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Bilayered constructs aimed at osteochondral strategies: The influence of medium supplements in the osteogenic and chondrogenic differentiation of amniotic fluid-derived stem cells

Márcia T. Rodrigues [a,b,c], Sang Jin Lee [a], Manuela E. Gomes [b,c], Rui L. Reis [b,c], Anthony Atala [a], James J. Yoo [a,*]

[a] Wake Forest Institute for Regenerative Medicine, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157, USA
[b] 3B's Research Group – Biomaterials, Biodegradables and Biomimetics, University of Minho, Headquarters of the European Institute of Excellence on Tissue Engineering and Regenerative Medicine, AvePark, 4806-909 Taipas, Guimarães, Portugal
[c] ICVS/3B's – PT Government Associate Laboratory, Braga/Guimarães, Portugal

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ABSTRACT

The development of osteochondral tissue engineered interfaces would be a novel treatment for traumatic injuries and aging associated diseases that affect joints. This study reports the development of a bilayered scaffold, which consists of both bone and cartilage regions. On the other hand, amniotic fluid-derived stem cells (AFSCs) could be differentiated into either osteogenic or chondrogenic cells, respectively. In this study we have developed a bilayered scaffolding system, which includes a starch/polycaprolactone (SPCL) scaffold for osteogenesis and an agarose hydrogel for chondrogenesis. AFSC-seeded scaffolds were cultured for 1 or 2 weeks in an osteochondral-defined culture medium containing both osteogenic and chondrogenic differentiation factors. Additionally, the effect of the presence or absence of insulin-like growth factor-1 (IGF-1) in the culture medium was assessed. Cell viability and phenotypic expression were assessed within the constructs in order to determine the influence of the osteochondral differentiation medium. The results indicated that, after osteogenic differentiation, AFSCs that had been seeded onto SPCL scaffolds did not require osteochondral medium to maintain their phenotype, and they produced a protein-rich, mineralized extracellular matrix (ECM) for up to 2 weeks. However, AFSCs differentiated into chondrocyte-like cells appeared to require osteochondral medium, but not IGF-1, to synthesize ECM proteins and maintain the chondrogenic phenotype. Thus, although IGF-1 was not essential for creating osteochondral constructs with AFSCs in this study, the osteochondral supplements used appear to be important to generate cartilage in long-term tissue engineering approaches for osteochondral interfaces. In addition, constructs generated from agarose–SPCL bilayered scaffolds containing pre-differentiated AFSCs may be useful for potential applications in regeneration strategies for damaged or diseased joints.

1. Introduction

Osteochondral interfaces are one of the most susceptible areas in the human body to traumatic injuries and aging associated diseases, such as osteoarthritis [1]. Understanding and mimicking the complexity of the osteochondral system are critical for designing a successful tissue engineering (TE) approach that can restore the functionality of a joint. However, bone and cartilage, which are the tissues that make up the osteochondral interface, have different molecular compositions and cellular organizations, which create differences in structural and mechanical properties, between these tissues. Thus, current TE strategies are hampered by the difficulties inherent in designing a seamless interface between these two very different tissues.

The ideal cell source for osteochondral TE strategies has not yet been found. The cell source should be proliferative, yet it should possess the phenotypic plasticity to differentiate into the various cell types that form the osteochondral interface. Recently, amniotic fluid-derived stem cells (AFSCs) have been shown to have the capacity to differentiate along both the chondrogenic [2,3] and osteogenic [2] lineages. Also, the use of AFSCs does not raise the ethical concerns that are associated with the use of embryonic stem cells for research and therapy [4,5].

Osteochondral interfaces are exposed to a number of different in vivo stresses and strains that result from the patient's daily

* Corresponding author. Tel.: +1 336 713 7294; fax: +1 336 713 7290.
E-mail address: jyoo@wakehealth.edu (J.J. Yoo).

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