Microfluidic collagen patterning for tendon regeneration

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Microfluidic Collagen Patterning For Tendon Regeneration

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INTRODUCTION

Tendon injuries are a common but challenging clinical problem due to the limited healing capacity of the tissue. Tendon tissue is predominantly comprised of aligned type-I collagen fibers, which are responsible for the mechanical strength of the tissue and provide a unique microenvironment for tendon cells.

AIM

The aim of this project is to develop an *in vitro* model that mimics a tendon-like microenvironment. To this end, a microfluidic collagen patterning platform was developed, in which arrayed pillars in combination with laminar flow were used to control the orientation of collagen fibers.

MATERIALS AND METHODS

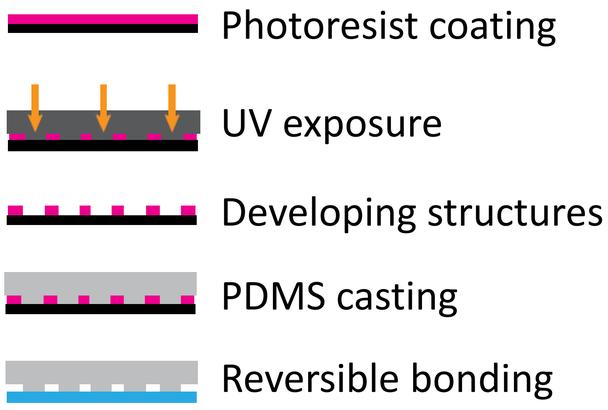
Device design

Computer-aided design

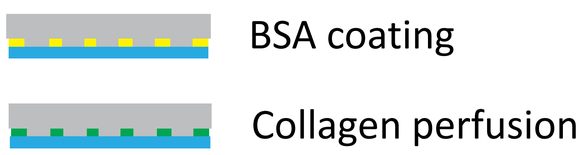
Computational modeling

COMSOL MULTIPHYSICS®

Fabrication



Collagen patterning



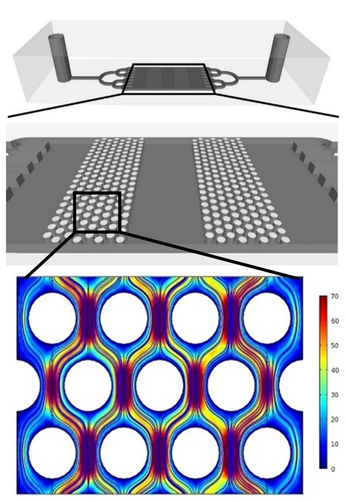
Alignment quantification

Cell culture

Cell morphology
Tenogenic marker expression

RESULTS

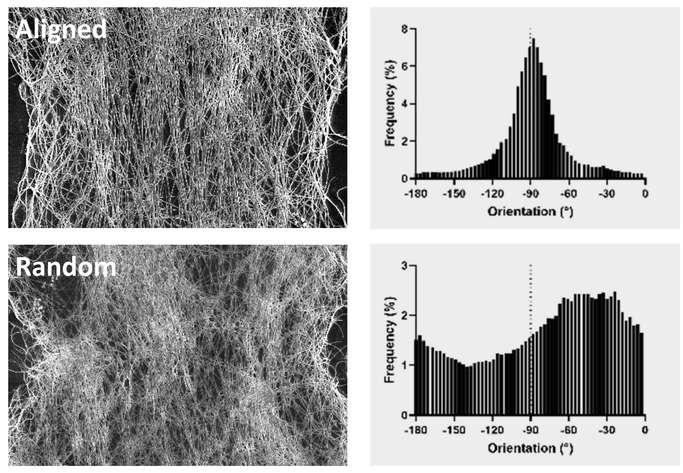
Hydrodynamic focusing



Microfluidic device with the arrays of micropillars with a diameter of 50 µm and a pillar-to-pillar spacing of 50 µm were designed and fabricated.

