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Research paper

Effect of vacuum-treatment on deformation properties of PMMA bone cement

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ABSTRACT

Deformation behavior of polymethyl methacrylate (PMMA) bone cement is explored using microindentation. Two types of PMMA bone cement were prepared. Vacuum treated samples were subjected to the degassing of the material under vacuum of 270 mbar for 35 s, followed by the second degassing under vacuum of 255 mbar for 35 s. Air-cured samples were left in ambient air to cool down and harden. All samples were left to age for 6 months before the test. The samples were then subjected to the indentation fatigue test mode, using sharp Vickers indenter. First, loading segment rise time was varied in order to establish time-dependent behavior of the samples. Experimental data showed that viscous part of the deformation can be neglected under the observed test conditions. The second series of microindentation tests were realized with variation of number of cycles and indentation hardness and modulus were obtained. Approximate hardness was also calculated using analysis of residual impression area. Porosity characteristics were analyzed using CellC software.

Scanning electron microscopy (SEM) analysis showed that air-cured bone cement exhibited significant number of large voids made of aggregated PMMA beads accompanied by particles of the radiopaque agent, while vacuum treated samples had homogeneous structure. Air-cured samples exhibited variable hardness and elasticity modulus throughout the material. They also had lower hardness values (approximately 65–100 MPa) than the vacuum treated cement (approximately 170 MPa). Porosity of 5.1% was obtained for vacuum treated cement and 16.8% for air-cured cement. Extensive plastic deformation, microcracks and craze whitening were produced during indentation of air-cured bone cement, whereas vacuum treated cement exhibited no cracks and no plastic deformation.

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