OPTIMIZATION OF MAGNESIUM PHOSPHATE CEMENT : INFLUENCE OF MG-P AND P-L RATIOS ON BIOMEDICAL EFFICACY

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Introduction

Bone cements represent a category of injectable and functional medical materials extensively utilized in orthopedic surgery and traumatology. These materials are formulated by combining a powder and a liquid to create a moldable paste, which subsequently hardens at the site of the treated defect [1].

Materials and Methods

The investigation employed a cement powder consisting of calcined magnesium oxide and potassium hydrogen phosphate (MPC) in various molar ratios of Mg-P (3:1, 4:1, 5:1) and variable P-L ratios using demineralized water (2:1, 2.5:1, 3:1), along with two different sizes of MgO particles (I ~52,75 µm, II ~ 7,48 µm).

The aim of the study

The objective of this study was to examine the impact of varying technological parameters for creation of MPC cement on its fundamental characteristics, such as setting time and temperature, microstructure, microhardness, surface wettability, injectability and cytocompatibility.

Results

Setting time and temperature:

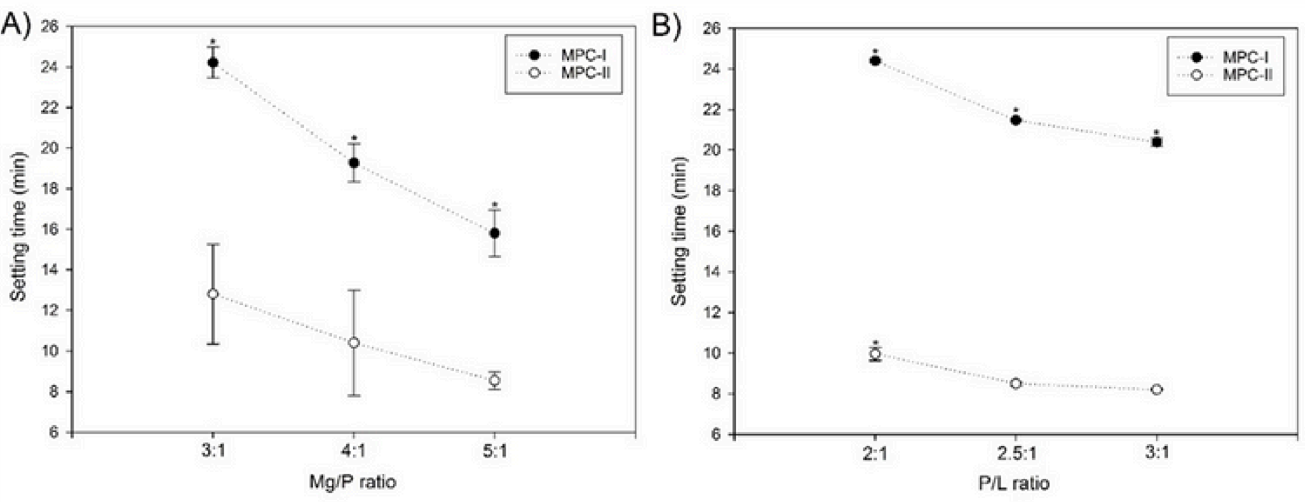

Fig.1. Setting time of tested cements (n=3, $p < 0.05$)

