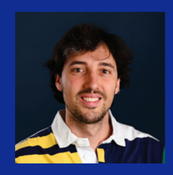
Faraday waves-induced densification of articular cartilage progenitor cells (ACPCs) for in vitro cartilage model development

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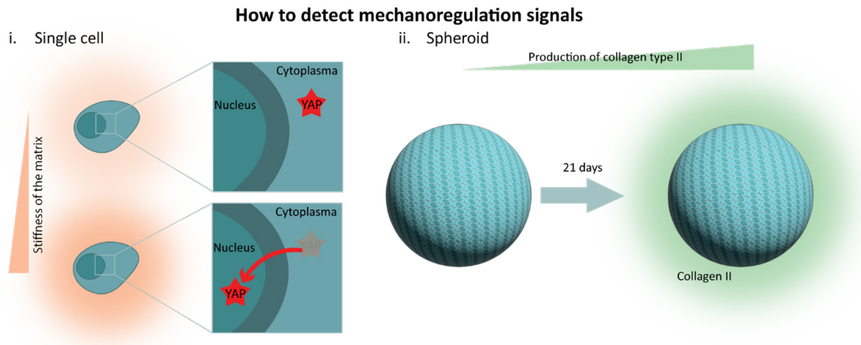
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BACKGROUND AND AIM OF THE STUDY

- Articular cartilage exhibits limited self-repair capacity
- Articular cartilage progenitor cells (ACPCs) are promising due to their intrinsic chondrogenic potential
- Cell fate is strongly regulated by biophysical cues, including spatial organization and matrix mechanics
- Current *in vitro* models lack the ability to **independently control**:
  1. **Local mechanical microenvironment**
  2. **Cell spatial distribution**

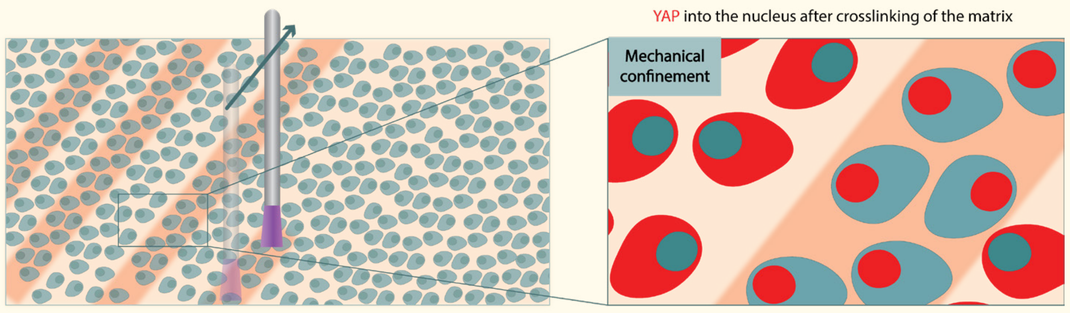


Convergence of two biofabrication strategies to address this gap:

Optical Fiber Assisted Printing (OFAP)

Benchtop, cost-effective, easy to integrate, fully automated and customizable optical fiber-based LED set-up

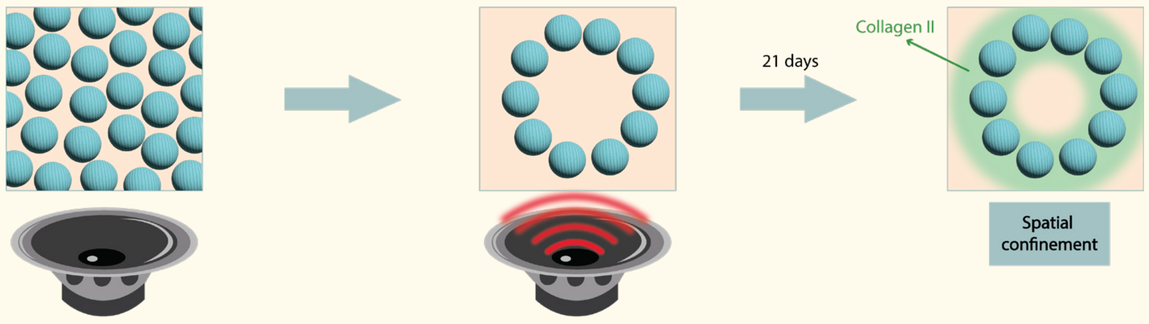
- High-resolution selective patterning
- Spatial controlled modulation of hydrogels stiffness
- Suitable for single-cell and spheroids encapsulation



