Introduction: The optimal surface finish of cemented femoral components in total hip arthroplasty remains controversial. Rough surface finish has been implicated in the early failure of some femoral components. On the other hand, rough surface finished cemented femoral components have excellent track records over 10-years, 15-years and 20-years. To investigate this issue scientifically, we have developed a stair-climbing loading apparatus, which tests femoral components by applying the high torsional loads that occur during stair climbing. This type of loading is thought to be more adverse to the cement-metal interface than single leg stance or normal gait. To separate the issue of surface finish from that of component design, we analyzed the effect that two different surface finishes on the identical femoral components had on debonding, rotational stability and early mechanisms of loosening.

Materials and Methods: Twelve Centralign size 1 femoral components (Zimmer, Warsaw, IN) were implanted into fiberglass femora (Pacific Research Laboratories, Vashon, WA) using contemporary cementing techniques (canal plug, cement gun, centrifugation of the cement, pressurization) with the cement in doughy consistency. Six of the components had a polished surface, with a Ra value of 1.86 µ inch (range 1.2 to 3.2). Six had a rough finish with Ra value of an average Ra of 95.3 µ inch (range 91 to 100). None of the components were pre-coated. The rough components were macrotextured proximally. The polished components had no proximal macrotexturing. The femora were then loaded in the stair-climbing loading jig, which mounted them in a position of 30° flexion, 20° abduction, and neutral rotation. This loading jig was designed to reproduce the strains in the proximal femur and the proximal cement mantle which occur during stair climbing. The stems were then loaded to a joint reaction force (JRF) of approximately 200 kg corresponding to a body weight of approximately 50 kg. The femoral head used was a 28-mm diameter with a neck-length of 17.5 mm. This was to maximize the offset and the torsional stresses. The load was cycled at 2 Hz. At approximately every million cycle interval, loading was stopped and the specimens were examined. The proximal cement mantle was examined visually for cracks. AP, lateral and 2 oblique contact radiographs were taken and examined for signs of debonding or loosening. A 30 NM internal rotation torque was applied to the stem and the rotational motion was recorded. Then, loading was continued, to a total of 6 million cycles.

Results: Micromotion was detectable in all femoral components after the first million cycles. It progressed each 1 million cycles in all components until by 6 million cycles all components were visibly loose to the naked eye. At 6 million cycles the polished components had an average micromotion of 465 microns (range 200-660 microns), Table 1, and the roughed components had an average micromotion of 457 microns (range 195-870 microns), Table 2. Proximal cracks in the cement became visible at micromotions of 300 microns. Even though all 12 components were visibly loose upon torquing at the end of the test, none of the components exhibited any radiographic evidence of loosening during any time of this study. No femoral components had burnishing.

Conclusion: This model was designed to stress femoral components maximally, as occurs in stair climbing. Since stair climbing occurs perhaps 20% of the gait cycles; 1 million cycles is equivalent to 5 years of use and 6 million cycles may amount to the equivalent of 30-years of use. Of interest, changing the surface finish did not effect the outcome or rate of loosening.

The lack of evidence of radiographic debonding or loosening is noteworthy as it sheds light on the sensitivity and grading of debonding or radiolucencies of femoral components. Even with gross loosening and micromotion of over 400 microns, debonding was not shown on any of the four contact radiographs.