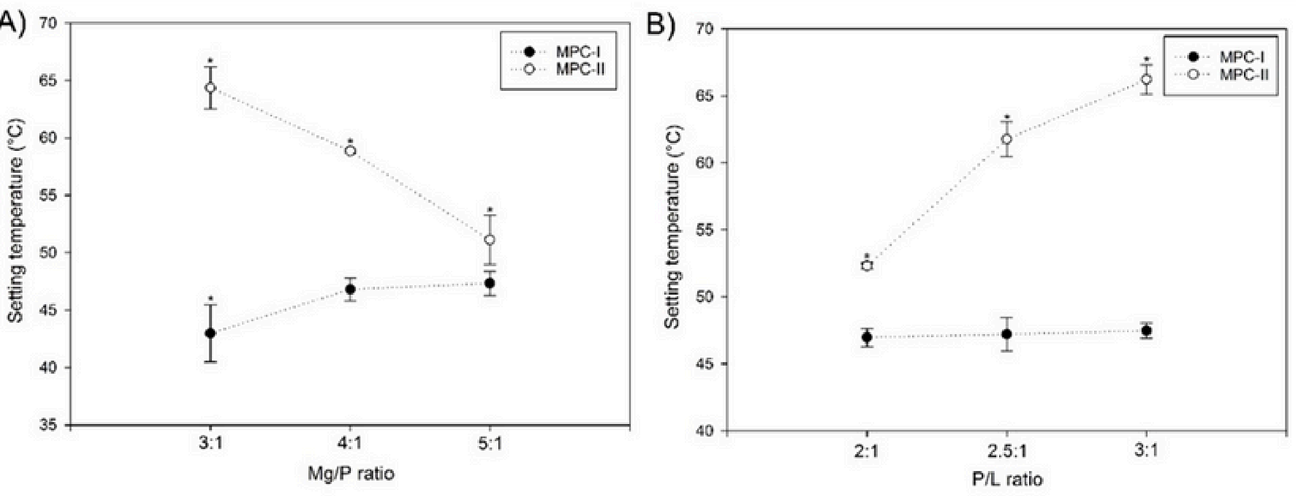

Fig.2. Setting temperature of tested cements (n=3, $p < 0.05$)

Cohesion and injectability:

Mg/P ratio	P/L ratio	Injectability
variable P/L ratio		
4 : 1	2:1	average (B)
	2.5:1	good (A)
	3:1	average (B)
variable Mg/P ratio		
3:1	2.5:1	good (A)
4:1		good (A)
5:1		good (A)

Tab.2. Qualitative assessment of the injectability of the tested cements

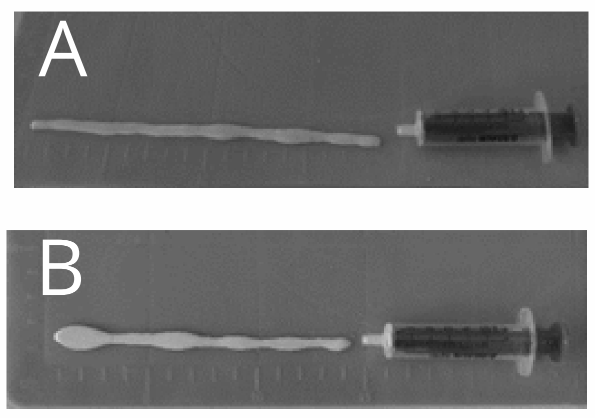

Fig.6. Injectabillity of the tested cements A) MgO I and B) MgO II

Microstructure:

