

Stem Cells: The Hidden Healers

Raksha Thakur¹, Ravindranath Achari C.², H V Kambalimath³, Amit Kumar Sahu⁴, Raju Umaji⁵, Milind Atulkar⁵

1,2,3,4-Dept of Paedodontics and preventive dentistry, RCDS & RC, Bhopal (M.P.). 5-Dept of Paedodontics and preventive dentistry, Sinhgad dental college, Pune(Maharashtra). 6-Dept of Paedodontics and preventive dentistry, Swargiya Dadasaheb Kalmegh Smruti Dental College, Nagpur (Maharashtra).

Correspondence to:
Dr. Amit Kumar Sahu, A-22, Suvaidh Vihar Colony,
Airport Road, Bhopal (M.P.).
Contact Us: www.ijohmr.com

ABSTRACT

Stem cells have the special property of self-renewable through asymmetric cell division and capability of differentiating into the different type of cells. This special property and capability make them a very useful tool in regenerative medicine. The disease often leads to loss of function due to loss of tissue which can be rehabilitated with the use of tissue engineering and stem cell-based tooth regeneration. Studies have shown the promising results of stem cells in tooth and tissue regeneration. The field is further revolutionized by the discovery of induced pluripotent stem (iPS) cells in regenerative medicine (dentistry) through which autologous transplantation is possible. In this article, we reviewed the general outline and classification of stem cell-based tooth regeneration and discussed the properties of iPS cells for regenerative medicine.

KEYWORDS: Stem Cell, Regenerative Medicine, Tissue Engineering

INTRODUCTION

Stem cells are a heterogeneous variety of undifferentiated cells that have capacity self-renewal and to differentiate into mature specialized cells. (multilineage differentiation)^{1,2,3} Through asymmetric mitosis they divide themselves rapidly and continuously and to create renewed mother stem cell and new daughter stem cells.^{4,5,6,7,8,9} Cellular morphology comprises low ratio cytoplasm/nucleus dimension, i.e. a sign of synthetic activity expression of several markers including alkaline phosphatase.^{8, 10-14}

HISTORY

The concept of stem cells originated at the end of the 19th century and Credit goes to Russian scientist Alexander Maksimov who proposed the term stem cell in 1909. He was first to discuss the presence of hematopoietic stem cells that have the ability to migrate through blood to a different niche where they can proliferate and differentiate into various specialized cells. Morphologically, they resemble lymphocytes.¹⁵

SOURCE

Postnatal stem cells can be derived from many tissues. According to Indian Council of Medical Research Guidelines & Regulatory Framework on Stem Cell Banking & Application, the various sources for different stem cells are :-

Bone marrow (Castro-Malaspina et al., 1980; Civin et al., 1984),¹⁶ Adipose tissue, Neural tissues (Johansson et al., 1999),¹⁶ Cord blood, Placenta/AF, Cartilage 17, Muscle (Chen and Goldhamer, 2003; Huard et al., 2003)²², Skin (Lavker and Sun, 2003), Liver.¹⁶

More specifically in relation to tooth, stem cells can be derived from Dental Pulp - permanent(DPSC) & deciduous(SHED) (Gronthos et al., 2000, 2002; Miura et al. 2003; Seo et al., 2004; Akintoye et al., 2006)^{16,17}, Apical Papilla (SCAP), Periodontal ligament(PDLSC), Dental follicle progenitor cells.(DFPC)¹⁸

STEM CELL CLASSIFICATION

Stem cells have been classified based upon the following:-

a) Based on their ability and potency to differentiate (Table 1):-^{18,19}

Totipotent stem cells	Pluripotent stem cells	Multipotent stem cells
-Early embryos up to the eight-cell stage of the morula -Each cell has the capability of developing into an entire organism E.g. Identical twins.	-Undifferentiated cell mass (inner) of the blastocyst with capacity of formation of tissues of all embryonic germ layers, i.e. endoderm, mesoderm, and ectoderm Eg. Embryonic stem cells etc.	- Cord blood stem and adult stem cells. - Differentiation- more limited than pluripotent stem cells. E.g. -adult stem cells from different sources like bone marrow, Liver, Dental pulp stem cells, SHED etc

Table 1: Stem cells as per their ability to differentiate

How to cite this article:

Thakur R, Ravindranath AC, Kambalimath HV, Sahu AK, Umaji R, Atulkar M. Stem Cells-The Hidden Healers. Int J Oral Health Med Res 2017;4(1):100-102.

b) On the basis of sources of stem cells (Table 2):-¹⁹

Embryonic stem cells	Cell mass (inner) of the blastocysts, Pluripotent, give rise to all derivatives of three primary germ layers, that is, ectoderm, endoderm, and mesoderm. ³⁰ but they are unable to form extra embryonic membrane or placenta. Most important & potential use of these embryonic stem cells (ESC) are in the field of rehabilitation (transplantation medicine) where they are used for replacement therapies. Treatment of paralysis from a spinal cord injury and diseases of the eye have been reported.
Fetal stem cells	They are taken from the germ line tissues that will make up the gonads of aborted fetuses.
Umbilical cord stem cells	These are present in Umbilical cord blood, which are identical to cells found in bone marrow.
Placenta-derived stem cells	It is a source of numerous stem cells (Ten times as compared to cord blood).
Adult stem cells-	-Many adult tissues contains different stem cells that can be isolated. ²⁰ Multipotent, Not subjected to an ethical controversy that is associated with ESC.
Bone marrow-derived	-Pioneer success in stem cell therapies are achieved by bone marrow transplants.. today source of cells is from peripheral blood instead of bone marrow aspiration.
Adipose-derived	-These are derived from human fat, through the method of liposuction.
Dental stem cells	-Ease of accessibility makes them most accessible cells. These are present in healthy teeth dental pulp both in deciduous and permanent dentition, the tissue surrounding the tooth like periodontal ligament, apical region of developing teeth, and dental follicle. These cells have their derivation probably from a common lineage of neural crest cells.
Induced pluripotent cells (iPS)	Adult or somatic stem cells that have been genetically reprogrammed to behave like ESC. For gene expression, techniques like cell transfection via electroporation, lipid-mediated delivery or biolistics particle delivery, as well as cell transduction through viral mediated gene delivery are used. ²¹ Other methods like Transfection and nucleofection with an enhanced green fluorescence protein (eGFP) are also have been tried in the laboratory using plasmids. ^{21,22}

