Design and characterization of three-dimensional injectable microscaffolds to support tissue repair and regeneration

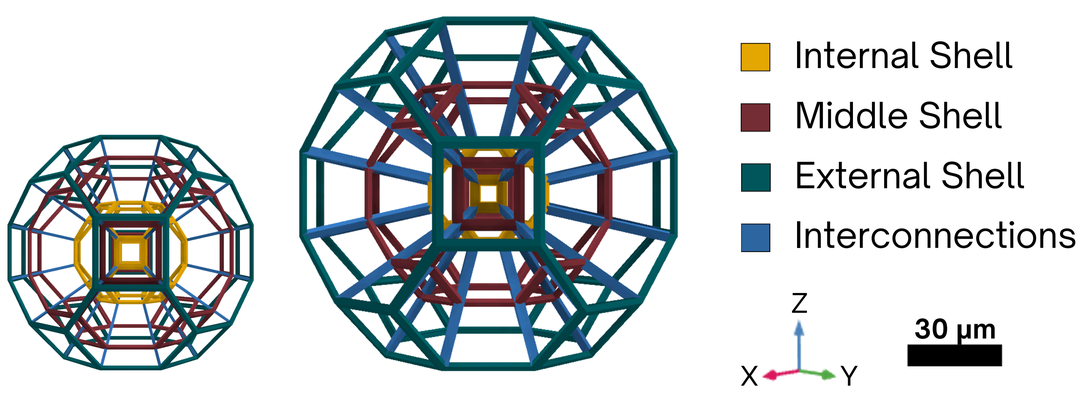
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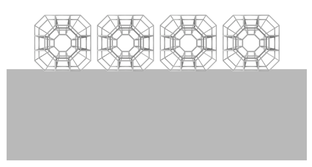
Personalized treatments for tissue repair rely on tightly regulated processes that depend on a fine balance between pro-inflammatory and pro-regenerative cues. Mesenchymal Stem Cells (MSCs) offer therapeutic potential due to regenerative, immunomodulatory, anti-inflammatory properties[1]. Currently employed scaffolds improve MSCs survival and retention compared to cell injections but fail to balance structural integrity with injectability[2,3].

We aim to develop injectable 3D microscaffolds to support *in vivo* MSCs delivery, while maintaining cell stemness and preserving long-term immunomodulatory potential.