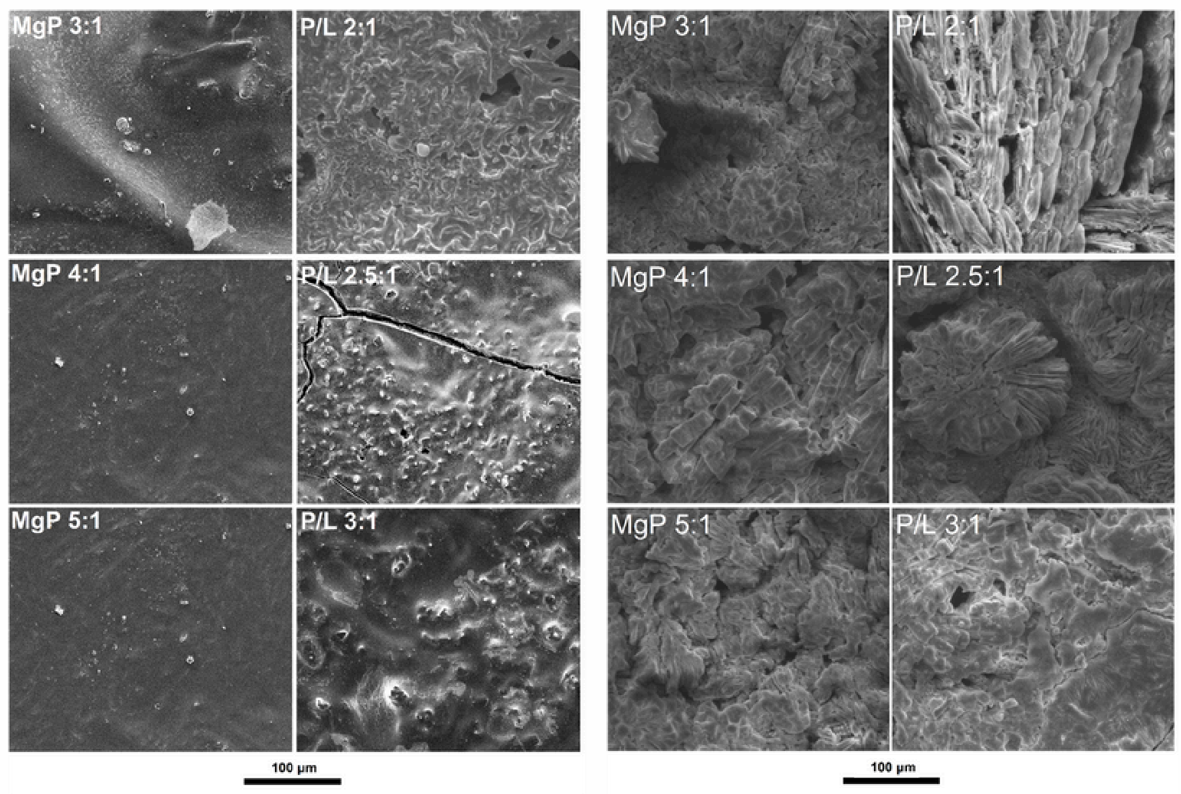

Fig.3. SEM microphotography of cement structures: A) MgO I and B) MgO II (magnification 500x)

Porosity

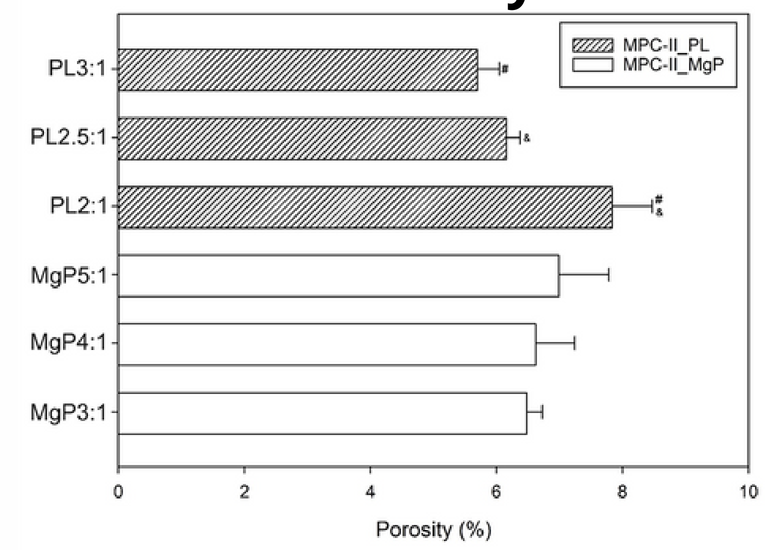

Fig.7. Porosity of the tested cements (n=3; $p < 0.05$)

Cytocompatibility:

