BEHAVIOR OF PIEZOELECTRIC DEVICES EMBEDDED IN BONE CEMENT

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Abstract

Bone cements based on polymethacrylate (PMMA) are essential products in joint arthroplasty. PMMA bone cement function is to locate the implants components in the body skeleton, load transition through the joint into the bone and muscle surrounding for a very long period of time. Its mechanical properties are well established in the literature [1]. Since bone cement fills the void between the prosthesis (polymer or metallic) and bone, it is subjected to high stress and has to operate in a relatively aggressive environment, like human body. Therefore, based on surrounding environment PMMA bone cements application, this material has specific mechanical properties that enhance a good performance in this condition. Theses stresses are mainly measured indirectly with non-invasive methods. *In-situ* measurements would be more interesting to really understand and quantify these stresses.

Piezoelectric devices are an interesting way to measure forces in difficult accessibility environment, since they are self-power, i.e., they are able to generate an electric signal by converting mechanical energy into electrics with no need for power supply [2]. When embedded in bone cement one expects to be able to analyze the health structure in real-time. Positioning of the sensing device is a critical factor worthy of a thorough study in order to understand its behaviour as a response to surroundings.

Methods and Results

In this study we used all the requirements for the bone cements so the results could be compared to the mechanical test present in the current literature. The entire test was followed by numerical modelling (FEM). The aim of this paper is to establish a relationship between stress distributions inside bone cement. To obtain better sensorial characterization of PMMA bone cement mechanical properties, the study was divided in two parts: longitudinal and transversal compression. The piezoelectric device used was previously characterized with respect to its electric response to mechanical excitations, and temperature dependence. The analysis of the obtained electric signal from within bone cement, and the FEM model, apart from the characterization of the behaviour of the cement, will also allow for an assessment of the influence of the embedding on the PZT sensor.

With this work, we were able to establish the feasibility of embedding ceramic piezoelectric devices in biocompatibility materials and their very good performance in sensing different strain distribution and improved smart materials characteristics to this material.

References

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