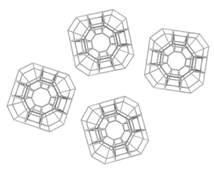
Design Concept



Tested Configurations

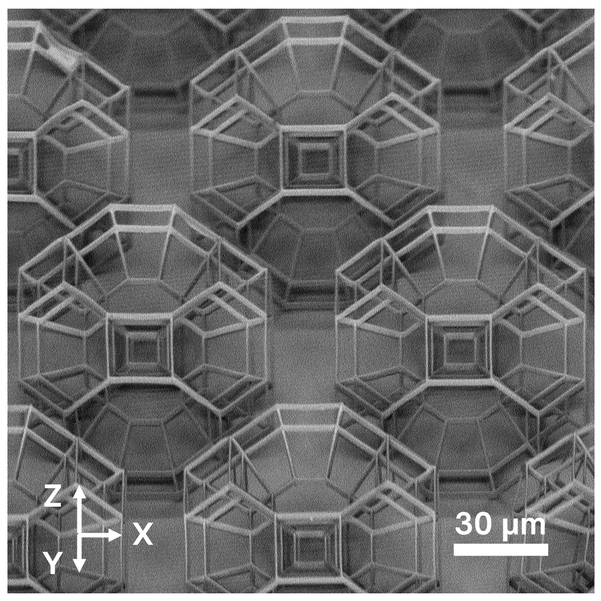


Anchored to glass coverslip



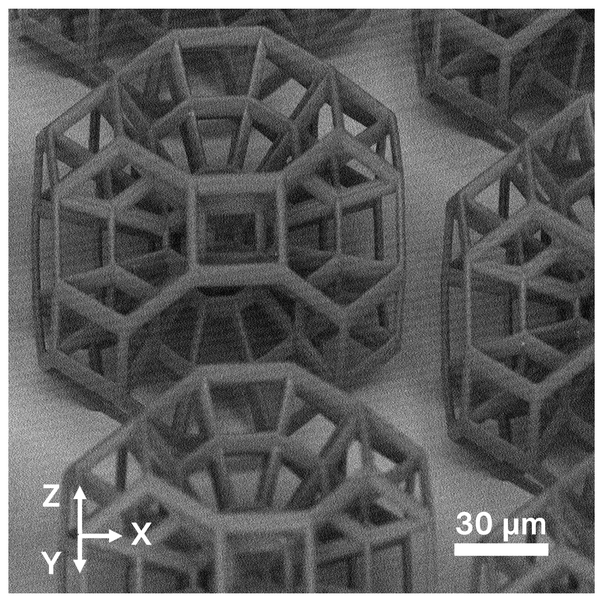
Floating in suspension

Fabrication via Two-Photon Polymerization



Non-commercial Laser Setup[3]

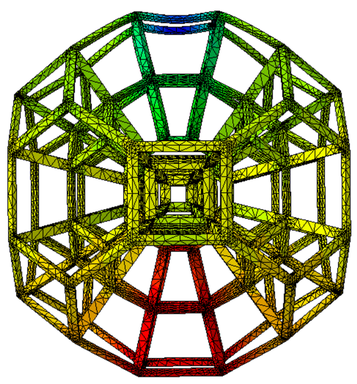
λ = 1030 nm, PRR = 1 MHz,
100X objective, NA 1.4



Nanoscribe Quantum X Shape

λ = 780 nm, PRR = 80 MHz,
25X objective, NA 0.8

Compression Finite Element Analyses



Uniaxial Compression (Z)

+ 1,444 E-03 µm
- 4,589 E+00 µm

Z
X
Y
30 µm

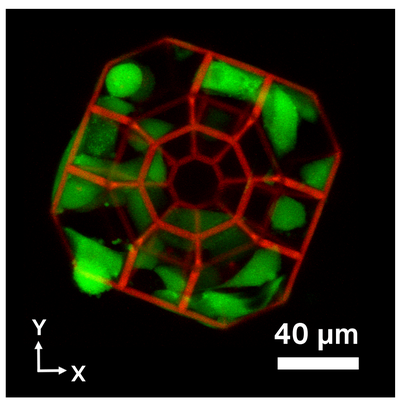
	Stress	Strain	Displacement
Small Configuration	0.51 MPa	6.98%	5.5 µm
Large Configuration	1.95 MPa	5.71%	7.1 µm

IP-S
ρ = 1111 kg/m^3
E = 2.1 GPa
ν = 0.3

	Stress	Strain	Displacement
Small Configuration	0.63 MPa	5.59%	4.5 µm
Large Configuration	1.95 MPa	3.47%	4.5 µm

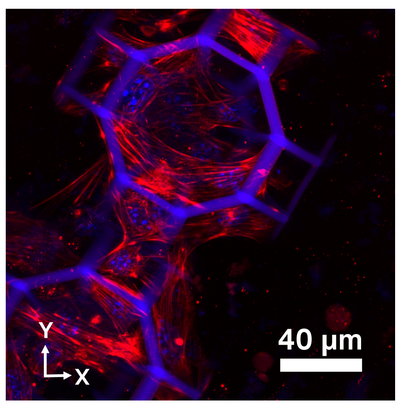
SZ2080
ρ = 1200 kg/m^3
E = 3.03 GPa
ν = 0.49

