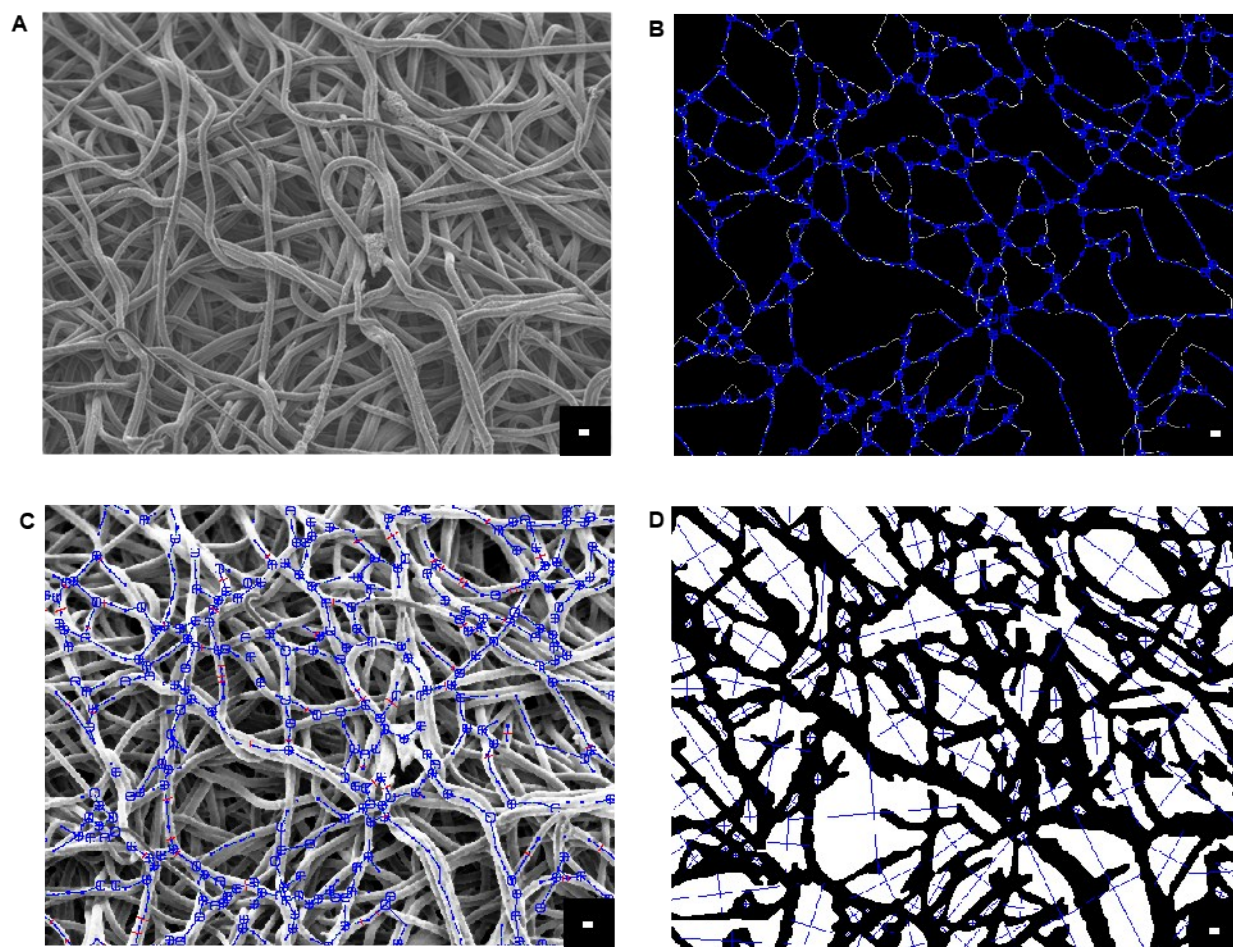
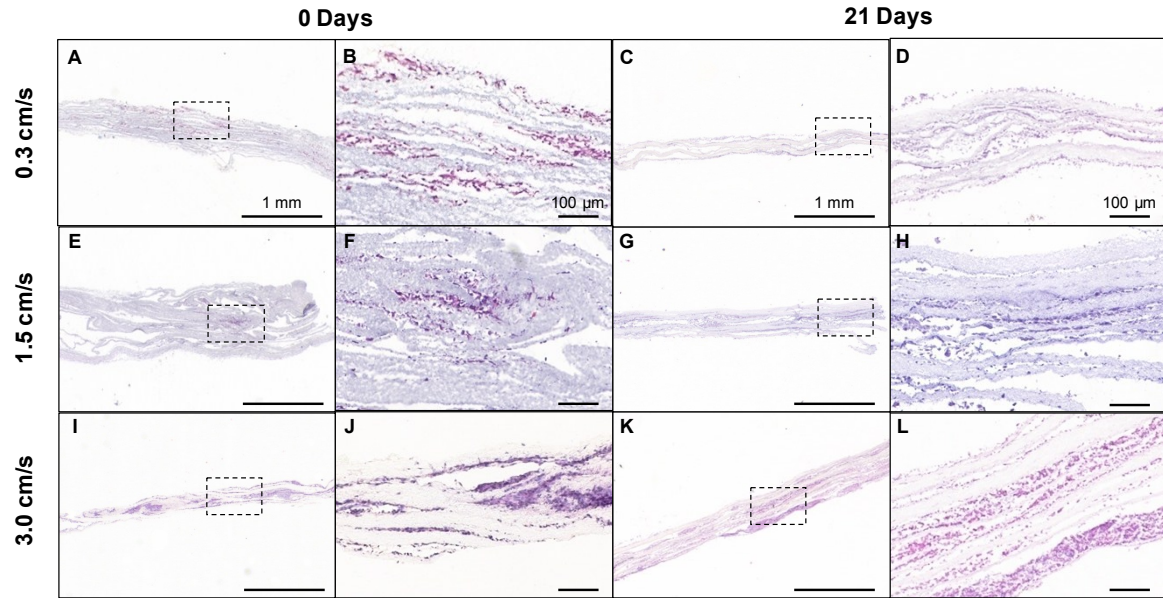


