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SCAFFOLDS FROM THE SEA: A COMPARISON OF THE MECHANICAL, STRUCTURAL AND BIOLOGICAL PROPERTIES OF DIFFERENT MARINE-DERIVED COLLAGEN BIOMATERIALS

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INTRODUCTION

To date, the majority of collagen-based biomaterials explored for biomedical applications have been of bovine or porcine origin, which raises some concerns about the high cost, environmental impact and potential prion and viral transmission associated with their manufacturing. These challenges have led to an increased interest in alternative collagens, such as those derived from marine organisms, which could potentially be leveraged as cost-effective sources of the biopolymer. However, a recent study from our lab reported poor mechanical properties and sub-optimal pore structures of salmon-derived collagen scaffolds [1], which highlights that the optimum source and composition of marine-derived collagen scaffolds remains to be elucidated. To that end, we sought to compare the mechanical, structural and biological properties of a range of marine-derived collagen scaffolds (fabricated from blue shark, catshark and jellyfish sources), with an eye towards optimizing their composition for use as porous three-dimensional scaffolds in tissue engineering applications.

MATERIALS AND METHODS

Blue shark and catshark collagens were extracted according to previous protocols [2] and jellyfish collagen was donated by Jellagen® Limited. The different marine-derived collagens were blended in 0.5 M acetic acid at a concentration of 1% w/v, freeze-dried to form porous scaffolds, and crosslinked using dehydrothermal and carbodiimide treatments. 0.5% w/v bovine collagen scaffolds served as a control. Mechanical properties were assessed using an unconfined compression test in a saline bath (n=6). Pore structure was visualised using scanning electron microscopy (SEM). Scaffolds were seeded with porcine mesenchymal stem cells (MSCs) and maintained in a medium supplemented with 10% foetal bovine serum for 7 days. Metabolic activity and DNA content was assessed using Alamar Blue and Picogreen assay kits, respectively (n=4). Statistical analyses were performed using one and two-way ANOVAs. Significance was accepted at $p<0.05$ and results are presented as mean + standard deviation from the mean.

RESULTS

No significant differences in the compressive moduli (≈ 0.6 kPa) were observed between the scaffolds and SEM illustrated that all scaffolds demonstrated porous, interconnected networks (Fig 1A). When seeded with MSCs, blue shark and jellyfish scaffolds were shown to have a higher DNA content compared to catshark scaffolds at day 1, whereas at day 7 no significant differences in DNA content were observed between the three marine scaffolds. Bovine scaffolds were shown to have a significantly higher DNA content at day 7 compared to the three marine scaffolds and also compared to their respective content at day 1 (Fig. 1B). MSCs seeded on jellyfish scaffolds demonstrated enhanced metabolic activity at day 1 compared to blue shark and catshark scaffolds, while at day 7, MSCs seeded on bovine scaffolds were found to be more metabolically active than MSCs seeded on the three marine scaffolds (Fig. 1C).

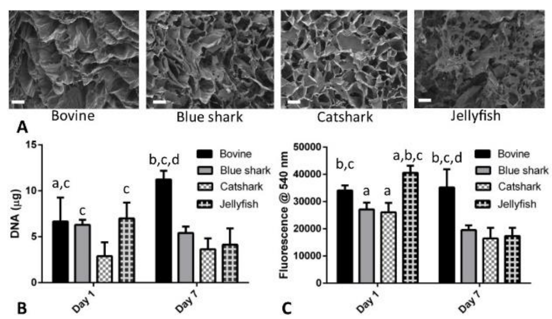

Figure 1 A) SEM of scaffolds. Scale bar - 100µm. B) DNA content of MSC-seeded scaffolds. C) Metabolic activity of MSC-seeded scaffolds. Significance $p<0.05$; a vs. same group at day 7, b vs. blue shark, c vs. catshark, d vs. jellyfish.

DISCUSSION

Herein, we report the development of a range of marine-derived collagen scaffolds with mechanical properties matching those of bovine scaffolds. Upon examining the biological performance of the different materials, bovine scaffolds were shown to promote the greatest degree of MSC proliferation, whilst jellyfish scaffolds enhanced initial MSC attachment over blue shark and catshark scaffolds. Given future advances in media optimisation/biomaterial optimisation, these marine scaffolds therefore offer the scope to be further improved and potentially leveraged as viable, cost-effective alternatives to mammalian-derived biomaterials for tissue engineering applications.

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