SYNERGISTIC EFFECTS OF INTERMITTENT STRETCH AND 3D ARCHITECTURE ON HUMAN PERIODONTAL LIGAMENT STEM CELL MECHANOBIOLOGY

Massai D.[1,2], Masante B.[1,2], Santos M.S.[3], Putame G.[1,2], Silva J.S.[3], Tosini M.[1,2], Lugas A.T.[1,2], Roato I.[4], Gabetti S.[1,2], Mussano F.[4], Audenino A.L.[1]

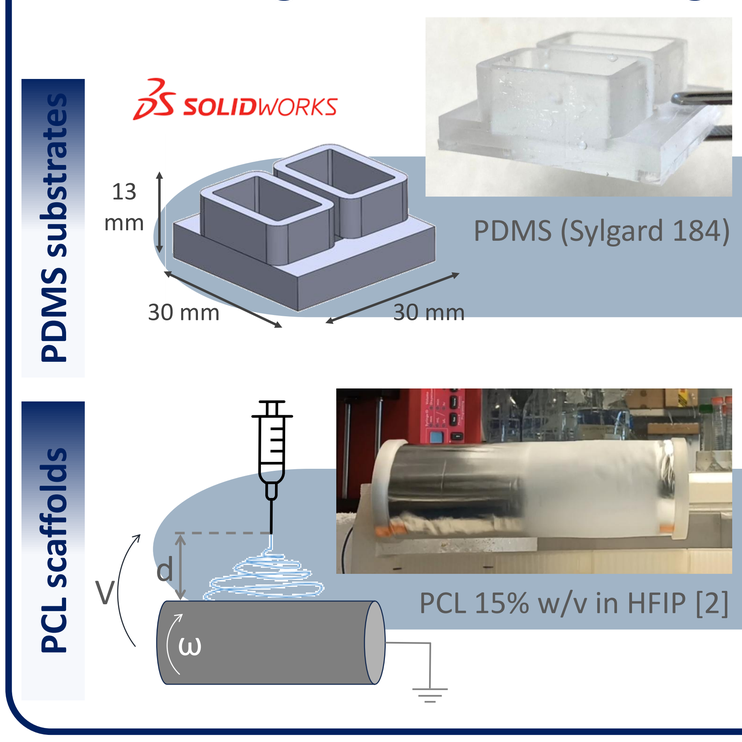
1. Dept. of Mechanical and Aerospace Engineering and Polito[BIO]Med Lab, Politecnico di Torino, Italy; 2. Interuniversity Center for the Promotion of the 3Rs Principles in Teaching and Research, Italy; 3. Dept. of Bioengineering and iBB -Institute for Bioengineering and Biosciences, Instituto Superior Técnico, Universidade de Lisboa, Portugal; 4. Bone and Dental Bioengineering Lab, CIR-Dental School, Dept. of Surgical Sciences, University of Torino, Italy

beatrice.masante@polito.it

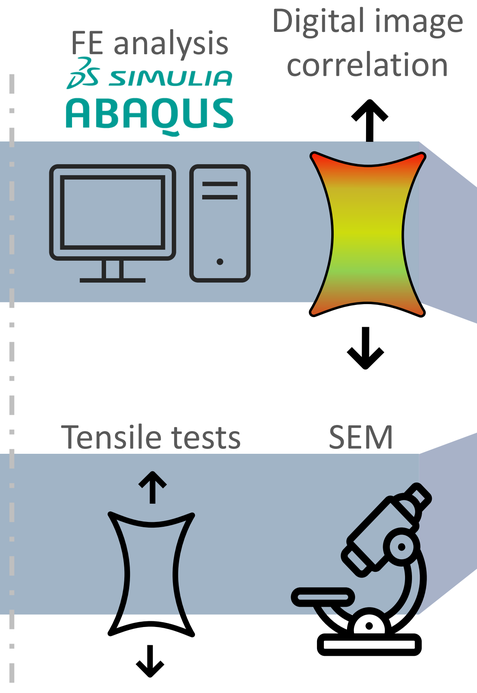
The **periodontal ligament** (**PDL**) provides **mechanical stability** and **absorbs masticatory forces.** These **functions deteriorate** with **periodontitis,** leading to the **loss of PDL** and **alveolar bone** [1]. Enhancing the **regeneration capability** of **PDL-derived stem cells** (**PDLSCs**) is one of the goals of treating periodontitis.

AIM: development and validation of a bioreactor platform to study cyclic uniaxial stretch on human PDL stem cells (hPDLSCs) cultured on 2D and 3D substrates.