Faraday waves-induced acoustic patterning

Rapid, benchtop, cost-effective and customizable set-up based on Faraday-waves

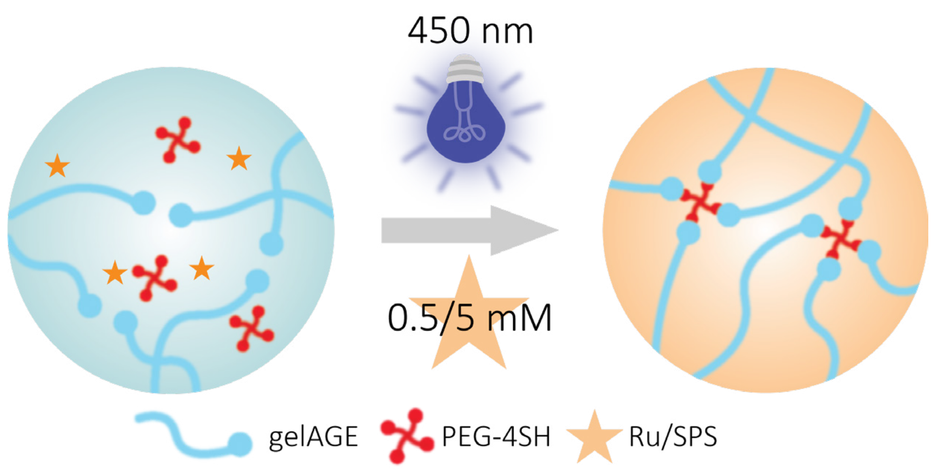
- Rapid acoustic-driven controlled patterning of cells/spheroids
- Tunable pattern geometry depending on processing parameters:
  1. Frequency
  2. Amplitude
  3. Frame shape
- Compatible with cell encapsulation and long-term culture



