INTRODUCTION

The stability of a cemented stem in total hip replacement (THR) is dependent on the integrity of the stem-cement interface, the cement-bone interface or the material properties response of the bone cement or host bone. Like many other polymeric materials, acrylic bone cement undergoes creep, i.e., deformation under constant load well below static strength values [1,2]. The significance of viscoelastic properties of commercially available cements in successful (or failed) cemented THR is not well understood. It has been proposed that creep may contribute to loosening as gross plastic deformations associated with creep have been found in retrieved cement from post-mortem studies [3]. However, creep has also been identified as a mechanical feature contributing to the success of polished tapered stems by engaging a taperlock mechanism through the action of creep-induced subsidence [4,5,6]. The purpose of this study is to examine the creep response of commercially available bone cements to elucidate potential implications to cement selection and THR model parameters.

METHODS

Three commercially available bone cements (Palacos R (Merck, Darmstadt, Germany), Zimmer R (Zimmer, Warsaw, IN) and Osteobond (Zimmer, Warsaw, IN)) were manually mixed according to manufacturers’ specifications. Osteobond cement was also vacuum mixed using a vacuum mixing chamber (Howmedica Inc., Rutherford, NJ). After mixing, specimens were injected into 6 cc syringe molds and allowed to cure for 24 hours at room temperature. After curing the specimens were removed from the syringe molds and machined into right circular cylinders measuring 22 mm in length and 12.5 mm in diameter [7]. A total of five specimens from each cement were randomly selected for each of the four test groups (5, 10, 20 and 30 MPa). Compressive creep tests were conducted over 24 hours of compressive loading using a cantilever-type creep testing machine within one week after curing. Specimens were submerged in saline in a temperature controlled chamber held at body temperature (37°C). A constant compressive load was applied corresponding to stress levels of 5, 10, 20 and 30 MPa. Specimen displacement was measured using an LVDT mounted on the loading rod. Both load and displacement were recorded over a 24 hour period from which stress and strain were calculated. The average creep strains at each stress level and cement were calculated.

RESULTS

The average creep strains at each stress level were fit using an interpolation function (Figure 1). All three cements exhibited non-linear behavior, i.e., for increases in applied stress, there was a disproportionate increase in creep strain. The creep behavior of each cement was different. Palacos R exhibited the highest creep strain in 24 hours (~ 7%) and the highest creep strain rate compared to the other cements followed by the Zimmer R. Creep strain was especially pronounced above 20 MPa. Vacuum mixing produced noticeable creep strain although the difference was not significant as reported for other cements [8]. The Osteobond cement exhibited minimal creep in 24 hours (< 1%).

DISCUSSION

Results of this investigation show that the creep behavior of three commercially available bone cements can be drastically different. These differences are especially pronounced at stress levels above 15-20 MPa where creep rates change significantly. Stresses near or above these levels simulate differences are especially pronounced at stress levels above 15-20 MPa where commercially available bone cements can be drastically different. These results of this investigation show that the creep behavior of three commercially available bone cements (Palacos R, Zimmer R and Osteobond) were calculated.

REFERENCES


Figure 1. Creep behavior of commercially available bone cements after 24 hours.

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