Biophysical properties of stem cells

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1. Introduction: Stem cells are defined by their **potential to self-renew** and to differentiate into many different cell types. These cells play fundamental rule in development of tissue engineering and regenerative medicine. Normally, **stem cells are in contact to** a specialized **microenvironment**, which include of signalling factors, cell-cell contacts, stem cell niche supporting cells, and extracellular matrix (ECM). Therefore, biophysical studies on the **extra cellular matrix**, membrane capacitance, migration, and **differentiation** is crucial for dynamic regulation of stem cell.

2. Methods: The biophysical features of stem cells were investigated by several techniques including **dielectrophoresis (DEP), confocal microscopy,** ultra-high voltage electron microscopy and **Microcontact printing**. The study was focused on biophysical **differentiation potential of neural stem cells** and shear stresses of **osteocyte ECM structures**.

3. Results and Discussion: It was observed that substrate stiffness and **ECM composition** have **essential role** in cell proliferation, spreading, migration and even **stem cell differentiation**.

4. Conclusion: Biophysical characteristics of stem cell provide a completely novel and quantitative measure of stem cell fate potential to identify different type of stem cells. It is obvious that the **extracellular microenvironment**, or niche, is **complex**. So, further studies are needed to confirm both direct and indirect mechanisms of biophysical regulation within the in vivo system of stem cell niche.

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Fig 1. Molecular ECM based interaction in stem cell adhesion

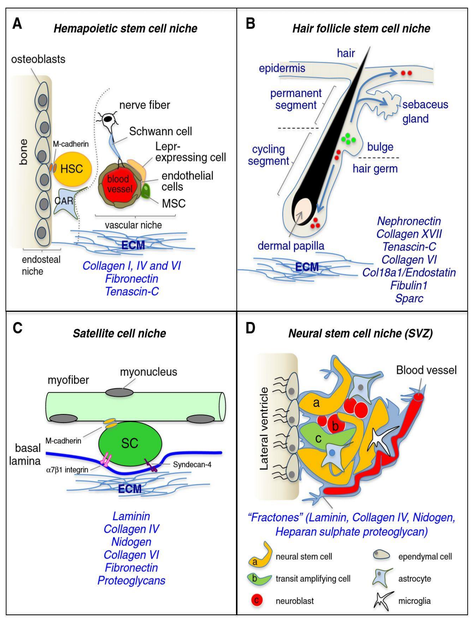

Fig 2. Effect of ECM on stem cell adhesion (2D and 3D culture)

