Introduction: In revision total hip surgery, extensively coated prostheses are commonly implanted in an attempt to stabilize the prosthesis within the femoral diaphysis. Typically, the rough distal stem of the device is driven into the slightly undersized canal, thereby creating an interference fit to resist torsional loading. Although this method of implant fixation is often successful, the revision femur often presents a limited area for implant contact. Moreover, the ingrowth coatings used within the body have been selected to promote bony ingrowth, regardless of the strength of the interfaces formed at the moment of implantation. This study was conducted to determine the minimum length of stem/bone contact necessary to provide adequate distal fixation in the revision femur.

Material and Methods: Cylindrical test specimens of two popular ingrowth coatings were fabricated from commercially available femoral stems: (1) plasma sprayed titanium (diameters=14.0 & 15.5mm) and (2) cobalt-chromium beads (Porocoat, DePuy Inc.), (stem diameters=13.5 & 15.0mm). Cadaveric femora were selected on the basis of radiographic measurements of the canal diameter performed on standard AP and lateral radiographs. Each specimen was sectioned 60mm below the lesser trochanter to provide an 80mm tube of diaphyseal bone. The medullary canals were reamed using straight rigid reamers to provide 0.5mm of press-fit interference (0.25mm per side). Following preparation, the potted specimens were placed on a floating platform of a servohydraulic testing machine (MTS Corp, MN). Each stem was inserted under machine control to a depth of 20mm at a rate of 10mm per second while the insertion force was recorded. Each specimen was loaded in unidirectional cyclic torsion (0.5Hz) using a ramping amplitude function which increased the peak torque by 1 Nm per cycle. Loading was performed to a maximum torque of 40Nm or until 100 µm of motion was detected at the stem/bone interface.

The entire test procedure was conducted in each femur with the stems inserted to depths of 20, 40 and 60mm. After the torsional testing was completed, the force required to extract each implant from the femur was also recorded. Data was tested for normality using the Shapiro-Wilk test and analyzed for significant differences between the insertion depths with ANOVA and Unpaired t-test.

Results: The average forces required to insert the plasma-sprayed stems to depths of 20,40, and 60mm were 633 ± 137N, 1963 ± 304N, and 3614 ± 607N, respectively (fig.1). The forces required to insert the porous coated stems were 959±398N, 2239±397N, and 3064±557N at each of the depths examined, (p = .5846). The torque required to produce 100µm of interface motion of the plasma spray coated stems was 6.1 ± 1.7Nm, 19.1 ± 4.4 and 28.4 ± 3.7Nm at 20, 40, and 60 mm. The corresponding values for the porous coated stems were 13.2 ± 2.4Nm, 13.7 ± 3.0Nm and 15.9 ± 3.0Nm (fig. 2). The difference between the torsional resistance and the two coatings became close to statistical significance at 20mm (p=0.0546), was not significant at 40mm (p=0.296) and was significant at 60mm (p=0.0186). At 60mm, the strength of the interfaces formed by the plasma spray coated specimens exceeded the porous coated specimens by 81%. The strength of the porous coated interfaces did not increase significantly with depth of insertion (p=0.5). In contrast there was a statistically significant correlation between the strength of the plasma spray interfaces and insertion depth (p=0.0001). Extraction forces recorded with the plasma spray specimens were 50% higher than the porous coated specimens.

Discussion: In cases of revised total hip replacements with structural deficiency of the proximal femur, the distal stem/bone interface must provide stable fixation in the face of torsional loads of at least 25Nm during routine daily activities. On the basis of our results, this level of torsional resistance is provided by the plasma spray coated stems if inserted to a depth of 50mm, but not by the porous coated specimens at 60mm. An interesting finding of this study is that the beaded coating generated minimal increases in torsional resistance with increased depth of insertion. This suggests that only the distal region of the coating forms an effective interface with cortical bone presumably because the medullary surface located more proximally is eroded as the coating passes down the canal. In conclusion, in revision cases in which torsional resistance and distal bony ingrowth are primary goals, a plasma-spray coated prosthesis will provide superior diaphyseal fixation, however, at least of 50mm of diaphyseal contact must be available for distal implant fixation.

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