Stem Cell Applications of Nanohydroxyapatite

Introduction

Hydroxyapatite (HA) is a calcium phosphate ceramic which has great biocompatibility and bioactivity since it is very similar to the bone's mineral component.

On being implanted in the body, this ceramic can form strong and stable chemical bonds with bone tissue. Microscale HA is being used extensively in the healthcare industry in prosthetic coatings and bone graft substitutes. With nanotechnology emerging, nanoscale HA has been produced and studied in order to enhance HA properties.

Nanoscale HA presents optimized biological performance as cell proliferation and osteoblast adhesion because of the higher surface.

nanoXIM - Nanocrystalline HA Pastes

FLUIDINOVA produces nanoXIM HAp100 product series which are high purity, single-phase, nanocrystalline HA pastes. These products are supplied in the form of pastes having 15% and 30% (wt) of HA in pure water.

Since they possess structural and chemical similarity with natural bone, the nanoXIM HAp100 formulations are suited for medical applications.

The nanoXIM HAp100 series has a high specific surface area greater than 80m^2/g and an accurate stoichiometry of Calcium/Phosphate ions resulting in a Ca/P ratio always near to 1.67.

Impact of nanoXIM HAp102 on Human Mesenchymal Stem Cells

Since human mesenchymal stem cells (HMSCs) can differenentiate in a wide range of cell types including the osteogenic lineage, they are considered an excellent candidate for cell-based therapies.

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In bone regeneration cases, HMSCs can move to the affected location and differentiate which enables the healing process. Considering the great importance of these cells in bone regeneration, it was evaluated the biological performance of nanoXIM HAp102 in the proliferation and osteoblastic differentiation of HMSCs.

There was no adverse impact on HMSCs culture by the presence of nanoXIM HAp102 in the range 1-10µg/mL [1]. To be accurate, HMSCs that were exposed to 10µg/mL of nanoXIM HAp102 had not just increased the proliferation but also alkaline phosphatase (ALP) and collagen synthesis as shown in Figure 1 and a typical cytoskeleton organization as shown in Figure 2.

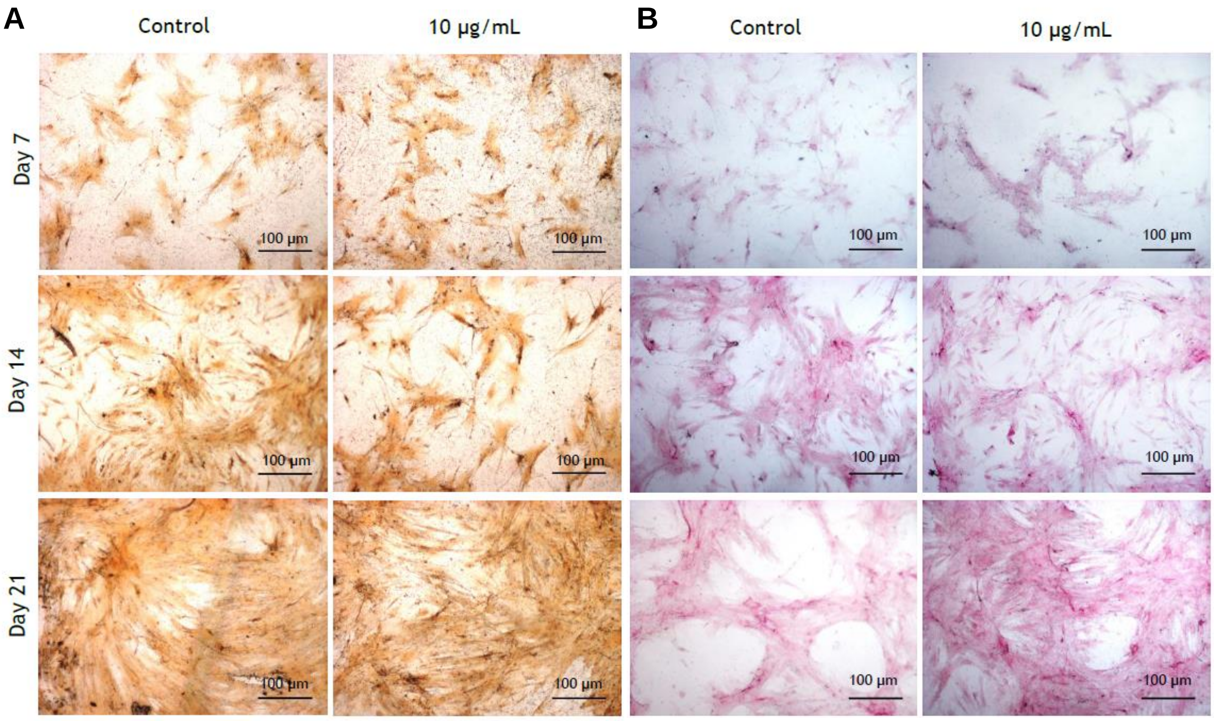

Figure 1: Histochemical staining for ALP (A) and collagen (B) of HMSCs cultured in the absence (control) and in the presence of 10 µg/mL of nanoXIM HAp102 at days 7, 14 and 21. The synthesis of ALP is observed by the presence of a brown to black stain and collagen by a pink to red stain.