Table 2: Sources of Stem Cells

CONCLUSION

Stem cells act as a promising source of tissue for regenerative and tissue-engineering. This led to an upgraded version as compared to a traditional treatment option for replacement of diseased and mutilated tissue. However, field is lacking definite results which require extensive and explorative studies to prove its potential and this will be definitively a success in near future

REFERENCES

- Herberts CA, Kwa MSG, Hermsen HPH. Risk factors in the development of stem cell Therapy. *Journal of Translational Medicine* 2011, 9:29:1-14.
- Otsu K, Kumakami-Sakano M, Fujiwara N, Kikuchi K, Keller L, Harada H. Stem cell sources for tooth regeneration: current status and future prospects. *Frontiers in physiology*. Feb 2014;5(36):1-10
- Telles PD, Machado M, Sakai VT, Nör JE. Pulp tissue from primary teeth: new source of stem cells. *J Appl Oral Sci* 2011;19(3):189-194.
- Sloan AJ, Waddington RJ. Dental pulp stem cells: what, where, how? *Int. J. Paediatr. Dent.* 2009;19: 61-70.
- Doe CQ: Neural stem cells: balancing self-renewal with differentiation. *Development* 2008, 135(9):1575-1587.
- Knoblich JA: Mechanisms of asymmetric stem cell division. *Cell* 2008, 132(4):583-597.
- Zhong W, Chia W: Neurogenesis and asymmetric cell division. *Curr Opin Neurobiol* 2008, 18(1):4-11.
- Lodi D, Iannitti T, Palmieri B. Stem cells in clinical practice: applications and warnings. *Journal of Experimental & Clinical Cancer Research* 2011, 30:9:1-20.
- Mao JJ, Giannobile WV, Helms JA, Hollister SJ, Krebsbach PH, Longaker MT, Shi S. Craniofacial tissue engineering by stem cells. *J Dent Res.* 2006;85(11): 966-79.
- Pittenger MF, Mackay AM, Beck SC, Jaiswal RK, Douglas R, Mosca JD, Moorman MA, Simonetti DW, Craig S, Marshak DR: Multilineage potential of adult human mesenchymal stem cells. *Science* 1999, 284(5411):143-147.
- Baksh D, Song L, Tuan RS: Adult mesenchymal stem cells: characterization, differentiation, and application in cell and gene therapy. *J Cell Mol Med* 2004, 8(3):301-316.
- Barry FP, Murphy JM: Mesenchymal stem cells: clinical applications and biological characterization. *Int J Biochem Cell Biol* 2004, 36(4):568-584.
- Thomson JA, Itskovitz-Eldor J, Shapiro SS, Waknitz MA, Swiergiel JJ, Marshall VS, Jones JM: Embryonic stem cell lines derived from human blastocysts. *Science* 1998, 282(5391):1145-1147.
- Baharvand H, Ashtiani SK, Valojerdi MR, Shahverdi A, Tae A, Sabour D: Establishment and in vitro differentiation of a new embryonic stem cell line from human blastocyst. *Differentiation* 2004, 72(5):224-229.
- Kabir R, Gupta M, Aggarwal A, Sharma D, Sarin A, Kola MZ. Imperative Role of Dental Pulp Stem Cells in Regenerative Therapies: A Systematic Review.
- Sanchez-Lara PA, Zhao H, Bajpai R, Abdelhamid AI, Warburton D. Impact of stem cells in craniofacial regenerative medicine. *Frontiers in physiology* June 2012; 3: 1-10
- Alipour R, Adib M, Karimi MM, Hashemi- Beni B,

- Sereshki N. Comparing the Immunoregulatory Effects of Stem Cells from Human Exfoliated Deciduous Teeth and Bone Marrow-derived Mesenchymal Stem Cells. *Iran J Allergy Asthma Immunol* December 2013; 12(4):331-344
18. Petrovic V, Stefanovic V. Dental Tissue – New Source for Stem Cells. *The Scientific World Journal* 2009; 9: 1167–1177.
 19. Rai S, Kaur M, Kaur S. Applications of Stem Cells in Interdisciplinary Dentistry and Beyond: An Overview. *Annals of Medical and Health Sciences Research* Apr-Jun 2013; 3(2):245-54.
 20. Barbosa DD. Stem cells, their niches and the systemic environment: an aging network. *Genetics*. 2008;180:1787.
 21. Feng R, Lengner C. Application of stem cell technology in dental regenerative medicine. *Advances in wound care* 2013; 2(6):296-305.
 22. Volponi AA, Pang Y, Sharpe PT. Stem cell-based biological tooth repair and regeneration. *Trends Cell Biol.* Dec 2010; 20(12):715–722.

Source of Support: Nil
Conflict of Interest: Nil