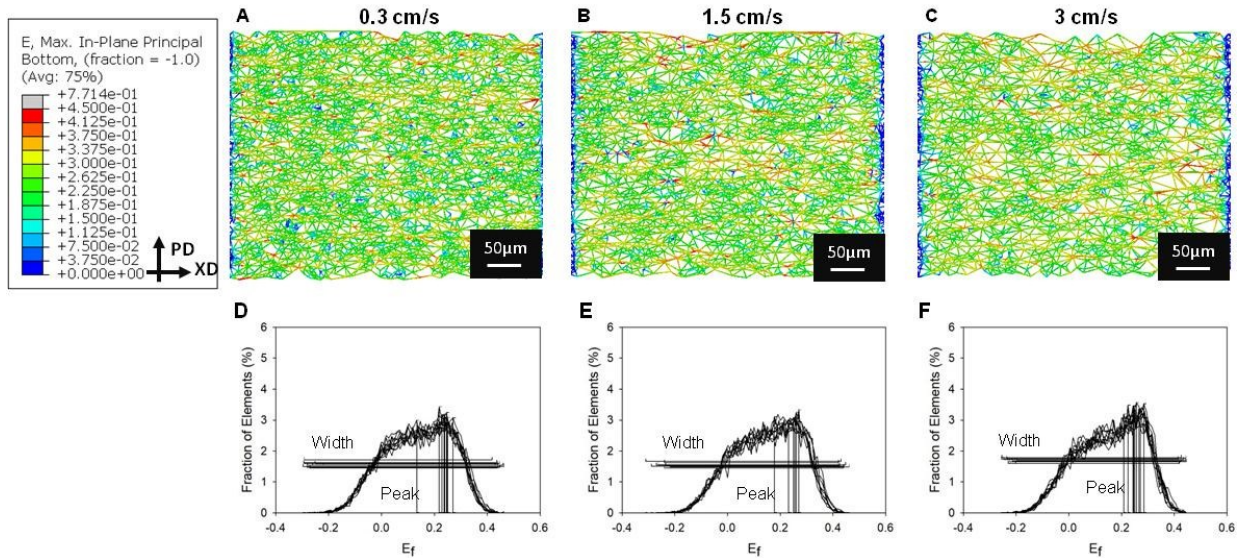
Supplementary information



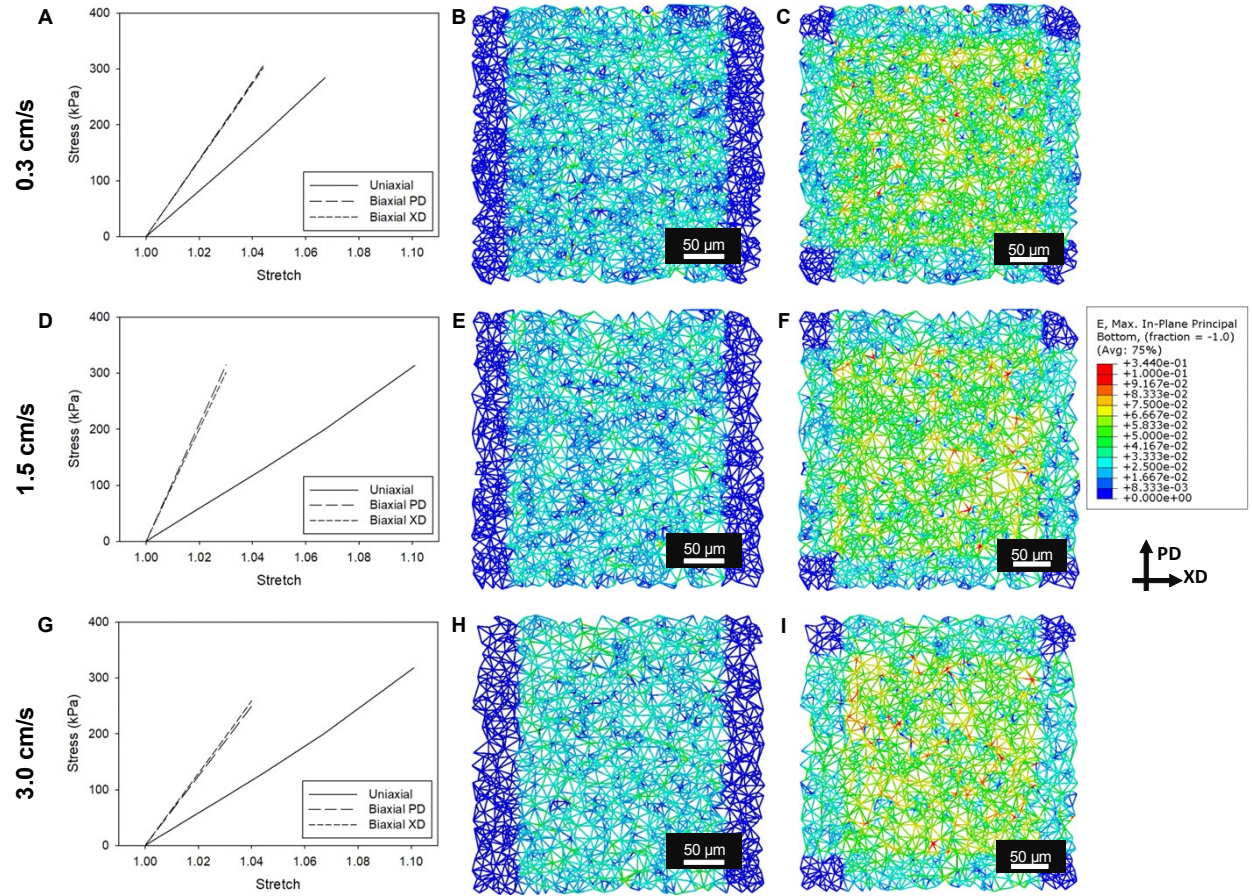
Supp. fig. 1: Fiber network detection algorithm, key steps in the processing cascade: **A)** starting SEM image, **B)** detected fiber skeleton (grey), identified fiber intersections (circles) and connecting fiber segment (blue), **C)** starting SEM image with overlaid detected network, on the last step of the processing fiber diameters are detected (red), **D)** pore sizes and shapes are estimated as void space complementary to the detected scaffold volume, the length of the scale bar is 1 μm .



