In-situ silk fibroin conformational change using a coaxial-printing strategy for knee meniscus replacement

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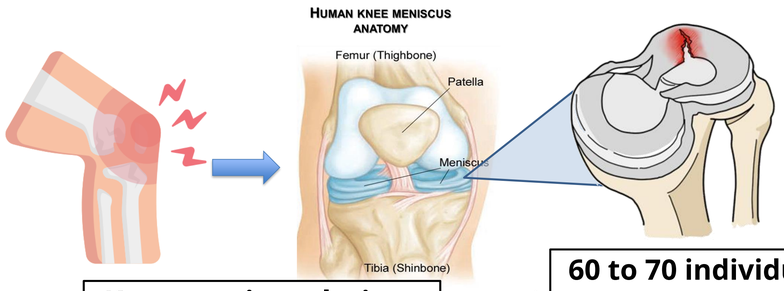
Introduction & Objectives



Knee meniscus lesions → AFFECT → **60 to 70 individuals per 100,000 persons per year** [1]

Current treatments lack long-term effectiveness [2]:

- ✕ **Degenerative changes**
- ✕ **Altered knee biomechanics**
- ✕ **Early onset of osteoarthritis**

Solution

COAXIAL 3D PRINTING

Conjugation of two different materials within the same bioink

Polycaprolactone (PCL)
Good mechanical properties

Silk Fibroin (SF)
Good biological properties

Optimize the printing of both materials, to create a functional scaffold

Methods

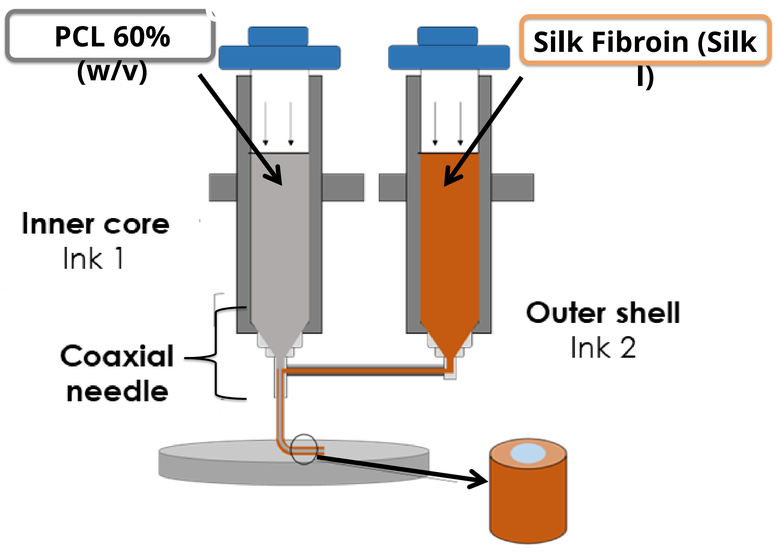
BIOINK OPTIMIZATION

Polycaprolactone → **Acetone** → **PCL 60% (w/v)**

Bombix mori cocoons → **Degumming** → **Silk Fibers** → Dissolution in **Lithium Bromide**

SF in random coil conformation (Silk I)
Exhibits low crystallinity, instability and is water soluble.

PRINTING



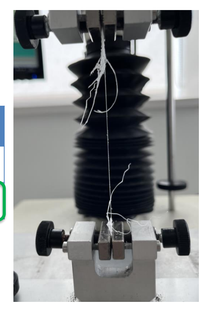
Results

PCL PRINTING OPTIMIZATION

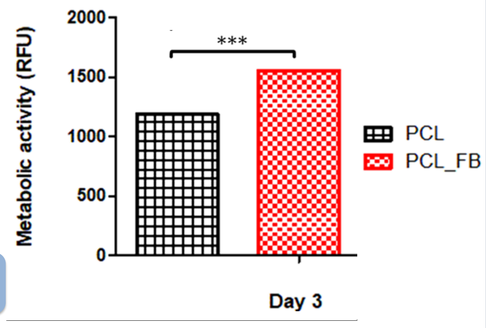
Material	Composition (w/v)	Printing Parameters: Pressure (Psi)	Temperature (ºC)	Speed (mm/s)	
PCL	100%	95	120	2	High temperatures
PCL	60% (diluted in acetone)	80	30	3.5	✓
PCL	40% (diluted in acetone)	74	30	3	Difficult to build in height

