Stem Cells: The Next Innovative Technology in Dentistry

Angela Marotta and Denisse Mazariego
Farmingdale State College

Farmingdale State College
State University of New York

What are Stem Cells?

Stem cells can be classified into four broad types based on their origin: stem cells from embryos, stem cells from the fetus, stem cells from the umbilical cord, and stem cells from the adult. The term "Stem cell" was founded by William Sedgwick back in the late 1800 while he was researching the regenerative properties of plants. And since the first discovery many years ago, studies have been conducted with stem cells, and researchers have been working to address both oral and systemic health problems with their use.

When regular cells replicate, they create more of their own type of cell. For instance, when a bone cell replicates it can only make more of the same bone cells. On the other hand, when stem cells replicate, they can become either bone cells, or muscle cells, or brain cells, etc. They can differentiate and become any type of cell in the human body. That is why stem cells are unique. No other cell in the body has the natural ability to generate new cell types. With this ability, stem cells can be used for regeneration in any area of the body that has been damaged, including the oral cavity.

Researchers are now examining dental stem cells retrieved from dental tissues and the role they can potentially play in regenerative dentistry and other areas of the body. Dental stem cells would fall under the category of stem cells from the adult, and they come from several different regions of the periodontium and inside the tooth. Dental stem cells use is relatively new and has emerged as a promising new approach for therapeutic purposes to treat dental and non-dental diseases.

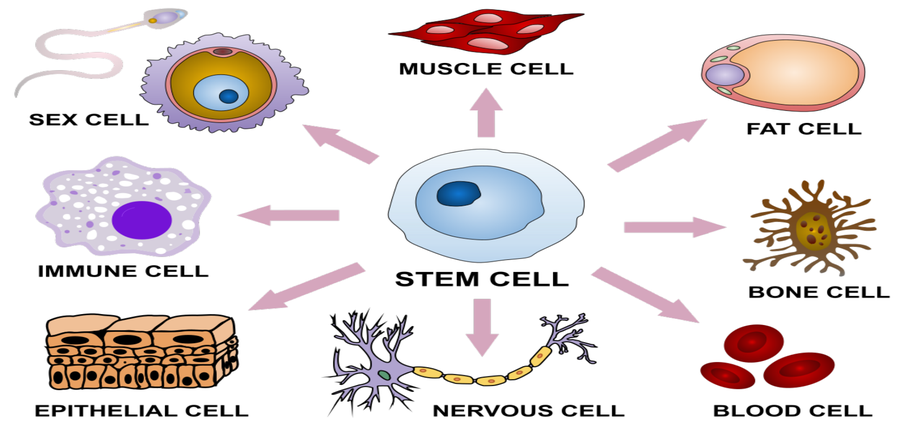


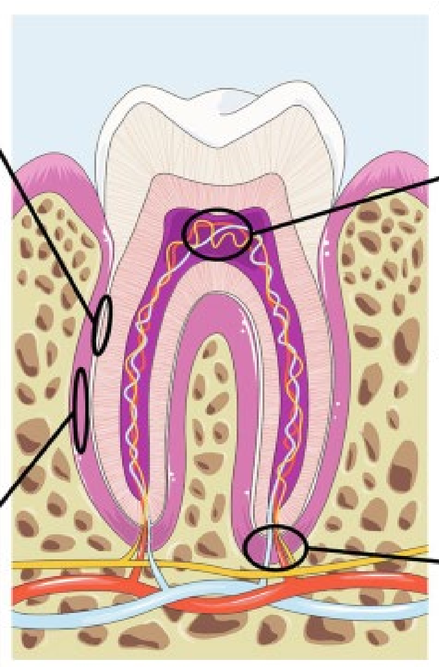
Figure 3

Dental Follicle Stem Cells (DFSCs)

Staminal Markers	Cell Surface Markers	Neural Markers
OCT4	CD44/CD90	Nestin
SOX2	HLA-ABC	β-III-tubulin
	Stro-1	p75
		GFAP

Peridontal Ligament Stem cells (PDLSCs)

Staminal Markers	Cell Surface Markers	Neural Markers
OCT3/4	CD105	NG2
NANOG	CD90	
SSEA4	CD73	
	CD146	
	Stro-1	
	CD44	



Dental Pulp (DPSCs & SHED)

Staminal Markers	Cell Surface Markers	Neural Markers
OCT3/4	CD13	Nestin
NANOG	CD29	β-III-tubulin
SSEA4	CD44	Synaptophysin
	CD146	S100
	TNF receptor superfamily	GFAP
	IL-receptors	

Stem Cells from Apical Papilla (SCAP)

Staminal Markers	Cell Surface Markers	Neural Markers
OCT3/4	Stro-1	Nestin
NANOG	CD146	GFAP
SSEA4	CD24	

