Journal of Biotechnology & Biomaterials
ISSN: 2155-952X

Katti, J Biotechnol Biomater 2013, 3:3
DOI: 10.4172/2155-952X.1000e121

Editorial Open Access

Use of Adult Stem Cells in Biomaterials Research

Kalpana S Katti*

Department of Civil Engineering, North Dakota State University, Fargo ND, USA

All mature cells in the human body originate from stem cells. Stem cells are generally defined as cells that can renew themselves in addition to possessing potential to differentiate in one or multiple lineages. Current studies indicate great possibilities for use of both embryonic as well as adult stem cells in regenerative medicine. The more easily available adult stem cells, especially mesenchymal stem cells have led to extensive application of their use in a variety of topics in regenerative medicine. The self-renewal characteristic of MSCs occurs through symmetric and asymmetric cell divisions [1]. Specific criteria are laid out by the International Society for Cellular Therapy for the identification of MSCs [2]. The potential for use of stem cells in regenerative medicine is tremendous and progress in recent years suggests an advent of transformational improvement in regenerative medicine capabilities through engineering design of stem cell use in comparison to transplant technologies. The use of stem cells opens many challenges that are of clinical, scientific and ethical nature. Adult stem cells are being extensively studied for application in replacement of tissues. Human Mesenchymal Stem Cells (hMSCs) derived from the bone marrow are adult stem cells that are easily available and are used in tissue generation including tissue engineering methodologies. Tissue engineering, a field pioneered by Langer and Vacanti [3] utilizes 3D porous structures called scaffolds that are seeded with human cells. These scaffolds are provided appropriate growth factors and life-like conditions often inside bioreactors. The materials of the scaffold degrade as the seeded cells grow and proliferate (and differentiate) and make new tissue. Many advances have been reported recently, in all areas of the scaffold design and fabrications [4], materials design of scaffold [5], parameters of bioreactors such as flow rates of media as well as the choice of growth factors and their delivery methods. Rapid prototyping techniques show much promise in development of custom designed tissues and organs [6,7]. The role of porosity (sizes and connectivities) in scaffolds in appropriate differentiation, proliferation and eventual role on vasculature formation is also an important design parameter [8]. Nanominerals such as hydroxyapatite in combination with various synthetic [9,10] and biobased polymers [11-13] are extensively investigated as materials for scaffolds. Efforts in experimental investigation of degradation of these composites in their solid and scaffold forms are extensive. Recently, nanoclays have been demonstrated as a potential new material system for scaffolds in tissue engineering [14,15]. For MSCs applications in tissue engineering, the MSCs cells seeded on the scaffolds need to adhere to the scaffold materials and also easily migrate to the interior regions of the macroscopic scaffold. The role of integrins and focal adhesions of the cells are significant in the adhesion and migration of the cells. Integrins are the most important receptors responsible for cellular adhesion processes with the extracellular matrix as well as with other cells. It is paramount that the materials used in tissue engineering, and the nano-micro-meso structure of the scaffold provides an environment that is conducive to cell-scaffold adhesion. The mechanism of the integrin activity is through binding to a range of ligands on the cell surface and the extracellular matrix [16]. This binding enables the receptors ability for signal transport between inside of the cell and outside.

Further advantage of use of MSCs involves their ability to avoid allogenic rejection in humans and animals [17]. Problems associated with immune rejection are avoided with use of MSCs due to the immunomodulatory effects of MSCs in tissue engineering. Currently, during *in vitro* expansion of MSCs an important issue encountered is senescence resulting in permanent arrest of cell division due to a permanent growth arrest phase during the cell cycle [18]. On some occasions, loss of multipotentiality is also observed in the MSCs. The controlled and effective *in vitro* expansion of MSCs remains an important area of research that needs to be pursued for extensive applications of MSCs in tissue engineering. In addition both electrical and mechanical stimuli are potentially useful for influencing behavior of MSCs and their use in tissue engineering [19-21].

One area of research that is most promising and currently least developed is *in silico* design of biomaterials as well as scaffold design. Although much work has been done on use of finite element and other continuum based approaches to model scaffold characteristics [22,23], degradation of the scaffold-cell constructs over time is not well understood and investigated. Scaffold degradation behavior is primarily modeled through existing degradation models of polymers, while the nanocomposite scaffold materials exhibit degradation mechanisms, fairly different from those of pristine polymers. Further, extensive molecular models of materials of scaffolds present a significant design parameter that would require extensive studies in multiscale modeling to develop robust predictive capabilities of scaffolds over the time scale of degradation and cellular attachment, migration, proliferation and differentiation. In addition, computational approaches that enable predictive capability to scaffold degradation as well computational materials science [24,25] for design of nanocomposite scaffolds has shown much promise.

The vast and extensive literature on use of hMSCs in tissue engineering has certainly led to high expectations on the potential of use of hMSCs in tissue engineering primarily due to large numbers of successes in achievement of vasculature, enhanced differentiation capabilities etc. reported. Fundamental cell biology studies in behavior of hMSCs their interaction with engineered materials are still a challenge. Additionally advanced characterization tools that enable characterization of the living-nonliving interface *in situ*, such as nano mechanical characterization and scanning probe microscopy appear promising based on a few recent studies [26]. The promise of successful clinical possibilities in this area is a real possibility. Multiscale computational studies as well as fundamental cell biology studies are key to fulfillment of the promise. Advances in materials design and manufacturing techniques aided by the above two factors, is likely to revolutionize and increase exponentially the use of stem cells for regenerative medicine in the coming decades.