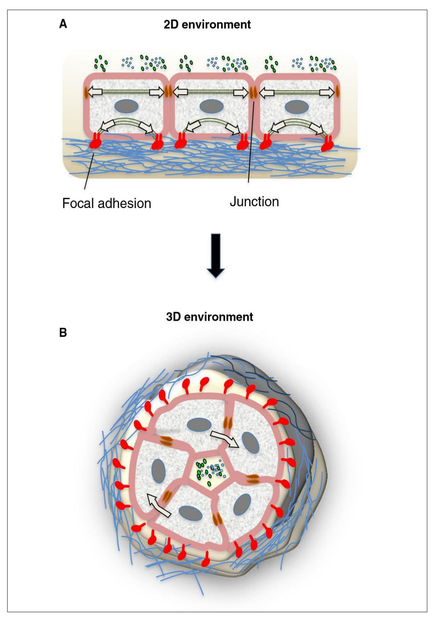

Fig 3. Effects of stretched membrane stiffness on NSPC differentiation

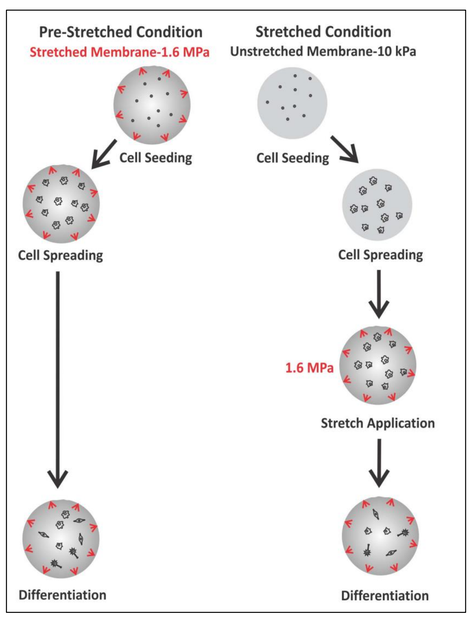

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Fig 4. Confocal microscopy

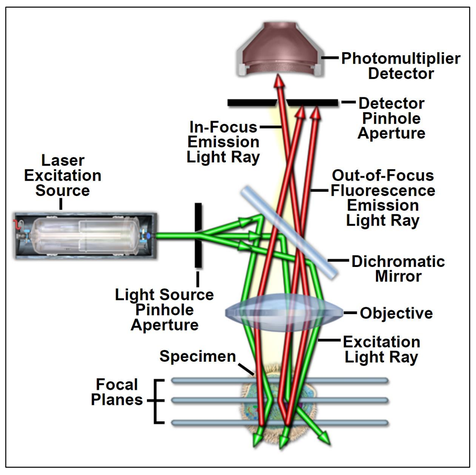

Fig 5. Dielectrophoresis of the cell

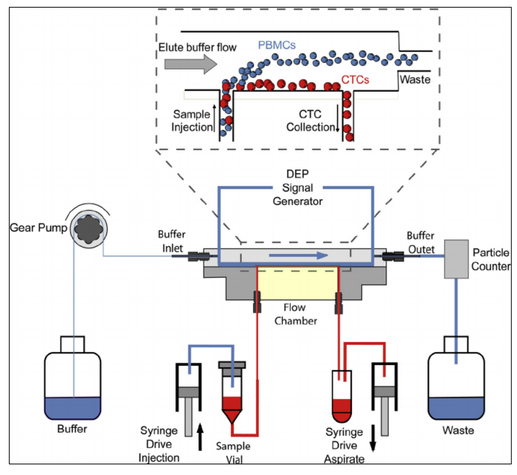

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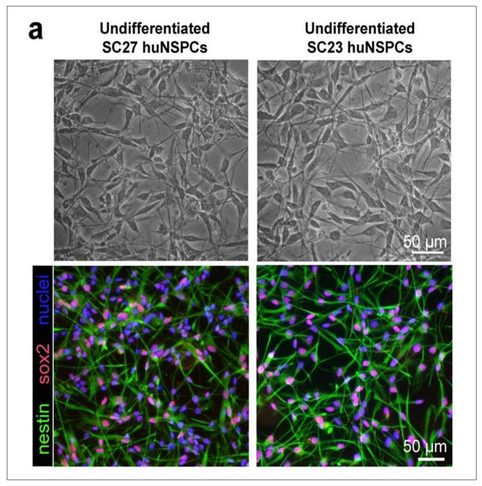
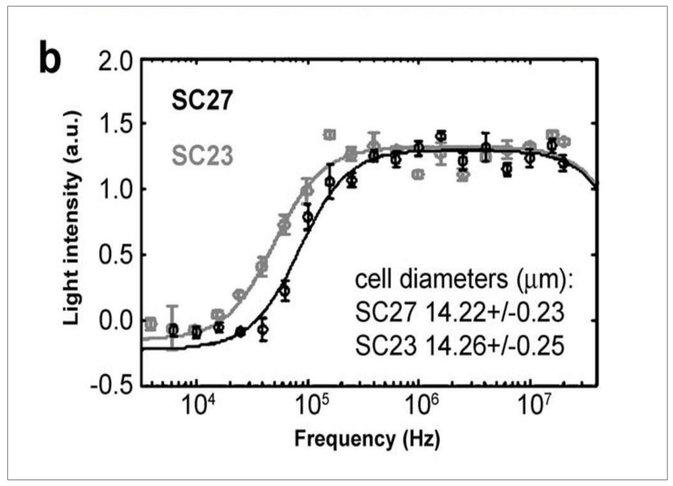
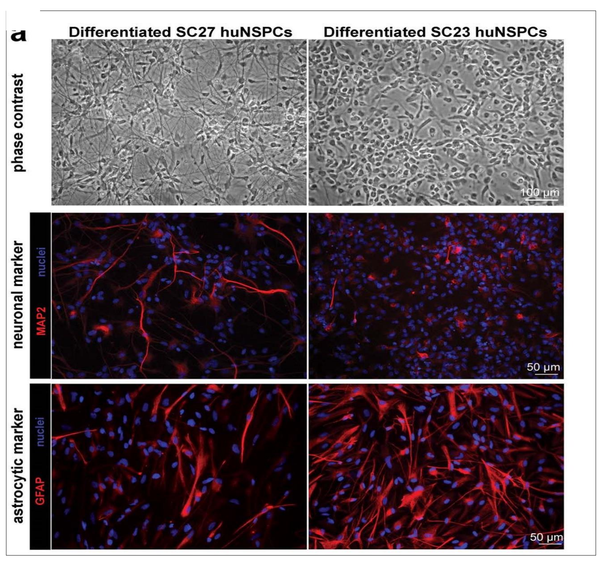
Fig 6. Biophysical basis of undifferentiated stem cell





