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FINITE ELEMENT MODELING OF THE PRIMARY STABILITY OF ACETABULAR CUP IMPLANTS

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Summary: Biomechanical phenomena occurring at the bone-implant interface during the press-fit insertion of acetabular cup implants are poorly understood because of the complexity of this multiscale problem. A 2D axisymmetric finite element model assuming large displacements and aiming at modeling the biomechanical behavior of the AC implant as a function of the bone Young's modulus Eb, of the diametric interference fit (IF) and of the friction coefficient μ is proposed. The maximal contact pressure tN is localized at the peri-equatorial rim of the acetabular cavity and reaches a value of 15 MPa for μ = 0.4, Eb= 0.2 GPa and IF = 1 mm. The behavior of the AC implant depends linearly on Eb. Increasing μ from 0.2 to 1 (for IF = 1 mm) leads to an increase of the pull-out force from 121 to 1821.5 N, which is reached at the transition between the non-sliding and sliding regimes. The main finding of this study is that for a given value of μ, the pull-out force reaches a maximum value Fo at an interference fit IFo, corresponding to an optimal primary stability condition. When μ varies from 0.1 to 1, Fo increases from 1.21 to 2576.7 N, while IFo first increases from 0.1 to 1.7 mm for μ comprised between 0.1 and 0.4 and then stays equal to 1.7 mm for μ > 0.4. The value of IFo does not depend on Eb. The results may be useful to understand the biomechanical determinant of the AC implant primary stability.