***Corresponding author:** Kalpana S Katti, Department of Civil Engineering, North Dakota State University, Fargo ND, USA, E-mail: Kapana.Katti@Ndsu.Edu

Received August 01, 2013; **Accepted** August 03, 2013; **Published** August 06, 2013

Citation: Katti KS (2013) Use of Adult Stem Cells in Biomaterials Research. J Biotechnol Biomater 3: e121. doi:10.4172/2155-952X.1000e121

References

1. Morrison SJ, Kimble J (2006) Asymmetric and symmetric stem-cell divisions in development and cancer. Nature 441: 1068-1074.
2. Kuhn NZ, Tuan RS (2010) Regulation of stemness and stem cell niche of mesenchymal stem cells: implications in tumorigenesis and metastasis. J Cell Physiol 222: 268-77.
3. Langer R, Vacanti JP (1993) Tissue engineering. Science 260: 920-926.
4. Katti KS, Katti DR, Ambre AH (2010) Use of unnatural amino acids for design of novel organo modified clays as components of nanocomposite biomaterials. Philos Trans A Math Phys Eng Sci Germany 368:1963-1980.
5. Hutmacher DW (2000) Scaffolds in tissue engineering bone and cartilage Biomaterials 21: 2529-2543.
6. Peltola SM, Melchels FP, Grijpma DW, Kellomaki M (2008) A review of rapid prototyping techniques for tissue engineering purposes. Ann Med 40: 268-280.
7. He CL, Tang ZH, Tian HY, Chen XS (2013) Acta Polymerica Sinica:722.
8. Karageorgiou V, Kaplan D (2005) Porosity of 3D biomaterial scaffolds and osteogenesis. Biomaterials 26:5474-91.
9. Lutolf MP, Hubbell JA (2005) Synthetic biomaterials as instructive extracellular microenvironments for morphogenesis in tissue engineering. Nat Biotechnol 23: 47-55.
10. Nair LS, Laurencin CT (2007) Progress in Polymer Science 32: 762.
11. Burg KJL, Porter S, Kellam JF (2000) Biomaterial developments for bone tissue engineering. Biomaterials 21: 2347.
12. Place ES, Evans ND, Stevens MM (2009) Complexity in biomaterials for tissue engineering. Nat Mater 8: 457-470.
13. Jayakumar R, Prabaharan M, Nair SV, Tamura H (2010) Novel chitin and chitosan nanofibers in biomedical applications. Biotechnol Adv 28: 142-150.
14. Ambre AH, Katti DR, Katti KS (2013) Nanoclays mediate stem cell differentiation and mineralized ECM formation on biopolymer scaffolds. J Biomed Mater Res 101: 2644-2660.
15. Ambre A, Katti KS, Katti DR (2011) Materials Science & Engineering C-Materials for Biological Applications 31:1017-10.
16. Docheva D, Popov C, Mutschler W, Schieker M (2007) Human mesenchymal stem cells in contact with their environment: surface characteristics and the integrin system Journal of Cellular and Molecular Medicine 11: 21-38.
17. Vaananen H. Annals of Medicine 37: 469.
18. Sethe S, Scutt A, Stolzing A (2005) Ageing Research Reviews 5: 91-116.
19. Kurpinski K, Chu J, Hashi C, Li S(2006) Anisotropic mechanosensing by mesenchymal stem cells Proc Natl Acad Sci U S A 103: 16095-16100.
20. Friedl G, Schmidt H, Rehak I, Kostner G, Schauenstein K, Windhager R (2007) Undifferentiated human mesenchymal stem cells (hMSCs) are highly sensitive to mechanical strain: transcriptionally controlled early osteo-chondrogenic response in vitro. Osteoarthritis Cartilage 15: 1293-1300.
21. Park JS, Chu JSF, Cheng C, Chen FQ, Chen D, Li S (2004) Biotechnology and Bioengineering 88: 359.
22. Lacroix D, Planell JA, Prendergast PJ (2009) Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences 367: 1993.
23. Sandino C, Planell JA, Lacroix D (2008) Journal of Biomechanics 41: 1005.
24. Bhowmik R, Katti KS, Katti DR (2009) Molecular interactions of degradable and non-degradable polymers with hydroxyapatite influence mechanics of polymer-hydroxyapatite nanocomposite biomaterials.
25. Bhowmik R, Katti KS, Katti DR (2008) Influence of Mineral on the Load Deformation Behavior of Polymer in Hydroxyapatite-Polyacrylic Acid Nanocomposite Biomaterials: A Steered Molecular Dynamics Study. J Nanosci Nanotechnol 8: 2075-2084.
26. Khanna R, Katti DR, Katti KS (2012) Cmes-Computer Modeling in Engineering & Sciences 87: 530.