Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/jmbbm

Research paper

Bone marrow modified acrylic bone cement for augmentation of osteoporotic cancellous bone

Daniel Arens[a,*], *Stephan Rothstock*[a], *Markus Windolf*[a], *Andreas Boger*[b]

[a] *AO Research Institute, Clavadelerstrasse 8, 7270 Davos Platz, Switzerland*
[b] *Synthes GmbH, R&D Biomaterials, Eimattstrasse 3, 4436 Oberdorf, Switzerland*

ARTICLE INFO

Article history:
Received 31 March 2011
Received in revised form
12 July 2011
Accepted 18 July 2011
Published online 22 July 2011

Keywords:
Bone marrow
PMMA
Porosity
Low modulus
Polymerization temperature
Viscosity

ABSTRACT

The use of polymethylmethacrylate (PMMA) cement to reinforce fragile or broken vertebral bodies (vertebroplasty) leads to extensive bone stiffening. This might be one reason for fractures at the adjacent vertebrae following this procedure. PMMA with a reduced Young's modulus may be more suitable. The goal of this study was to produce and characterize PMMA bone cements with a reduced Young's modulus by adding bone marrow. Bone cements were produced by combining PMMA with various volume fractions of freshly harvested bone marrow from sheep. Porosity, Young's modulus, yield strength, polymerization temperature, setting time and cement viscosity of different cement modifications were investigated. The samples generated comprised pores with diameters in the range of 30–250 μm leading to porosity up to 51%. Compared to the control cement, Young's modulus and yield strength decreased from 1830 to 740 MPa and from 58 to 23 MPa respectively by adding 7.5 ml bone marrow to 23 ml premixed cement. The polymerization temperature decreased from 61 to 38 °C for cement modification with 7.5 ml of bone marrow. Setting times of the modified cements were lower in comparison to the regular cement (28 min). Setting times increased with higher amounts of added bone marrow from around 16–25 min. The initial viscosities of the modified cements were higher in comparison to the control cement leading to a lower risk of extravasation. The hardening times followed the same trend as the setting times. In conclusion, blending bone marrow with acrylic bone cement seems to be a promising method to increase the compliance of PMMA cement for use in cancellous bone augmentation in osteoporotic patients due to its modified mechanical properties, lower polymerization temperature and elevated initial viscosity.

1. Introduction

Vertebroplasty is regarded as a reasonable alternative to the non-operative treatment of osteoporotic vertebral body compression fractures. Immediate and lasting pain relief is seen in 80%–90% of the cases (Heini et al., 2000; Mathis et al., 2002). Today, the most commonly used bone substitute material in vertebroplasty is polymethylmethacrylate (PMMA) with a Young's modulus (2–3 GPa) 4–40 times higher than that of cancellous bone (50–800 MPa, Banse et al., 2002).

* *Corresponding author.* Tel.: +41 81 4142 300; fax: +41 81 4142 288.
E-mail addresses: daniel.arens@aofoundation.org (D. Arens), Stephan.Rothstock@aofoundation.org (S. Rothstock), Markus.Windolf@aofoundation.org (M. Windolf), Boger.Andreas@synthes.com (A. Boger).

1751-6161/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jmbbm.2011.07.007