

Injectability and Cohesion of α -Tricalcium Phosphate Based Cements

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INTRODUCTION

Calcium phosphate bone cements are biodegradable materials for bone tissue regeneration. Implantation by injection is a minimally invasive operation; therefore injectable calcium phosphate cements should be developed [1]. Injectability and cohesion are interlinked properties of calcium phosphate cements. It is expected that, if the cement paste has higher solid phase/liquid phase ratio, the cement will be less injectable, but the cohesion of the cement will improve. In this work the possibility to improve injectability of α -tricalcium phosphate (α -TCP) bone cements using citrate ion containing additives was investigated. It has been ascertained previously that both composition of setting solution [2] and α -TCP powder pre-treatment [3] can significantly alter the setting process.

MATERIALS AND METHODS

α -TCP for solid phase of the cement was synthesized by heating a mixture of CaCO_3 and CaHPO_4 (molar ratio 1:2) at 1300°C for 4 h and subsequent quenching to room temperature. Obtained α -TCP was milled to fine powders in a planetary ball mill at 300 rpm for 1 to 4 h.

Liquid phase was sodium phosphate solutions with differing pH values (4 – 9), 0.5 M phosphate ions and 0 – 0.2 M citrate ions.

Injectability and cohesion was determined for cements with solid/liquid phase ratio 1.75 g/ml or 2.00 g/ml.

Injectability was characterized by the fraction of injected paste and solid/liquid ratio of the injected paste. The amount of solid phase used in injectability experiment samples was 3.00 g.

Cohesion was determined by both visual evaluation and amount of particles released per square centimeter of cement surface.

Compression strength was determined for selected cement compositions.

RESULTS AND DISCUSSION

It was ascertained that the cohesion of calcium phosphate cement was strongly correlated with setting

time and that the presence of citrate ions was not a significant factor (cement compositions with similar setting times were compared). The injectability was higher for cements with basic liquid phase pH (> 7) and cements could be injected completely. If cement has acidic liquid phase pH (< 7), injectability is low ($< 80\%$), because of the initial precipitation of calcium hydrogen phosphate dihydrate (brushite). Presence of citrate ions prevents precipitation of brushite, but significantly decreases the setting time. Thus while the presence of citrate ions can affect setting of cements based on α -TCP, it is not possible to improve injectability in a significant manner.

As it was expected, longer milling time results in more reactive particles, the setting time was shorter, i.e. 10 ± 1 min for cement with solid phase milled for 1 h and 5 ± 0.5 min for cement with solid phase milled for 2h (solid/liquid phase ratio 1.75 g/ml, liquid phase pH 8).

CONCLUSIONS

The most suitable cement compositions for injectable cements are cements with basic liquid phase pH (pH 8 and higher). Addition of citrate ions to a basic liquid phase does not significantly affect injectability, but shortens setting time and thus improves cement cohesion.

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