INFLUENCE OF NAOH TREATMENT AND FIBER ORIENTATION ON PCL ELECTROSPUN SCAFFOLD FRICTIONAL PROPERTIES

Elisa Bissacco (1), Matthias X. T. Santschi (1), Stephen J. Ferguson (1)

1. ETH Zürich, Institute for Biomechanics, Switzerland

Introduction

Solution Electrospinning (SES) with Poly(ε-caprolactone) (PCL) is an established method to fabricate nanofibrous polymeric constructs that are relevant for tissue engineering applications. This technique offers the advantage of controlling fiber orientation, which may provide morphological and biomechanical similarities to e.g. articular cartilage [1]. However, the use of PCL presents a challenge to *de novo* tissue growth, due to its hydrophobic nature [1]. NaOH treatment is a method to improve surface wettability that can be applied to electrospun PCL to overcome this.
As the tribological function is an important mechanical property of articular cartilage, dependent on surface characteristics, the evaluation of frictional properties is crucial for articular cartilage regeneration constructs [3]. The aim of this study was to examine how NaOH treatment influences the frictional properties of electrospun samples with different fiber orientations.

Methods

Nanofibrous PCL-membranes were produced using conventional SES from a PCL/CH_3OH:$CHCl_3$ solution. A round collector was rotated at 200 RPM and 1500 RPM to form random and aligned fiber scaffolds. In addition, to obtain fiber alignment, conduction gaps (Kapton tape) were introduced on the collector surface. The obtained membranes were immersed in a NaOH solution (1M) for 1 hour.
Frictional tests were performed on treated and untreated scaffolds (r_{radius} = 0.2 cm) with different fiber orientations using an Anton Paar MCR-301 rheometer. Scaffold specimens were tested at loads of 3N, 6N and 12N, corresponding to contact pressures of 0.24, 0.48 and 0.95 MPa, respectively. Specimens, immersed in PBS at room temperature, were tested with a pin rotating frequency of 2 Hz.

Results

No structural alterations, such as fiber morphology, were observed for NaOH treated scaffolds compared to untreated scaffolds. Additionally, NaOH residues on the fiber surfaces could be observed (Fig 1).
The frictional response for each scaffold type was similar across all applied loads (Fig 2).
At an applied load of 12N, the frictional response (μ, coefficient of friction) for non-treated aligned samples was significantly ($p < 0.05$) higher than for unaligned fiber scaffolds (μ_{nA}= 0.269; μ_{nR}= 0.209). μ of treated aligned (μ_A= 0.277) and treated random (μ_R= 0.254) oriented fiber samples were not significantly different to non-treated membranes.

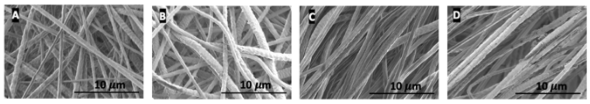

Figure 1: SEM images of random (A,B) and oriented (C,D) fiber morphologies before (A,C) and after (B,D) NaOH treatment.

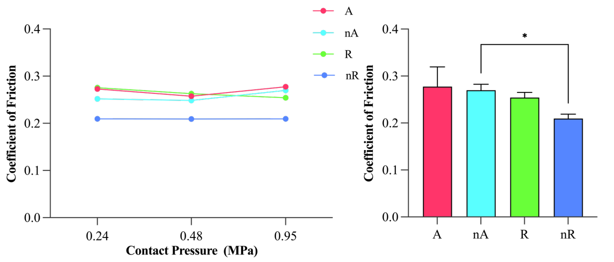

Figure 2: Left: Frictional response of treated aligned (A) and random (R) oriented fiber scaffolds and non-treated ones (nA, nR) at varying contact pressures. Right: μ of A, nA, R and nR samples at 0.95 MPa of contact pressure. n = 3 per sample & condition

Discussion

An average contact pressure of 0.95Mpa is comparable to the physiological compressive pressure occurring in native articular cartilage during normal motion [4], therefore frictional behavior of the membranes was evaluated at an applied load of 12 N.
In all 4 conditions, the measured coefficient of friction remained in a physiologically acceptable range [5]. Indicating that, even if there is an effect of NaOH treatment or fiber alignment on frictional properties, this effect is negligible and clinically insignificant.
In conclusion, this study showed that the fiber alignment and NaOH treatment had minimal effects on the frictional properties of the scaffolds, and could therefore be considered for future improvements of construct performance in articular cartilage regeneration.

References

1. Accardi et al, Tissue Engineering: Part A, Vol 19, 2013
2. Morita et al, Journal of biomechanics, Vol 39.1, 2006
3. Bennett et al, Proc Inst Mech Eng H, Vol 216, 2002
4. Oungoulian et al, Journal of biomechanics, 2015

Acknowledgement

Funded by European Union's Horizon 2020 Research and innovation programme (No. 956004). The author would like to acknowledge P. Weber (T.E. + Biofabrication Lab.) for the assistance provided on the rheometer used in this study.