16. FRACTURE OF ACRYLIC COMPOSITE BONE CEMENT

A. Castaldini and A. Cavallini

Department of Physics, University of Bologna
Bologna, Italy

1. INTRODUCTION

PMMA has been widely used in orthopaedics for several years because of the advantages it offers in prosthetic fixation since it makes stress distribution between prosthesis and bone uniform and continuous.

However, as failure of bone cement followed by fracture and consequent final removal of the endoprosthesis is statistically shown to be quite frequent, various methods, such as metal wire introduction, porosity induced in the cement to allow the bone ingrowth, etc. (1), have been gradually proposed to improve the mechanical characteristics of the acrylic resin surrounding the prosthesis and thereby to maximize the prosthetic joint life.

We concentrated our attention on a PMMA resin added with powdered crystalline hydroxyapatite (HA) because this material besides its well known biocompatibility, if selected with a suitable crystal size induces considerable modifications in the porosity patterns.

In other words our aim was to make the control of pore distribution and diameter possible so as to increase the bone cement strength.

This two-part investigation concerns the characterization of the consequent changes of HA addition in the propagation rate of the cracks, i.e. its resistance to impact measured at two different speeds by means of fracture toughness tests with the standard Charpy-V bar and the Izod tests. The fatigue results will appear in a forthcoming paper.
2. MATERIALS AND METHODS

The acrylic cements used in this study were radiopaque (RO) and plain (P) Simplex (Howmedica Inc., Rutherford, N.Y.).

In both the two series of measurements $X_0$ weight percentages of the commercial unit powder were replaced by an equal amount of synthetic HA, $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$ (average grain size 2 μm); the measurements were carried out by using the following $X_0$ values: 3, 5, 10, 15, and 25% (2).

The resulting powder and the liquid monomer were mixed at room temperature following the manufacturer directions, then the dough was proceeded for polymerization according to the ASTM F451-76 standard. The test specimens were cut from the mold so obtained. The HA content was thus selected as the only independent variable in all our measurements.

Owing to the relevant fluctuations characterizing the nature of the phenomenon under examination, the experiments were carried out so as to allow the results to be statistically processed.

For this purpose twelve specimens were analyzed in the toughness tests and nineteen in the impact tests at all the $X_0$ percentages: the values reported here are the average of the results obtained.

The toughness measurements were carried out with a laboratory manufactured apparatus on specimens machined from the mold to obtain the standard Charpy-V bar (ASTM E23-72).

Fig. 1 Left: load vs. displacement in the toughness test; right: crack propagation images at times corresponding to the points indicated.