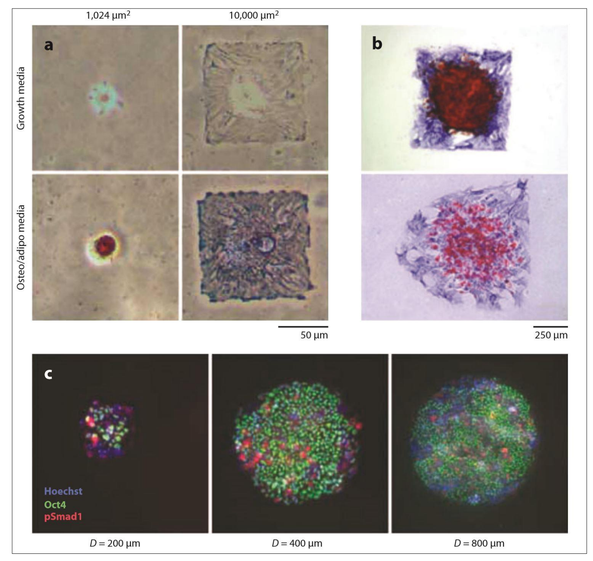
Unique sets of undifferentiated huNSPCs that are similar in morphology. The undifferentiated NSPCs were in suspension when assessed by DEP to determine electrophysiological properties and there was no significant difference in the diameters of SC27 and SC23 cells in suspension

Fig 7. Biophysical basis of stem cell differentiation



Differentiated SC27 (left panels) and SC23 (right panels) Human Neural Stem/progenitor cell (huNSPCs) are shown by phase contrast microscopy (top panels) and immunostaining for the neuronal marker MAP2 (middle panels, all cell nuclei stained blue) or the astrocytic marker GFAP (bottom panels, all cell nuclei stained blue). huNSPCs differ in neurogenic and gliogenic potential. In comparison to SC23 huNSPCs, SC27 cells generated numerous cells with compact and rotund cell bodies and extensive processes, which resembled neurons by phase contrast microscopy.

Fig 8. Biophysical basis of stem cell adhesion on ECM



Microcontact printing to manipulate the cell shape and colony size of stem cells to control their fate. (a) Brightfield micrographs of single hMSCs plated on different sized adhesive ECM islands. (b) Brightfield micrographs of different shaped multicellular hMSC colonies. (c) Immunofluorescent images showing different sized hESC colonies (H9). Thus, the effect of colony size on the pluripotency maintenance of hESCs appears to be mediated by interactions between exogenously controlled parameters and autocrine and paracrine secretion of endogenously produced factors from hESCs.

Reference:

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