Confocal Microscopy



LIVE/DEAD Assay

Calcein-AM
Ethidium Homodimer-I
Scaffold

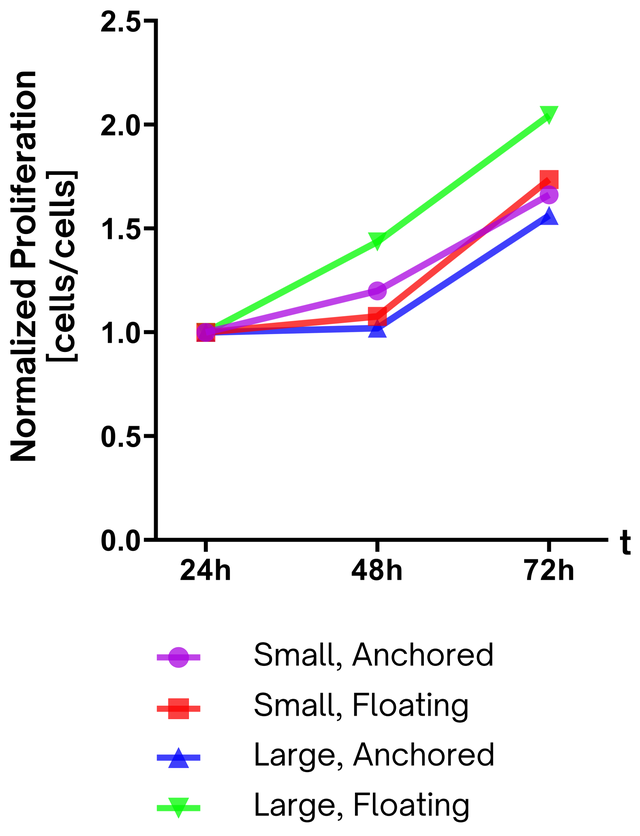


Cell Morphology

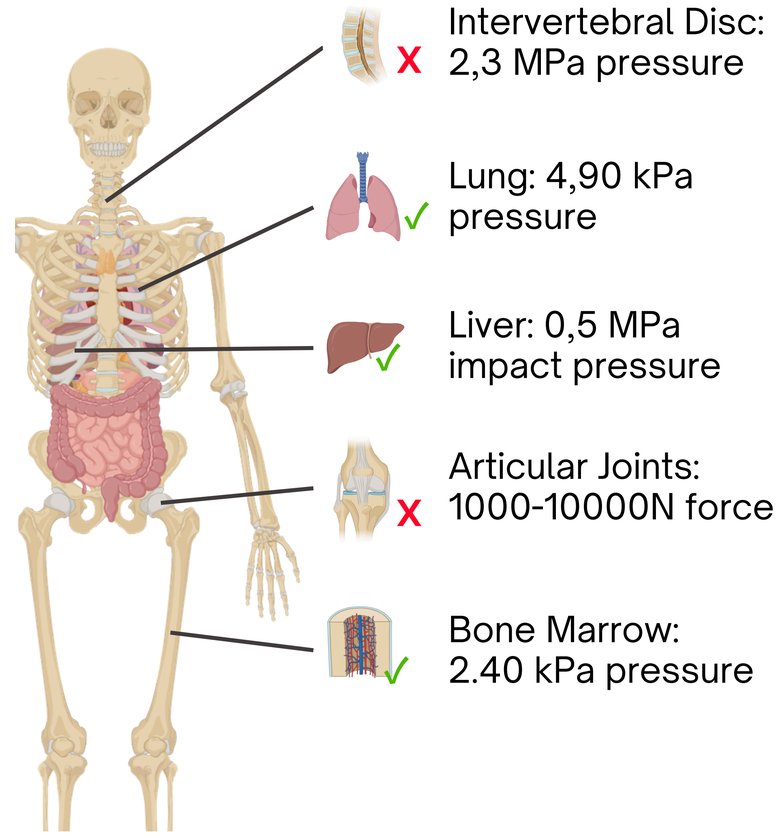
Actin (*SiR-Actin kit*)
Nuclei (*Hoechst 33342*)
Scaffold

** Large Floating microscaffolds acquired with A1R+ Nikon (20x objective)*

Cell Proliferation



In vivo Suitability



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PRIN2022-VISION, cod. 2022FLXS8T.

References

[1] Guillamat-Prats, *Cells*, 10, 1729, 2021
[2] Du et al., *Materials Horizons*, 12, 7370, 2025
[3] Jacchetti et al., *Scientific reports*, 2021, 11.1: 3021