ACETABULAR COMPONENT DEFORMATIONS AND PRESS-FIT LOADS IN TOTAL HIP ARTHROPLASTY

Introduction:
Acetabular component deformation secondary to forces encountered during insertion is a potential consequence of the press-fit technique. Because of the complex bony architecture of the acetabulum, diametral loads along the rim of the component cannot be expected to be constant. The result is a slightly ovoid component opening prior to liner insertion. While acetabular components may be deformed with initial insertion, relaxation of the acetabular bone over time most probably returns the metal shell to its hemispherical shape. Likewise, insertion of a thick metal liner would force the shell immediately back into concentricity. Acetabular component deformations, however, present potential problems, with regard to the insertion of ceramic liners. In this case, scratching of the liner backing surface can result in significant stress risers and loss of fatigue strength.

The purpose of this study was to document component deformations produced as a result of diametral rim loading of acetabular components in the laboratory and to perform interoperative measurements of these same deformations in a typical patient population during total hip replacement surgery. In addition to measurement of insertional component deformations, the corresponding laboratory data can be used to provide information with regard to interoperative component press-fit loading.

Methods:
Laboratory Tests: Mechanical testing of a series of acetabular components (DePuy, Pinnacle System, component diameters 48mm – 66mm) was performed to provide diametral deformation versus load curves for each component. Components were rim loaded in compression in 200 N increments up to 2000N of load. Measurements of deformation of the opening of each of the components were performed with a digital dial caliper accurate to ±0.01 mm (See Fig 1).

For each cup size, three series of measurements from 0 to 2000N of load were taken and a deformation versus load curve was constructed as the best-fit straight line to the 30 data points. Component compliance was defined as the slope (mm/kN) of this best-fit line. In laboratory tests, the vertical and horizontal axes were axes of principal (i.e. maximum and minimum) deformation and load.

Interoperative Measurements: Using a custom measuring device, measurements of acetabular component internal rim diameters were performed prior to and after component insertion into 20 patients using a 1 mm press-fit technique. This interoperative measurement protocol was approved by the institutional IRB and measurements were performed with appropriate patient consent. Measurements were taken along principal deformation axes which were determined to be anterosuperior-to-posteroinferior (i.e. axis of maximum compression) and an axis perpendicular to the first (i.e. axis of minimum compression) with regard to the acetabulum. Component compliance data was used to calculate the difference of maximal and minimal principal compressive diametral loads applied to each component. This difference is hereafter referred to as the deviatoric compressive load. Acetabular component deformations were also assessed for potential correlation with patient age, gender and bone quality.

Results:

Laboratory Tests: Compliance data for all 10 component sizes tested are provided in Figure 3.

Discussion:
The major limitation of this study was that only one type of press-fit acetabular component was tested. The study did demonstrate, however, that standard 1 mm press-fit insertion of hemispherical components consistently caused measurable component deformations during surgical insertion for the system evaluated. Deformations of the magnitude measured, have direct effect on the performance of component locking mechanisms and have the potential to result in marring of the backing surface of ceramic liners in metal components unless shell concentricity is reestablished prior to insertion. The study also demonstrates that component deformations and compliance data for the component involved, can be used to calculate deviatoric compressive loads on the acetabulum and the implant immediately after surgical insertion. Therefore, the measurement techniques developed in this study can also be applied to studies investigating the role of press-fit loads in enhancing or retarding bone ingrowth into porous coated acetabular implants.

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