IMPORTANCE OF MANUFACTURING TOLERANCES IN REPLACMENT ARTICULAR SURFACE DESIGN.

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The objective of this work was to record contact area distributions and the corresponding magnitudes of interface pressure obtained on the polyethylene tibial plateau component of a new design of total knee replacement.

A custom-built loading frame allowed the tibio-femoral joint to be loaded in a MTS Bionix electro-hydraulic universal testing machine with the femoral component rotated to any given flexion angle. Fuji Prescale pressure-sensitive film was placed on the superior and inferior articulating surfaces of the plateau component prior to the application of either 1 or 2 kN load. The resulting stains were digitized and rendered as false-colour pressure maps with a resolution of up to 0.2 Mpa, utilizing calibration data collected prior to testing. Contact areas were also investigated with “Toolmaker’s Blue” ink liberally applied to the metallic femoral and tibial tray components prior to loading. This produced a number of stains on both surfaces of the plateau component, indicating contact areas.

The inferior aspect of the plateau exhibited a lack of congruency, with contact on the anterior and posterior aspects, which was inconsistent with dial gauge measurements taken across this surface. Incongruent pressure and contact area distributions on the superior aspect, combined with further dimensional measurement of this and the femoral articular surfaces showed that a combination of varying femoral and under-size plateau radii was forcing an anterior-posterior curvature of the plateau component leading to the observed contact areas and pressure distributions on the inferior surfaces.

These results demonstrated that dimensional mismatch between articulating components will lead to surface incongruencies and a corresponding increase in surface pressures. Therefore, in any design, the magnitudes of, and adherence to, manufacturing tolerances is important in reducing stresses in the polyethylene component.