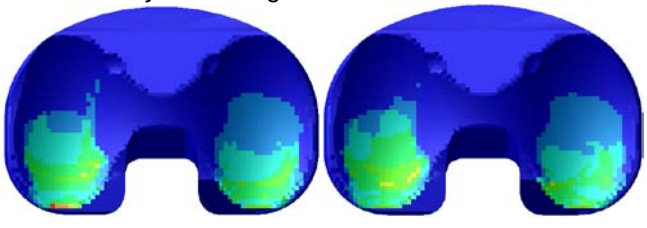

Fig. 1: LO events/cycle with condylar LO (left) & without (right). Local LO is only slightly greater with condylar LO.

The comparison of different designs shows that, for the same input conditions, changing the articular surface geometry can considerably alter the intermittency of contact, in terms of both LO event frequency and contact-time per cycle. For these six designs, the highest LO frequency was ~170% of the lowest (Fig.2), and the contact-time 130% (Fig.3).

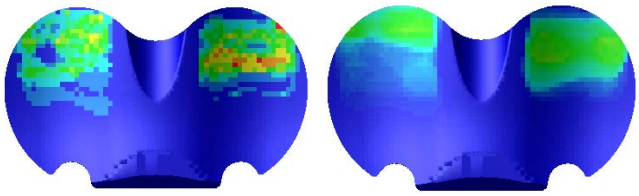

Fig. 2: LO events/cycle: high (left) & low (right).

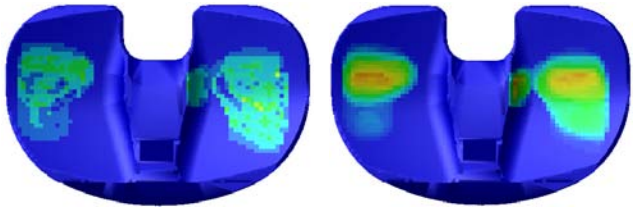

Fig. 3: Contact-time/cycle: low (left) & high (right).

Conclusion

The ability to visualise LO is an under-exploited support capability which *in-silico* models can provide for experimental testing. It is evident that a condylar LO study will not necessarily provide higher levels of 'local' LO. Bespoke studies would be needed to explore this factor in isolation, independently of condylar LO. The fact that the degree of 'local' LO appears to be device-dependent could have important implications for implant designers.

We have demonstrated the concept of simple metrics for qualitative visualisation purposes; ultimately these could to be incorporated into quantitative wear algorithms, but further work is needed to understand the role of LO in influencing wear.

Acknowledgements

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