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Research paper

Morphology based cohesive zone modeling of the cement–bone interface from postmortem retrievals

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ABSTRACT

In cemented total hip arthroplasty, the cement–bone interface can be considerably degenerated after less than one year *in vivo* service; this makes the interface much weaker relative to the direct post-operative situation. It is, however, still unknown how these degenerated interfaces behave under mixed-mode loading and how this is related to the interface morphology. In this study, we used a finite element (FE) approach to analyze the mixed-mode response of the cement–bone interface taken from postmortem retrievals. We investigated whether it was feasible to generate a fully elastic and a failure cohesive model based on only morphological input parameters.

Computed tomography-based FE-models of postmortem cement-bone interfaces were generated and the interface morphology was determined. The models were loaded until failure in multiple directions by allowing cracking of the bone and cement components and including periodic boundary conditions. The resulting stiffness was related to the interface morphology. A closed form mixed-mode cohesive model that included failure was determined and related to the interface morphology.

The responses of the FE-simulations compare satisfactorily with experimental observations, albeit the magnitude of the strength and stiffness are somewhat overestimated. Surprisingly, the FE-simulations predict no failure under shear loading and a considerable normal compression is generated which prevents dilation of the interface. The obtained mixed-mode stiffness response could subsequently be related to the interface morphology and subsequently be formulated into an elastic cohesive zone model. Finally, the acquired data could be used as an input for a cohesive model that also includes interface failure.

1. Introduction

In cemented total hip arthroplasty, the fixation at the cement–bone interface is one of the critical factors in the longevity of the cemented hip reconstruction. Since bone cement is not osteoconductive, physicochemical bonding cannot be expected (Oonishi et al., 2008), and therefore, interface fixation relies on cement interdigitation into the

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