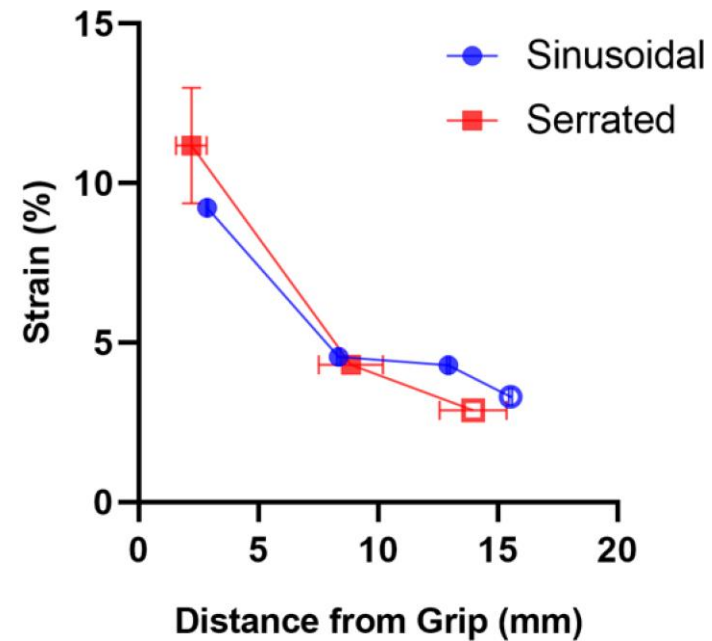
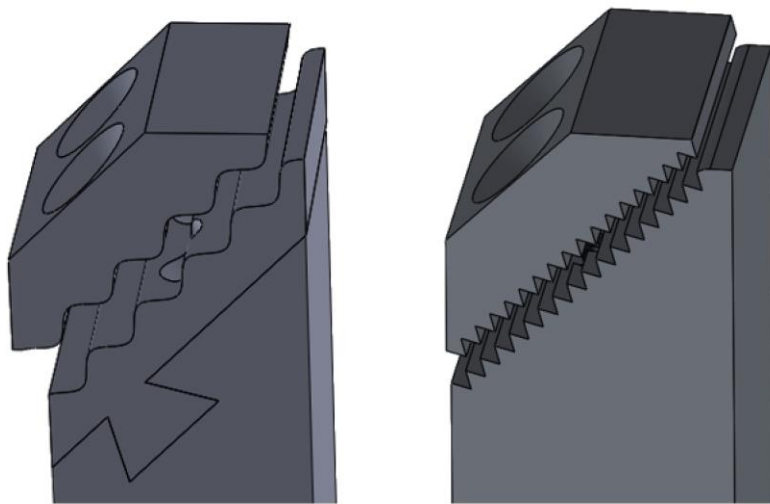
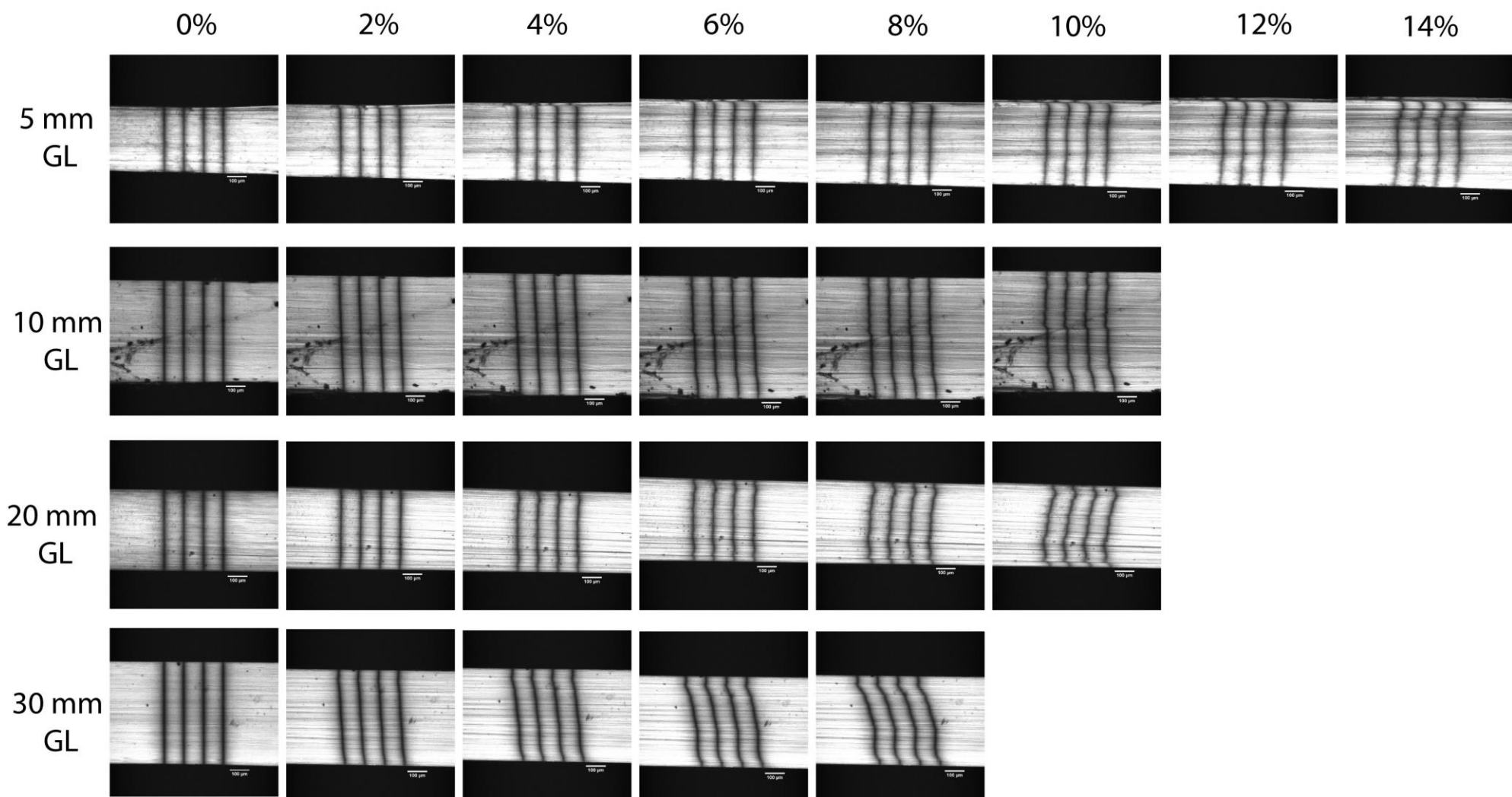


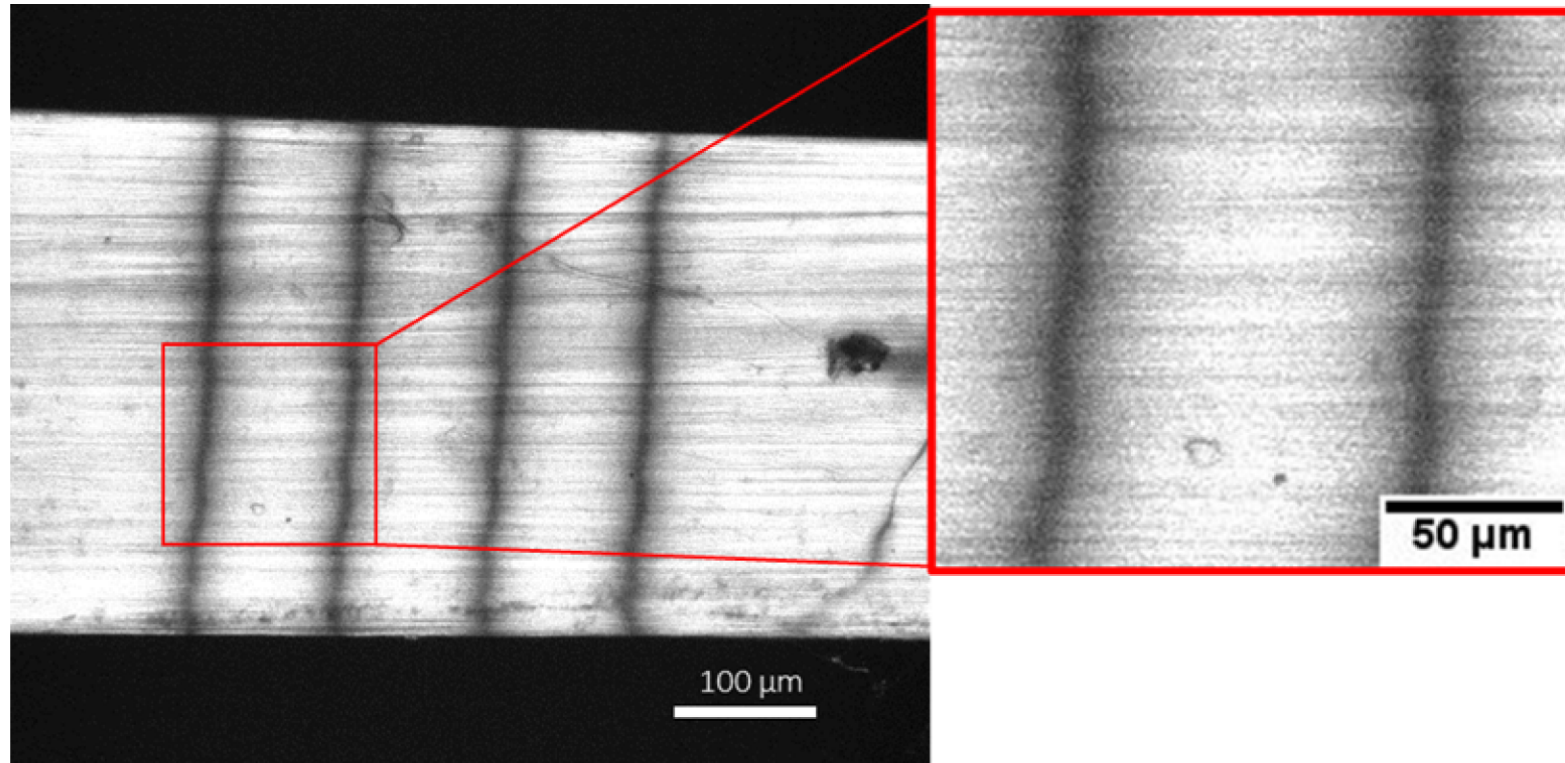
**Supplementary Figure 1:** Averaged stress versus time curves for each gauge length condition with the upper and lower standard deviations depicted by lighter colors. The strain increments used to determine the equilibrium modulus for each gauge length were as follows: 30 mm (first increment), 20 mm (first increment), 10 mm (first and second increments), 5 mm (first, second, and third increments).



**Supplementary Figure 2:** Strain heterogeneity along tissue length at 6% grip-to-grip strain for a 30 mm gauge length (GL) sample utilizing different grip types (sinusoidal and serrated). Both samples, regardless of the grip type used, exhibited a similar strain gradient from the grip interface towards the sample center. Macroscale tissue strains calculated using the  $\pm 1.25$  mm PBL sets (unfilled data points) are comparable and not unique to the gripping technique utilized in our setup.



**Supplementary Figure 3:** Representational images of the photobleached line for each gauge length at various grip-to-grip strains. Scale bar = 100  $\mu\text{m}$ .



**Supplementary Figure 4:** Representative image of the photobleached lines for the 5 mm gauge length samples at 8% grip-to-grip strain. Note that the photobleached lines are continuous down to the individual pixel, suggesting that the measured strains are representative of the fibrils and not fibril bundles (i.e., fibers).