**Introduction:** Aseptic loosening is the most prevalent indicator for revision surgery in cemented hip arthroplasty [1]. Pores and agglomerates of radiopaque powder have been identified as crack initiation points, and favourable paths for crack propagation [2]. To minimise the occurrence of aseptic loosening, novel design and analysis methods must be developed to ensure new medical devices likely to compromise cement mantle integrity are eliminated prior to clinical use [3]. This study aimed to present a method which included internal defects in fatigue simulations of bone cement, and compare the damage accumulation process predicted with that found experimentally.

**Materials and Methods:** 16 dog-bone-shaped specimens were moulded from vacuum-mixed CMW-1 bone cement (DePuy CMW, Blackpool, UK). Before experimental testing, the gauge length of specimens were micro-computed tomography (µCT) scanned at a resolution of 90µm. Specimens underwent uniaxial tensile fatigue loading at peak loads of 20, 15, 11 and 7MPa, at an R-ratio (ratio of minimum load to maximum load) of 0.1, and a frequency of 5Hz. Damage events were monitored using three Vallen Z-series acoustic emission (AE) sensors with an AMSY4 PC-based system (Vallen Systeme GmbH, Munich). Finite element models of approximately 80,000 elements were built from segmented µCT scans. Cement was modelled with a Young’s modulus of 2.8GPa, while appropriate elements were deleted to model pores. The mechanical properties of radiopaque barium sulphate (BaSO4) agglomerates were not known, so were modelled using methods: firstly with the same Young’s modulus as cement (A), secondly with a Young’s modulus of 0.28GPa (B), and thirdly by deleting the relevant elements (C). A continuum damage mechanics damage accumulation routine was used, based on that of Stolk et al [3], using a theoretically defect-free S-N curve [5] and assuming a linear damage accumulation rate.

**Results:** In total, 1544 defects were found in specimens, an average of 3.4±5.5 pores and 93.1±78.1 BaSO4 agglomerates per specimen respectively. While the majority of pores were of the same volume as BaSO4 agglomerates, 13% of the pores had a volume larger than 650 µm³, giving a 9% reduction in cross-section area in the gauge length. An approximately linear response was found between experimental and computational survival, with a R² of between 0.625 and 0.7 (Fig. 1). Specimens failed at BaSO4 agglomerates in five specimens, pores in five others, and at no specific defect in all other specimens. The failure zone (FZ) was only correctly identified in simulations in three instances (Fig. 2), though there was generally good agreement between AE damage location and predicted damage zones (DZ).

**Discussion:** This is the first study of bone cement to allow comparison between identical experimental and computational specimens. There was generally good agreement between simulated damage and AE damage location (Fig. 2), whilst µCT scans enabled the defects that gave rise to damage to be identified. Fig. 1 shows an improved correlation between specimen fatigue life in vitro and in silico than that achieved by Stolk et al [3]. Whilst the failure location was only predicted in three specimens, non-critical damage was found to accumulate in the experimental failure site in another six specimens, suggesting the model does not capture crack arrest, and subsequent crack growth at another location.