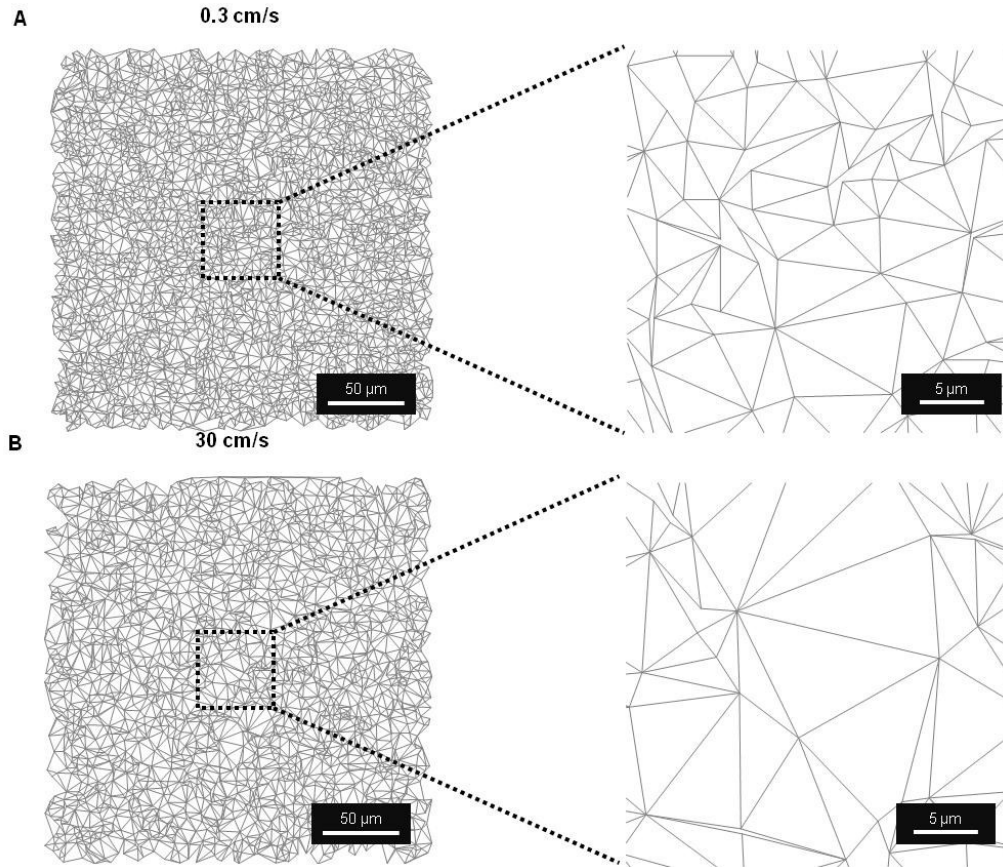
Supp. fig. 2: ECM elaboration, qualitative assessment of collagen formation via histology. The three different scaffolds were exposed to 21 days of mechanical conditioning at 30% strain with a frequency of 1 Hz. **A, E, I** Hematoxylin and Eosin (H&E) staining of samples at day zero showing comparable cell seeding density, onsets **B, F, J** providing additional level of detail at higher magnification. The same samples were imaged after 21 days of conditioning **C, G, K** showing results consistent with the quantitative analysis of collagen mass in Fig. 4 and Fig. 6. **D, H, L** onsets showing additional detail on ECM elaboration with group 3.0 cm/s producing a higher amount of collagen.



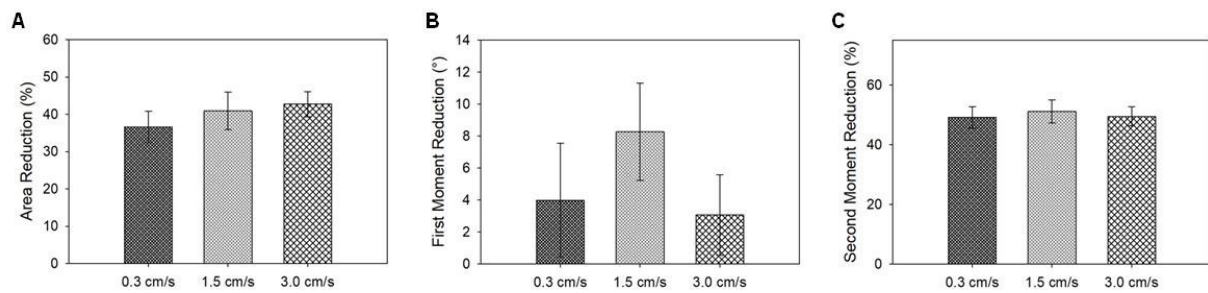
Supp. fig. 3: Finite element model results, effect of meso-scale topological cues on network mechanics: Green's strain map at 30% strain for the **A**) 0.3 cm/s, **B**) 1.5 cm/s, and **D**) 3.0 cm/s, and single fiber Green's strain histogram at 30% strain for the **D**) 0.3 cm/s, **E**) 1.5 cm/s, and **F**) 3.0 cm/s.



Supp. fig. 4: Strip biaxial (labelled as uniaxial) vs. equi-stress biaxial characteristics for **A)** 0.3 cm/s, **D)** 1.5 cm/s and **G)** 3.0 cm/s groups showing comparable macro scale mechanical responses. Strain map comparison between the groups for strip biaxial loading configurations **B)**, **E)** and **H)** and for the equi-stress biaxial load **C)**, **F)**, and **I)**.



Supp. fig. 5: Fiber networks with different ID showing scaffold models with **A)** 0.04 intersections / μm^2 and **B)** 0.02 intersections / μm^2 .



Supp. fig. 6: Finite element model results, effect of meso-scale topological cues on network mechanics: area, first and second moment of inertia. **A)** Change of mean cell area due to the 0-30% strain transition for the three groups modeled. First **B)** and second moment **C)** reduction at 30% strain.