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MONITORING OF THE FEMORAL STEM INSERTION IN BONE MIMICKING PHANTOMS BY IMPACT MEASUREMENTS

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Summary: The primary stability of the femoral stem (FS) implant is an important parameter for the surgical success of cementless hip arthroplasty. During the press-fit FS insertion, a compromise must be found regarding the number and the energy of impacts that should be sufficiently large to obtain a good primary stability of the stem, but that should not be too high to avoid risk of fracture. The aim of this study is to determine whether a hammer instrumented with a force sensor can be used to monitor the insertion of cementless FS.
FS of different sizes were impacted in four artificial femurs with the instrumented hammer, leading to 44 configurations. The impact number when the surgeon empirically felt that the FS implant was in an optimal position was noted Rsurg. The insertion depth E was assessed using digital image correlation and the impact number Rvid corresponding to the end of the insertion was determined. For each impact, two indicators noted I and D were determined based on the analysis of the variation of the force as a function of time. The impact number Rd corresponding to the first time when D<0.53 ms was determined. Then, the pull-out force F was measured.
For all configurations, the variation of D and E as a function of the impact number was are qualitative similar and an indicator based on this evolution is highly close to Rsurg. The average difference between Rsurg and Rd (respectively Rvid and Rd) was equal to 0.07 (respectively 0.09). Moreover, the pull-out force F was significantly correlated with the indicator I (R^2 = 0.70).
The method developed herein allows to determine the moment when the surgeon should stop the impaction procedure in order to obtain an optimal insertion of the FS and to assess the FS implant primary stability. This study paves the way towards the development of a decision support system to assist the surgeon in hip arthroplasty.