Introduction: Aseptic loosening of the femoral component continues to be a major long-term complication across a wide range of designs in total hip arthroplasty (THA). Early debonding at the stem/cement interface is emerging as an alarming problem [1] with the roughened surface finishes currently popular in clinical practice. The onset of stem/cement interface radiolucency is commonly regarded as evidence of impending aseptic loosening of femoral components implanted using contemporary cementing technique. However, interpretation of small radiolucencies in the diagnosis of debonding is a subjective matter, with readers’ inherent bias potentially playing a role in judgement. We here report results from a laboratory study undertaken to assess the reliability with which subtle radiolucencies at this interface may be routinely detected.

Method: A statistical power calculation, based on a 95% detection rate with 80% power, indicated an appropriate sample size of 72 stems, with 10 readers involved in reviewing the radiographs. Graded radiolucencies (thickness = 0.1, 0.3, 0.5, or 0.7 mm) were created by randomly tape-masking entire non-tip Gruen zones in a group of 36 matte-finish-straight-stem femoral components (DePuy) reproducibly implanted in fiberglass (Sawbones) femoral replicas. All preparations were reamed to allow a generous cement layer (Simplex P), with components being accurately positioned using a distal centralizer. Contemporary cementing technique was used, which consisted of vacuum mixing, retrograde canal filling with a cement gun, and pressurization after stem insertion. Clinically realistic soft tissue shadowing was achieved by wrapping the preparation in a full-thickness soft tissue sheath excised from a non-embalmed cadaver thigh. Standard AP and lateral radiographs were taken using conventional technique (54 kvp, 3 mAs, certified film cassettes, 100 cm source-to-cassette distance). The radiographs were then presented to a group of ten readers, who were asked to score each of the 432 non-tip Gruen zones (36 specimens x 2 views x 6 zones) for the presence or absence of radioluency. Readers were kept uninformed as to the frequency of radiolucencies employed (50% of all Gruen zones, equally divided among the four of the lucency thicknesses) so as to not bias the aggressiveness of their lucency identification.

Results: Readers’ detection rates ranged for 0% (worst individual reader score for 0.1 mm lucencies) to 98% (best individual score for 0.7 mm lucencies). The series average lucency detection rate was 58.2 ± 14.9%, with a categorical breakdown of 14.9 ± 14.0%, 46.2 ± 18.9%, 81.3 ± 15.5%, and 89.7 ± 7.5% for lucency thicknesses of 0.1 mm, 0.3 mm, 0.5 mm, and 0.7 mm respectively. False positive readings occurred at an average rate of 10.2 ± 8.6%. The average reader specificity of detection was 89.8%. The thickness-detection reliability increased between 0.1 mm and 0.5 mm, then plateaued between 0.5 mm and 0.7 mm (Figure 1). The percentage of thin lucency (0.1 or 0.3 mm) detection increased monotonically with the false positive rate, as shown on Figure 2, reflecting how individual reader aggressiveness of designating lucencies influenced assessment reliability. The readers consistently detected more lucencies on the AP views than on the lateral views. The true detection percentages for the AP vs. lateral views were 18% vs. 12%, 57% vs. 46%, 82% vs. 74%, and 94% vs. 85%, for the 0.1, 0.3, 0.5, and 0.7 mm lucencies, respectively. There was no statistically significant difference in detecting proximal, central or distal radiolucencies.

Discussion: Qualitatively, the clarity and contrast of the THA constructs radiographs obtained for this surrogate series were consistent with what would be regarded as excellent technique in the clinical arena. About 85% of 0.1 mm lucencies and over 50% of the 0.3 mm lucencies went undetected under even these ideal conditions. Only the detection of 0.7 mm lucencies was reliable, and even that only marginally. This finding argues strongly that many or perhaps most instances of in-vivo early debonding are probably not routinely detectable from conventional plane films. Potentially, computer-based edge detection techniques might improve upon visual examination for this purpose.

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References: [1] Mohler et al., JBJS 77-A(9), 1995

RELIABILITY OF DETECTING STEM/CEMENT INTERFACE RADIOLUCENCIES IN THA

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PC 8 ABSTRACT NO. 1277

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