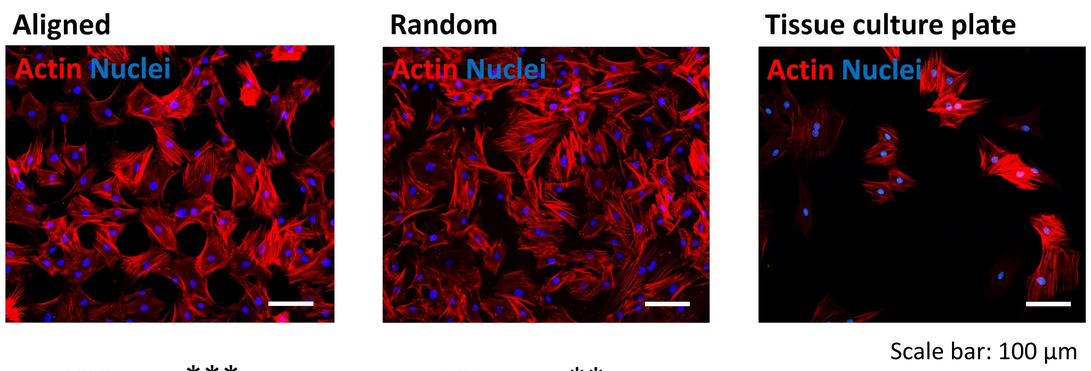
Computational modeling of fluid flows in the microchannel shows hydrodynamic focusing in the region between the pillars.

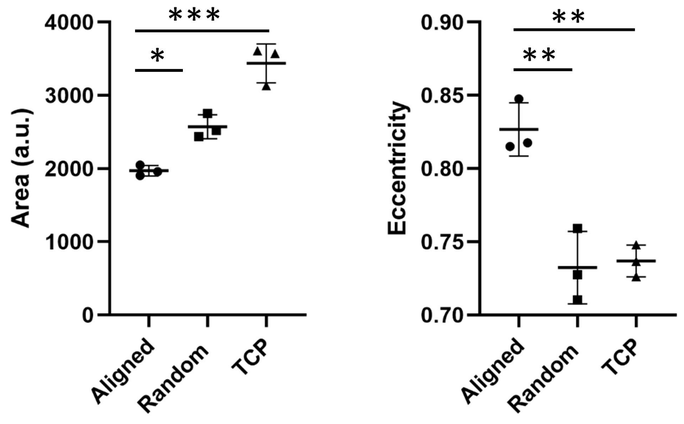
Collagen alignment quantification



Higher alignment of collagen fibers upon polymerization was observed in the regions between the pillars than the non-pillars region.

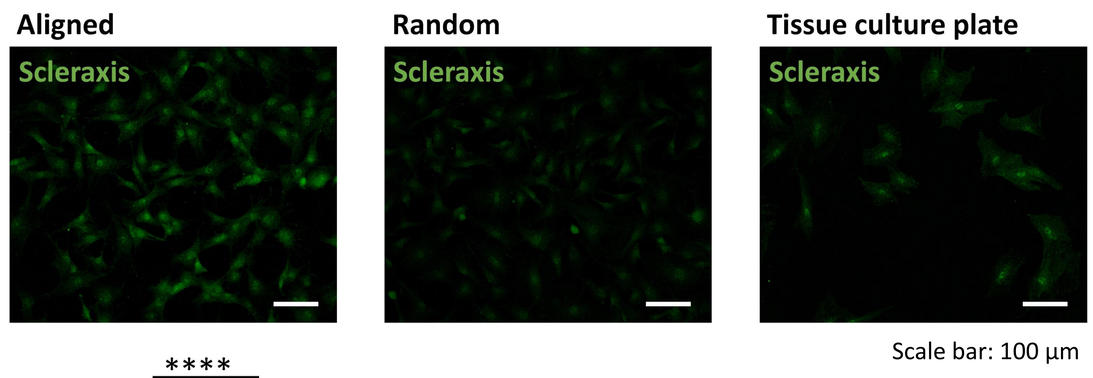
Cell morphology

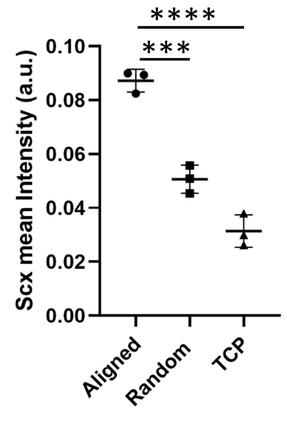




Primary tenocytes cultured on aligned collagen micropattern showed elongated morphology.

Tenogenic marker expression





Primary tenocytes cultured on aligned collagen micropattern showed significantly higher levels of scleraxis compared to randomly oriented fibers or not patterned regions.

ACKNOWLEDGEMENTS

This research was financially supported by the Gravitation Program "Materials Driven Regeneration," funded by the Netherlands Organization for Scientific Research (grant no. 024.003.013). This research has been made possible with support by the Dutch Province of Limburg (LINK project – grant no. SAS-2014-00837 and SAS-2018-02477).

CONCLUSIONS

We established a microfluidic approach to pattern aligned and non-aligned collagen fibers on the same device for mimicking tendon regeneration, including adhesion, elongation and retention of tenogenic phenotype.