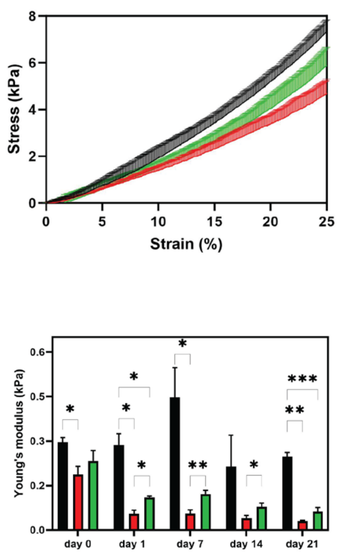
RESULTS

Hydrogel formulation and characterization

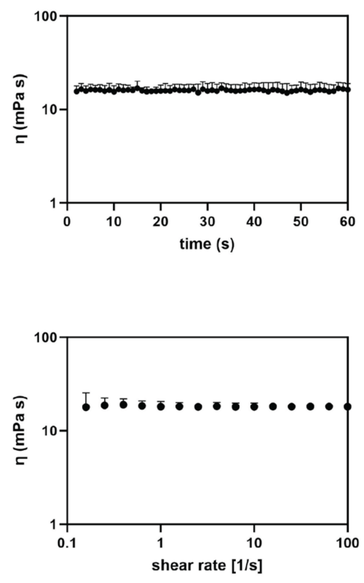
gelAGE 3%w/v + PEG-4SH 7.5 w/v



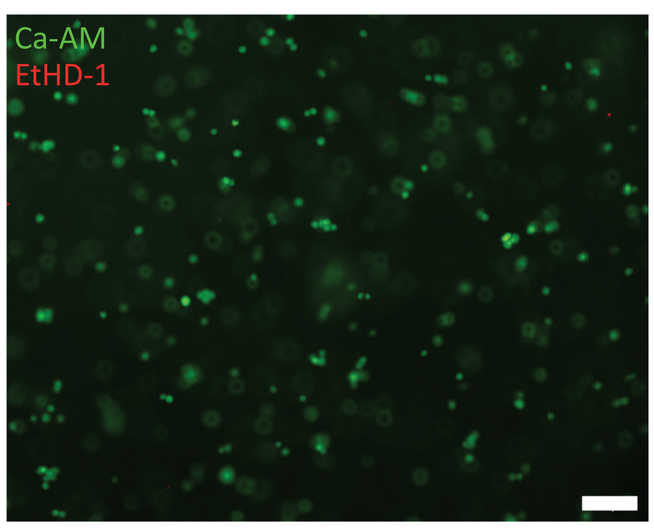
Mechanical properties



Rheological properties



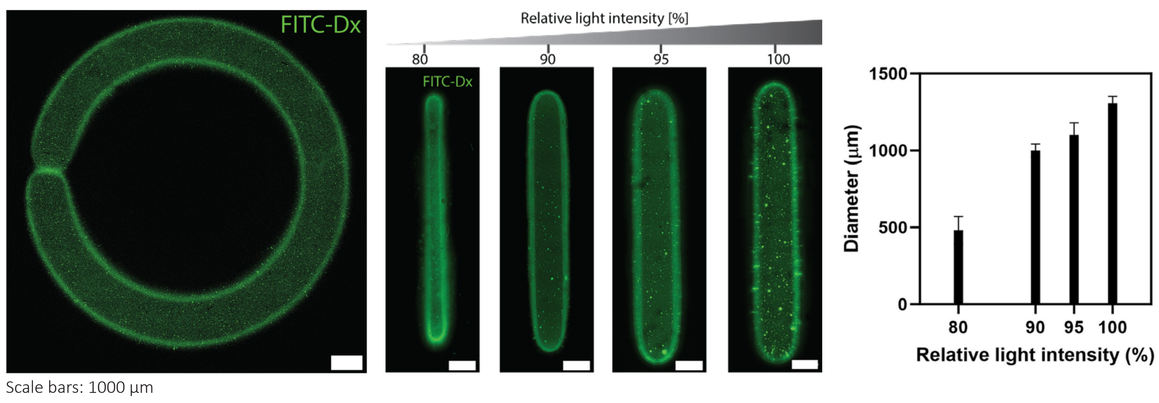
Cell-material interface



Scale bar: 100 µm
Magnification: 10x

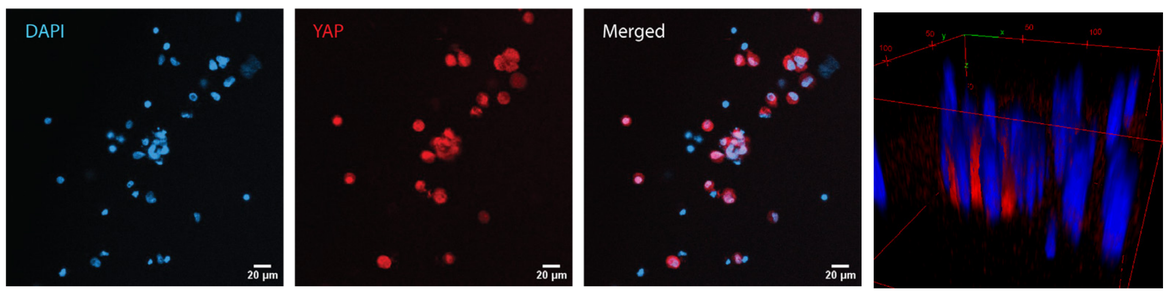
Optical Fiber Assisted Printing (OFAP)