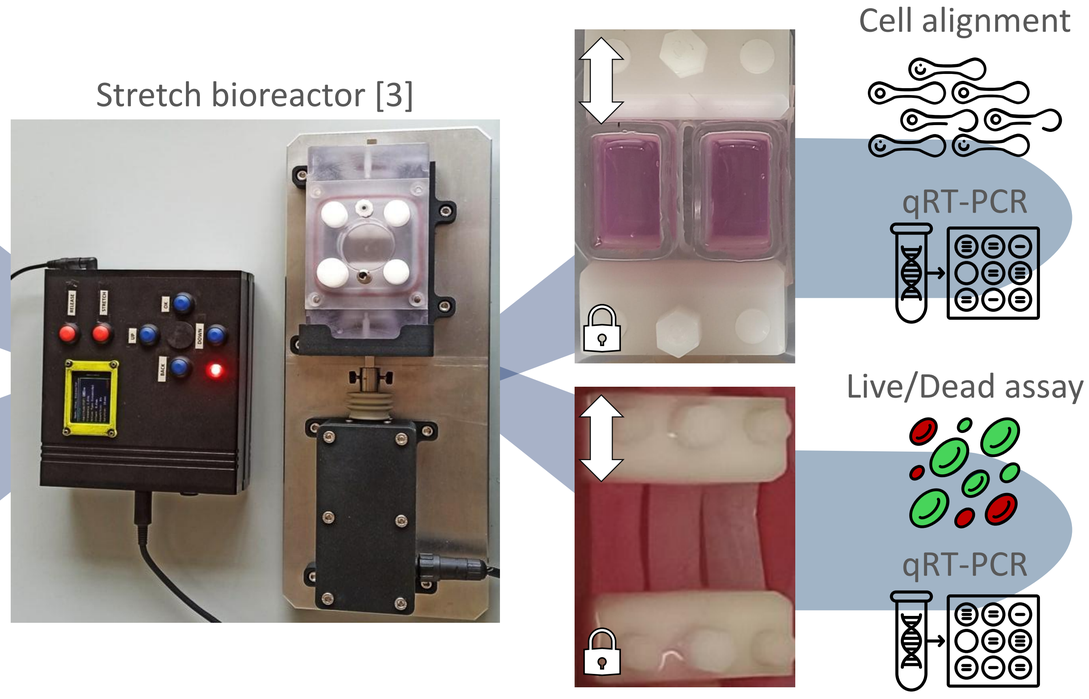
Design and manufacturing



Characterization

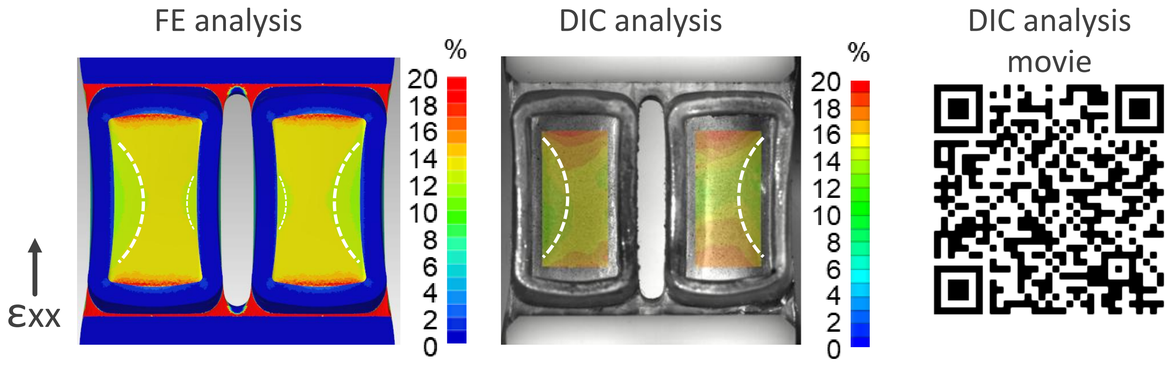


Biological experiments and analyses



PDMS substrates

FE vs DIC analysis comparison

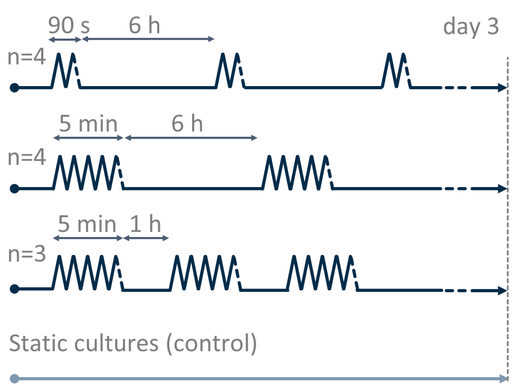


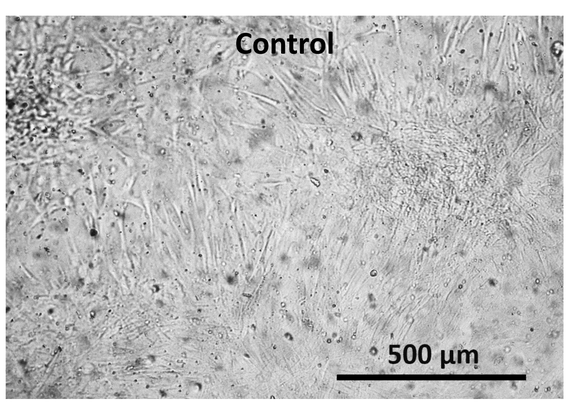
Biological experiments

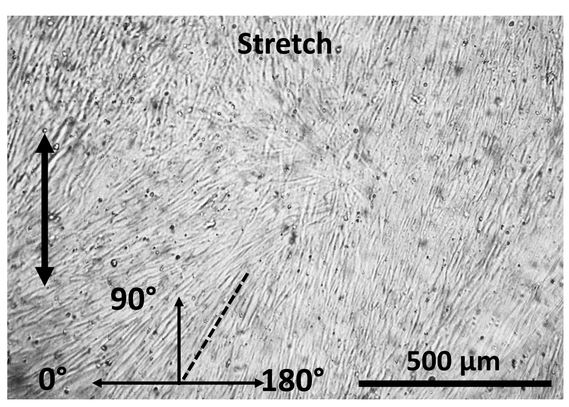
hPDLSCs from healthy patients

Stimulation protocol

- **8% static pre-strain + 7% dynamic strain** amplitude
- **1Hz** frequency
- **Triangular** waveform

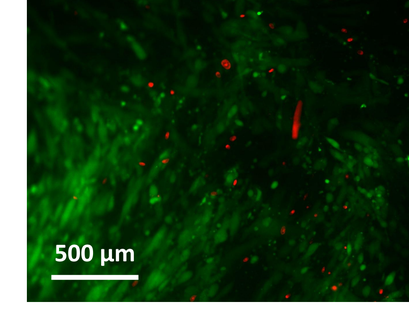


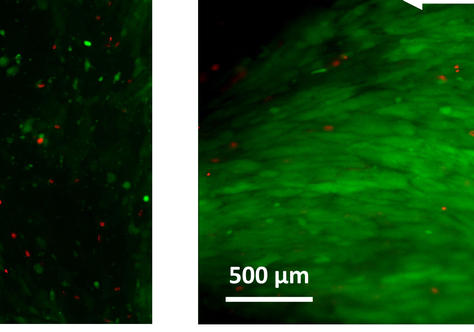


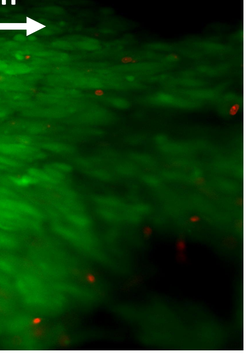


PCL scaffolds

SEM imaging and tensile tests







Mean fibers width = **203 ± 62 nm**

Young's Modulus (**E**) = **2.25 ± 0.37 MPa**

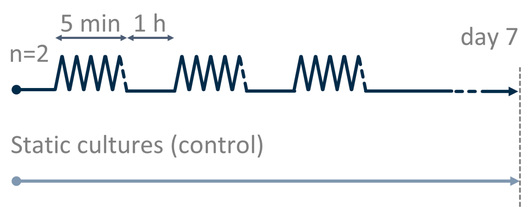
Ultimate tensile strain (**UTS**) = **20.3 ± 2.7 %**

Biological experiments

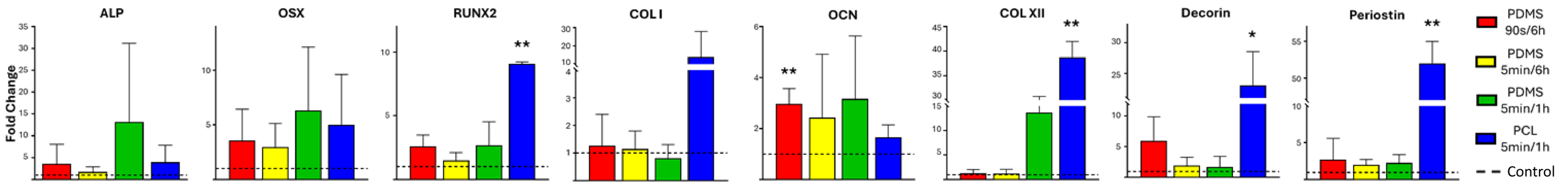
hPDLSCs from healthy patients

Stimulation protocol

- **2% static pre-strain + 5% dynamic strain** amplitude
- **1Hz** frequency
- **Sinusoidal** waveform



Live/**Dead** assay: 2 µM **Calcein-AM** and 4 µM **EthD-1** in PBS 1X



* p<0.05; **p<0.01

Controlled stretch stimulation induces

- ✓ **hPDLSCs alignment**
- ✓ **Increasing trend of osteogenic genes** (ALP, OSX, RUNX2, COL I, OCN)
- ✓ **Upregulation of PDL-related genes** (COL XII, Decorin, and Periostin) for PCL scaffolds



Next biological experiments

- ❖ Use of **PCL + ECM scaffolds**
- ❖ Culture of **hPDLSCs from periodontitis patients**
- ❖ Providing controlled **shear stress stimulation**

TERMIS EU-Chapter 2026 PALMA DE MALLORCA 21-24 APRIL / SPAIN

References

1.Roato et al, Nanomaterials 12(21):3878, 2022
2.Carvalho et al, Mater Sci Eng C, 99:479-490, 2019
3.Putame et al, Med. Eng. Phys. 84:1-9, 2020

In collaboration with

termis EUROPE