Acetabular Cup Geometry and Bone-Implant Interference have More Influence on Initial Periprosthetic Joint Space than Joint Loading and Surgical Cup Insertion

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Environmental variations in patient-dependent and surgical factors were modeled using robust optimization with a finite element acetabular cup-pelvis model. A previously developed statistical optimization scheme was used to: (1) determine the cup geometry and the optimal cup-bone interference that maximized bone-implant contact areas and minimized changes in the gap volume between the implant and bone surface during gait loading and unloading; and (2) determine the relative contributions of design, patient dependent, and surgical factors to variations in bone-implant contact areas and a change in gap volume. The statistical analyses indicated that the design variables, namely the equatorial diameter and eccentricity, explained most of the variations in the performance measures. Further, the hemispherical designs performed better than the nonhemispherical designs. The 58 mm hemispherical cup, with 2 mm diametral interferences, minimized the change in gap volume and attained 82% and 81% of the maximum predicted total and rim contact areas, respectively. The equatorial diameter and eccentricity, not the patient-dependent and surgical factors, explained most of the variations in the performance measures. Perfect surface apposition was not attained with any of the cup designs.