Cell-free system



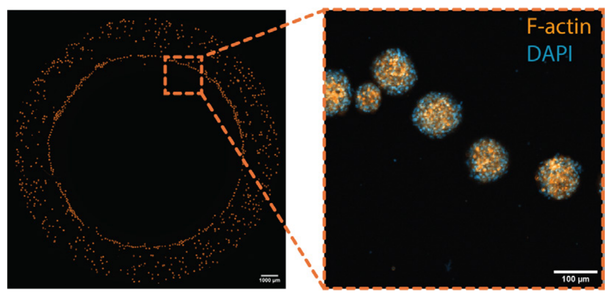
Scale bars: 1000 µm

Cellular system

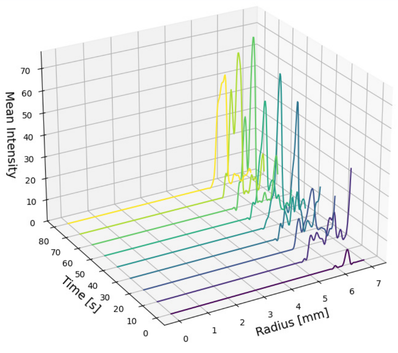


Faraday waves-induced acoustic patterning

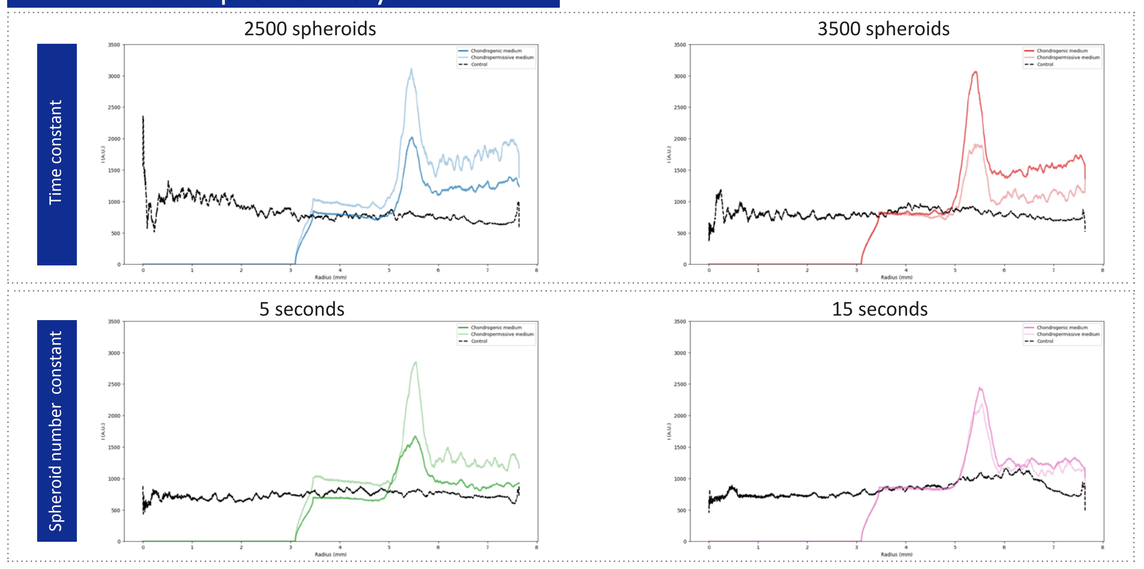
Pattern day 1



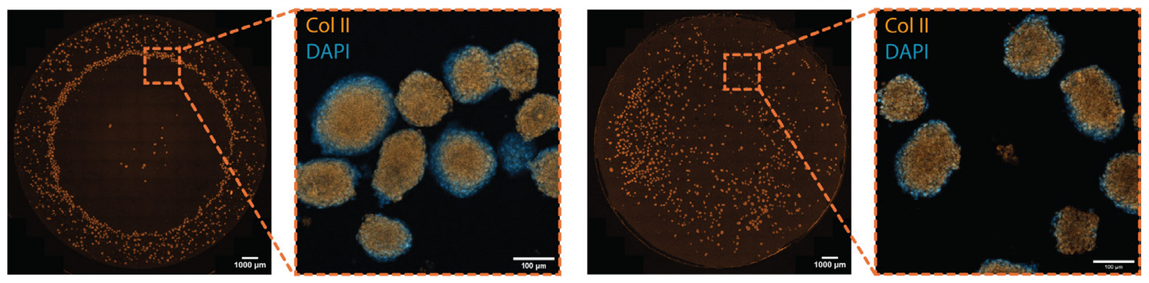
Kinetic Pattern formation



Radial profile analysis



Immunostaining day 21



CONCLUSIONS

- **Tunable Environment:** Hydrogel formulation and properties are precisely modulated for the processing techniques and the ACPCs
- **Integrated Strategy:** Successfully combined **Faraday waves-induced acoustic patterning** and **OFAP** to independently control cell distribution and local matrix stiffness
- **Rapid Acoustic Patterning:** fast, reproducible ACPC patterning (60 seconds) with high structural stability
- **Optical Fiber-based Patterning:** High-resolution, spatially controlled crosslinking to modulate local hydrogel stiffness
- **Biological Response:** ACPCs sense the microenvironment, showing different **YAP** nucleus/ cytoplasmic ratio after day 1 and **Collagen II** deposition by day 21
- **Advanced Tool:** A robust platform for studying how specific biophysical cues drive progenitor cell behavior