MECHANICAL PROPERTIES

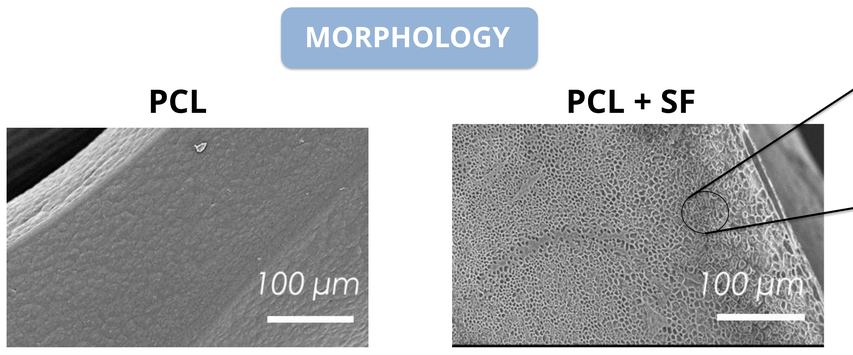
Formulation	Elastic modulus (Mpa)
PCL	0.58 ± 0.14
PCL_SF	0.75 ± 0.03



BIOLOGICAL PROPERTIES

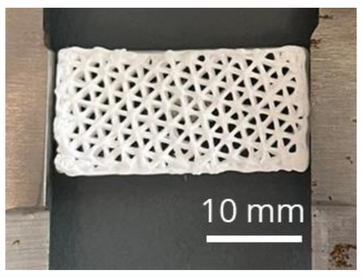


MORPHOLOGY



SF in β-sheet conformation (Silk II)
Exhibits high crystallinity and resistance to thermal and mechanical stress

PRINTED SCAFFOLD



Scaffold printed with **PCL in the inner core** and **SF in β-sheet** at the **outter shell**

Conclusions

- **PCL** and **SF** printing were optimized to allow 3D printing;
- A **3D coaxial printing system** was developed, and allowed the simultaneous print of both bioinks;
- Coaxial printing induced the transformation of SF **(Silk I -> Silk II)**, due to the contact with the acetone, further improving the mechanical properties of the scaffold
- The use of **SF as the outer shell** appears to enhance the biological properties of the scaffolds after a three-day culture period;
- **Coaxial 3D printing** allowed the fabrication of a **scaffold with promising mechanical and biological properties**

References

1 Chambers, H. G., & Chambers, R. C. (2019). The Natural History of Meniscus Tears. Journal of Pediatric Orthopaedics, 39. https://journals.lww.com/pedorthopaedics/fulltext/2019/07001/the_natural_history_of_meniscus_tears.14.aspx

2 E. Luvsannyam, M. S. Jain, A. R. Leitao, N. Maikawa, and A. E. Leitao, "Meniscus Tear: Pathology, Incidence, and Management," Cureus, vol. 14, no. 5, 2022, doi: 10.7759/cureus.25121.

Acknowledgements

This work was supported by National Funds from FCT - Fundação para a Ciência e a Tecnologia through projects 2022.08713.PTDC and UIDB/50016/2020. The authors would like also to acknowledge the support of Project No. IBEROS+ (0072_IBEROS_MAIS_1_E) - Instituto de Biofabricación en Red para El Envejecimiento Saludable, funded by "Interreg VI A España – Portugal (POCTEP) 2021-2027. JBC is grateful to FCT for the individual Junior Researcher contract (org.doi:10.54499/2022.02781.CEECIND/CP1745/CT0001).