DEVELOPMENT AND VALIDATION OF A FINITE ELEMENT MODEL TO PREDICT PATELLO-FEMORAL WEAR IN TKA

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Introduction
Experimental patello-femoral (PF) and femoral-tibial (FT) wear tests can be used to quantify wear in an implant but these procedures are expensive and time consuming. Therefore, a validated numerical model could be useful to predict wear in less time with less cost. For these reasons, the aim of this study was to develop and validate a numerical methodology to predict PF wear in TKA. Initially, the wear model was calibrated using the results of an experimental roll-on-plane wear test. The developed wear model was applied to predict PF wear and validated comparing the numerical predicted wear with experimental wear results.

Methods
Wear model
The adhesive/abrasive wear behavior was determined using the Archard model [Archard, 1953] with the Sarkar modification [Sarkar, 1980], in which linear wear \( h \) is determined as:

\[
h = k_w p s N (1 + 3\mu^2)
\]

in which: \( k_w \)=wear factor, \( p \)=contact pressure, \( s \)=sliding distance, \( \mu \) friction coefficient.

Roll-on-plane calibration
Three blocks of UHMWPE (GUR 1020) underwent a 6x10^6 cycles experimental roll-on-plane wear test (Fig. 1a). The full experimental test was reproduced by finite element analysis (FEA) (Fig. 1b) and the wear model was calibrated, adjusting \( k_w \), during the simulation as illustrated in Figure 2. The geometry of the block was updated every 500,000 cycles.

Patello-femoral wear prediction
Three patellar and femoral components were tested for 2x10^6 cycles in a wear simulator (Fig. 1c) [Vanbiervliet, 2011]. The full experimental test was numerically analyzed in a FEA model (Fig. 1d). The PF wear was predicted using the calibrated wear model (Fig. 2). Experimental wear data and numerical wear prediction were finally compared.

Results
Roll-on-plane
Using a \( k_w = 1.83x10^{-8} \) mm^3/Nm, the results of the numerical simulation show a linear wear of 0.127 mm, very close to the linear wear measured experimentally (0.125 mm, SD =0.01mm).

Patello-femoral
The numerical model results show a total volume wear of 0.38997 mm^3 after 2x10^6 cycles while the mean wear volume measured experimentally for the same number of cycles for three samples, is 0.37660 ± 0.326 [Vanbiervliet, 2011].

Discussion
In this study a wear model was developed and calibrated comparing an experimental and a numerical roll on plane test. The wear model was later validated comparing the wear predicted by the numerical model and from experimental test of 2x10^6 cycles of walking. The validated wear model can be used to predict wear between PF and FT articulations for several configurations to predict a TKA long-term performance for a specific patient and to optimize and improve implants designs.

References
Vanbiervliet, JBJS Br, 1348-54, 93-B(10), 2011.