Evaluating the influence of nano-topography and substrate stiffening in cell differentiation.

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Cells are profoundly influenced by their microenvironment, with the extracellular matrix (ECM) nanoscale attributes playing a crucial role in regulating cellular behavior. Nano-topography, encompassing surface features at the nanoscale level, has emerged as a key determinant in cellular activities. The intricate interplay between cells and their surroundings, including cell-ECM interactions, is increasingly being recognized as pivotal in tissue development and engineering. Here we demonstrate the development of a biomaterial comprising a layer of nanofibers within a hydrogel matrix to investigate the synergistic effects of nanotopography and substrate stiffening on cell differentiation. The synthesis involved fabricating magneto-responsive gelatin nanofibers via electrospinning, incorporating iron oxide nanoparticles, and crosslinking through heat treatment. The inclusion of magnetic nanoparticles facilitated substrate stiffening through an applied magnetic field during cell culture. Our results demonstrate that magnetic actuation-induced alterations in nano-topography and stiffness significantly influence adipose derived stem cells (ADSC) osteogenic differentiation, as well as myogenic differentiation of C2C12s. Moreover, nanofiber coated hydrogel samples without magnetic actuation exhibit a greater propensity for ADSC differentiation towards the adipogenic lineage than typical soft hydrogels. This approach holds promise for tissue engineering and regenerative medicine, offering a cost-effective and efficient alternative to traditional supplementation methods. By harnessing biophysical cues at the biomaterial interface, we pave the way for innovative strategies in cell differentiation and tissue regeneration.