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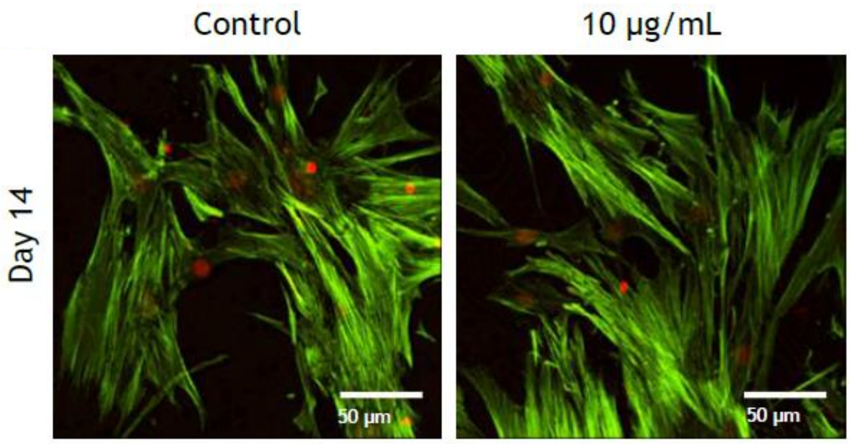

Figure 2: Confocal laser scanning microscopy of HMSCs cultured for 14 days in the absence (control) and in the presence of 10 µg/mL of nanoXIM HAp102. F-actin cytoskeleton organization is stained in green and nuclei in red. Adapted from [1].

As seen in Figure 3, HMSCs cultured in the presence of nanoXIM HAp102 showed significant osteogenic differentiation markets such as Runx-2, OPG and BMP-2. There is an increased expression of BMP-2 for HMSCs exposed to 10 µg/mL of nanoXIM HAp102. Osteogenic progenitor cells are induced by this protein during the bone regeneration process and they participate in the regulation of cell growth and differentiation.

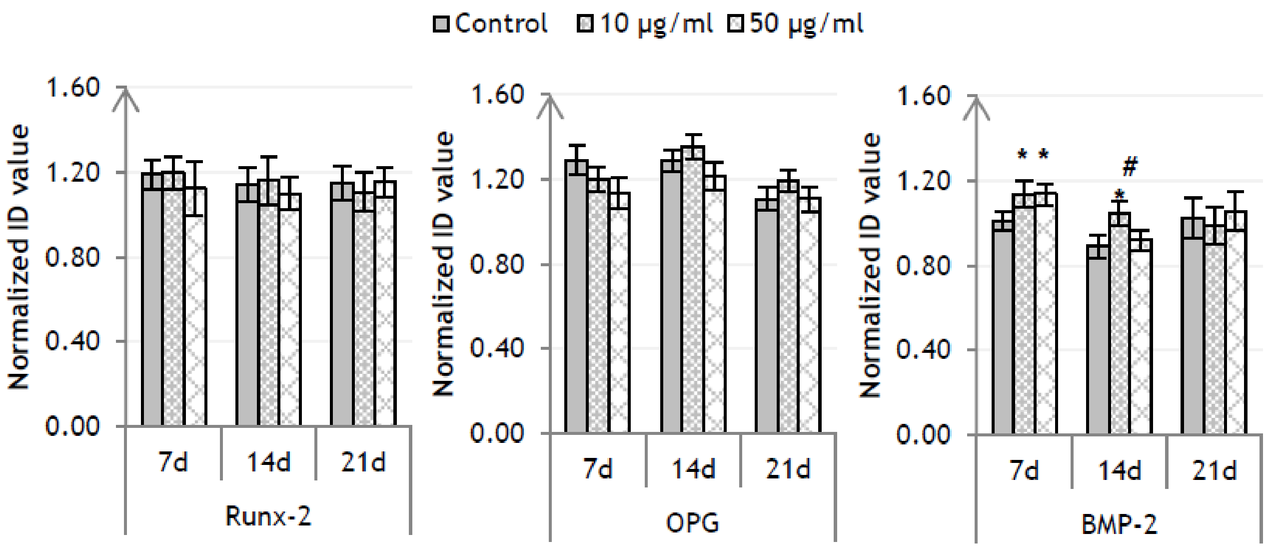

Figure 3: RT-PCR results of HMSCs cultured in the absence (control) and in the presence of 10 and 50 µg/mL of nanoXIM HAp102 during 7, 14 and 21 days. Adapted from [1].

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Conclusions

The nanoXIM HAp100 formulations can modulate the HMSCs proliferation and osteoblastic differentiation. These are promising products that can be used in bone regeneration applications. One application is to combine the HMSCs cells with nanoXIM HAp100 to create a bone substitute with improved regeneration capacity.

References

1. E. Pires, "Effect of the nanohydroxyapatite Formulation NanoXIM.HAp102 on the Proliferation and Osteogenic Differentiation of Human Bone Mesenchymal Stem Cells", Integrated MSc Thesis in Bioengineering, Faculty of Engineering, University of Porto (2013).

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