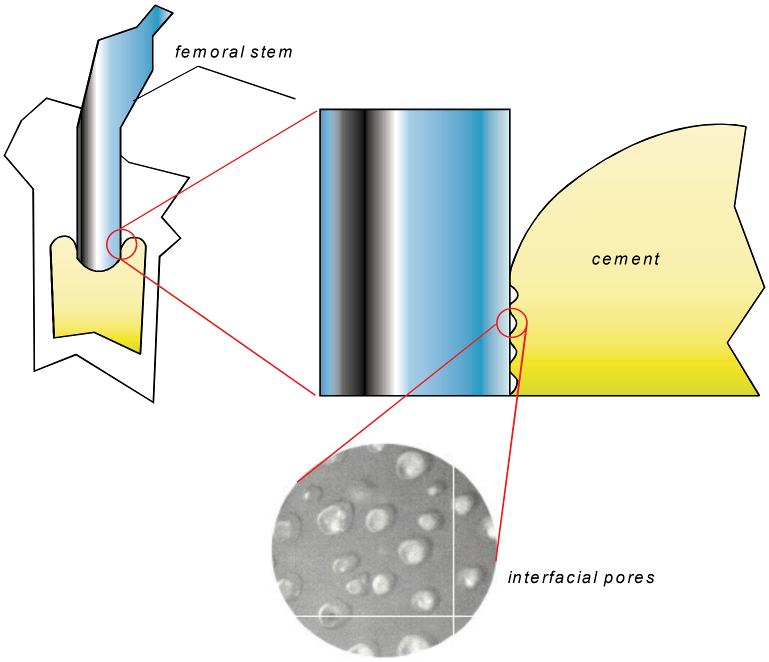
Fundamental fluid physics helps surgeons

Summary

When surgeons implant cemented stems they generally assume the femoral stem is completely coated with bone cement. In reality, the bone cement does not thoroughly wet the metal stem and a serious concern is cavitation or bubbles at the cement/component interface. This leads to reduced bond strength and the potential for loosening and ultimately implant failure. Understanding the rheology of the bone cement allows the surgical technique to be modified to enhance wetting and reduce interfacial porosity.

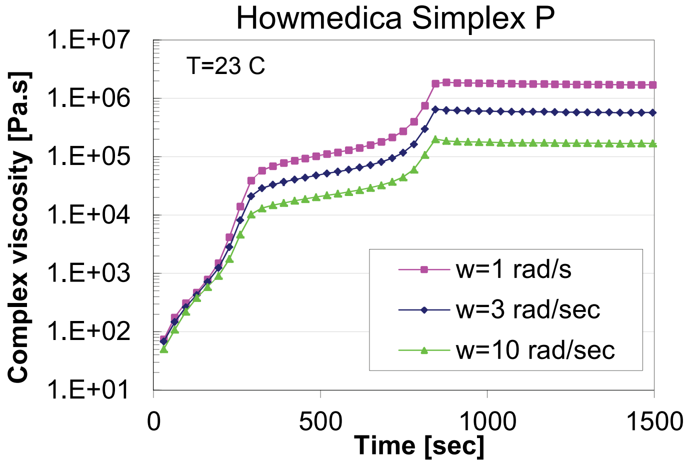


Description

Partially cured bone cements are composed of poly(methyl methacrylate) (PMMA) particles embedded in a polymerizing methyl methacrylate matrix. Conventionally, this material is mixed in the OR from liquid and powder starter materials. Over the period of about 5-10 minutes the cement begins to cure at which point the surgeon packs it in the insertion site and drives the implant in using a hammer. This implantation process is poorly controlled and although it seats the implant properly, it may not optimize the cement-implant interface. A simple tool that can be provided to the surgeon that allows better control of the insertion process and leverages basic rheological knowledge of how the cement responds to different oscillatory processes.

Analysis

Fluids containing particles and polymerizing polymers rarely exhibit simple rheological behavior. The cements used in orthopaedics exhibit strong rate sensitivity where their apparent viscosity falls as the imposed frequency increases. Thus, by understanding the basic rheology of the system, a surgical tool can be designed that superimposes a rapidly oscillating deformation on top of the general insertion deformation, thus improving interfacial porosity and reducing insertion force for the surgeon.



Key points

- Conventional, ubiquitous materials often behave in unusual ways when examined carefully
- Understanding the basic science of a process/procedure frequently yields new ways of performing the function
- Cambridge Polymer Group has the broad range of disciplines required to perform this efficiently

Cambridge Polymer Group

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