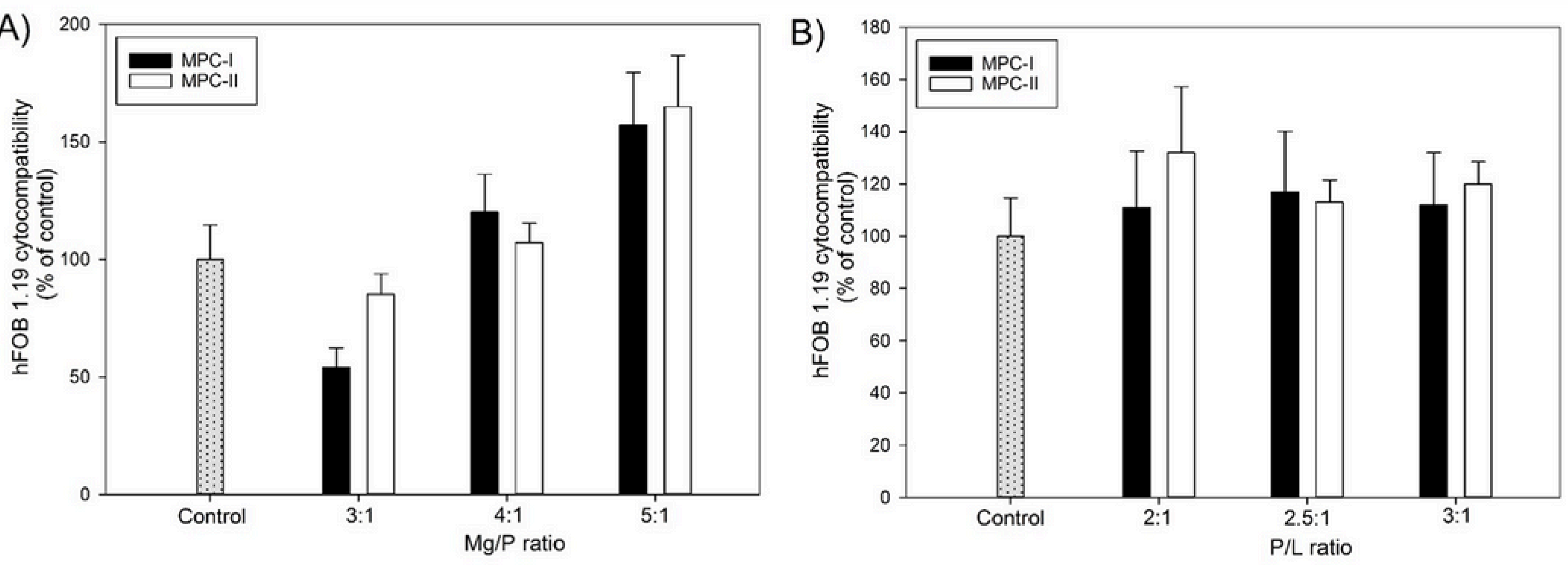

Fig.5. Cytocompatibility of the tested cements obtained using different types of magnesia powders (n=4, $p < 0.05$)

Mechanical strength:

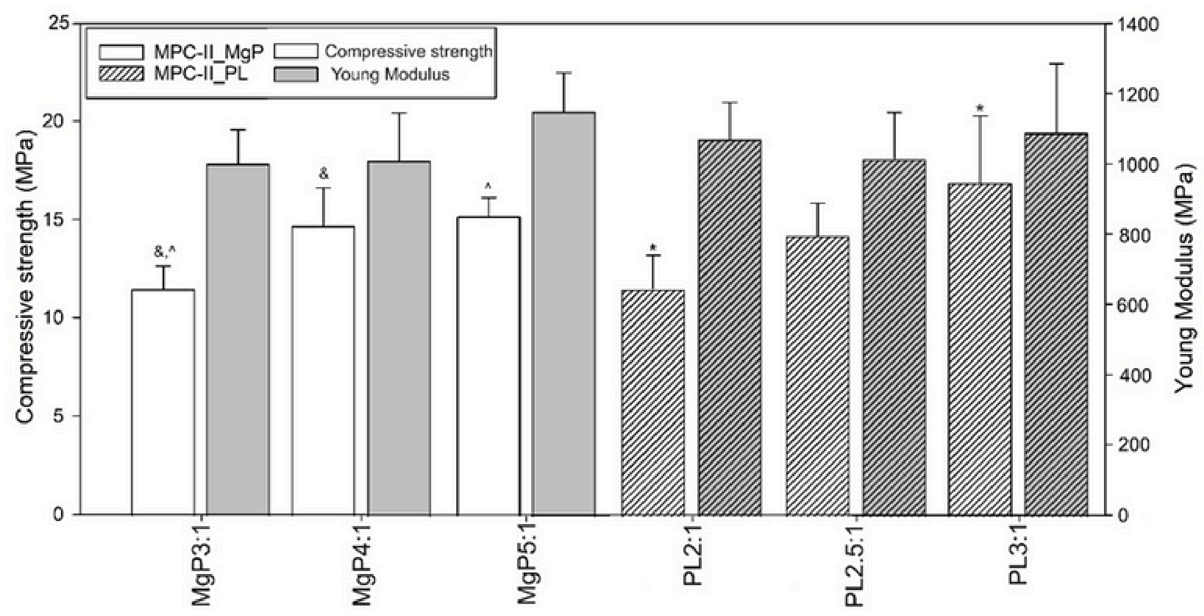

Fig.4. Mechanical properties of tested cements (n=8, $p < 0.05$)

Summary and discussion:

*The results of this study culminated in the formulation of an advantageous methodology for synthesizing magnesium phosphate-based cement tailored for biomedical uses.

*Material has a fast setting time (less than 25 minutes) and its maximum temperature does not exceed 50 degrees while maintaining high biocompatibility (Fig.1) and (Fig.2).

*The change in technological parameters positively affected the microstructure of the cements (Fig.3).
The MPC II cement has a more developed crystalline structure.

*Increasing the Mg/P ratio causes a temperature rise only in MPC I while in MPC II it has the opposite effect.
Decrease of the temperature is observed with the change in the P/L ratio (Fig.2).

*The higher the Mg/P ratio, the greater the cytocompatibility (Fig.5).

*Injectability was successful in all samples, but its quality depended on the P/L ratio (Tab.2) and (Fig.6).

*Based on these studies, the most optimal technological parameters are: a P/L ratio of 2.5:1, Mg/P ratio of 5:1 and magnesium oxide with a smaller structure, which improves the microstructure of the cement that results in less unreacted MgO.

References:

[1] Fernandez de Gardo G., et al.: Bone substitutes: a review of their characteristics, clinical use, and perspectives for large bone defects management. J. Tissue Engineering 9 (2018) 2041731418776819.
[2] Iaquinta M.R., et al.: Innovative Biomaterials for Bone Regrowth. International Journal of Oral Science 20 (2019) 618.

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