Figure 1

Types of Dental Stem Cells

- **SHED**- Stem Cells from Exfoliated Deciduous Teeth
  Potential cell sources in clinical applications such as dental regeneration, bone regeneration, intractable pediatric surgical diseases, liver failure, neural regeneration, and the revascularization for therapeutic applications (Lei, T., Zhang, X., & Du, H, 2021, p. 4).
- **PDLCs**- Periodontal Ligament Cells
  Natural periodontal regeneration material in orthodontic tooth movement (Lei, T., Zhang, X., & Du, H, 2021, p. 4).
- **DFCs**- Dental Follicle Cells
  Demonstrate the ability to differentiate multiple lineages, such as osteoblastic/cemento-blastic and neural lineages (Lei, T., Zhang, X., & Du, H, 2021, p. 5).
- **SCAP**- Stem Cells from the Apical Papilla
  Show immunosuppressive properties, which expand the application of SCAP in regeneration medicine, including immunotherapy and the reparation of multiple tissues (such as teeth, bone, nerve, and vascular tissue) (Lei, T., Zhang, X., & Du, H, 2021, p. 4).
- **DPSCs**- Dental Pulp Stem Cells
  Used for dentin regeneration, treatment of retinal degeneration, spinal cord injuries, Parkinson's disease, Alzheimer's disease, cerebral ischemia, myocardial infarction, muscular dystrophy, diabetes, and immune diseases (Lei, T., Zhang, X., & Du, H, 2021, p. 1).
- **GMSCs**- Gingiva Derived Mesenchymal Cells
  Mesenchymal stem cells that reside in human gingival tissues. (Lei, T., Zhang, X., & Du, H, 2021, p. 5).
- **TGPCs**- Tooth Germ Progenitor Cells
  Differentiate into muscle, cartilage, fat, nerve, bone, and tooth, and it is an alternative material in regenerative medicine (Lei, T., Zhang, X., & Du, H, 2021, p. 5).
- **ABMSCs**- Alveolar Bone-Derived Mesenchymal Cells
  Viable cell source for treating inflammation. (Lei, T., Zhang, X., & Du, H, 2021, p. 5).

Clinical Applications

Dental Stem Cell Uses in the oral cavity:

- Dental Pulp Regeneration
- Periodontal Disease
- Root Canal Therapy
- Endodontic Disease
- Alveolar Bone Atrophy
- Whole Tooth Regeneration

Dental Stem Cell Potential to Treat Non-Dental Related Diseases:

- Bone Defects
- Neural and Skin injuries
- Parkinson's Disease
- Ischemia
- Alzheimer's Disease
- Myocardial Infarction
- Muscular Dystrophy

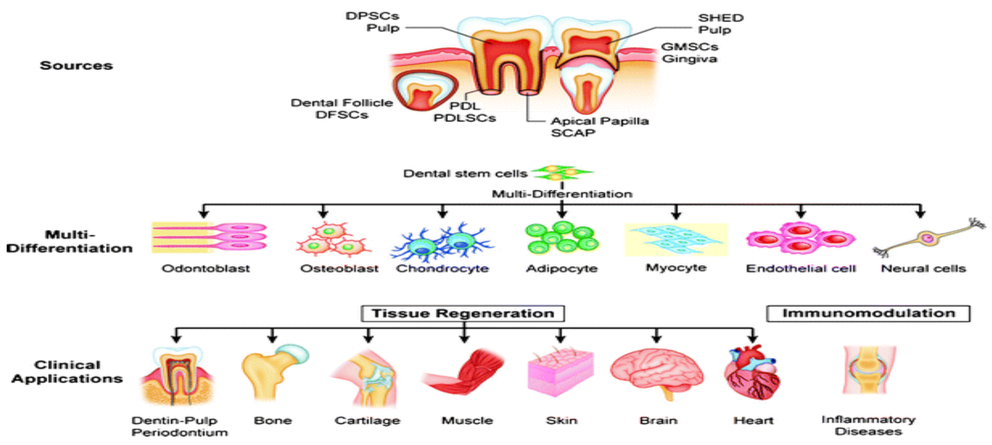


Figure 2

Advantages

- Dental stem cells have the ability to regenerate tissues in the oral cavity and tissues throughout the body (Majeski, J. 2009, p. 25).
- Patients will have the ability to freeze their own dental stem cells through cryopreservation and store them at a bank for future use.
- After cryopreservation, dental stem cells showed a high vitality and proliferation rate (Awais, S., Balouch, S. S., & Irum, S., 2021, p. 1).
- Using your own dental stem cells eliminates the risk for infection and the need for anti-rejection drugs (Majeski, J. 2009, p. 25).
- Dental stem cells are retrieved from adults therefore, they do not require the destruction of an embryo (Majeski, J. 2009, p. 25).
- Dental stem cells have the ability to replace damaged cells by proliferation.
- Dental stem cells could prove to be a valuable source in the treatment of several degenerative diseases such as Parkinson's disease, Alzheimer's disease, Myocardial Infarctions in addition to those that directly affect the oral cavity (Majeski, J. 2009, p. 25).
- Obtaining these cells is a relatively simple process. It can be done either by extracting deciduous or permanent teeth (Awais, S., Balouch, S. S., & Irum, S, 2021, p. 1).
- The tooth pulp is easily accessible for research purposes, whether it is dead or alive (Awais, S., Balouch, S. S., & Irum, S., 2021, p. 1).
- Patients can have access to their dental stem cells throughout the course of their lives (Awais, S., Balouch, S. S., & Irum, S., 2021, p. 1).

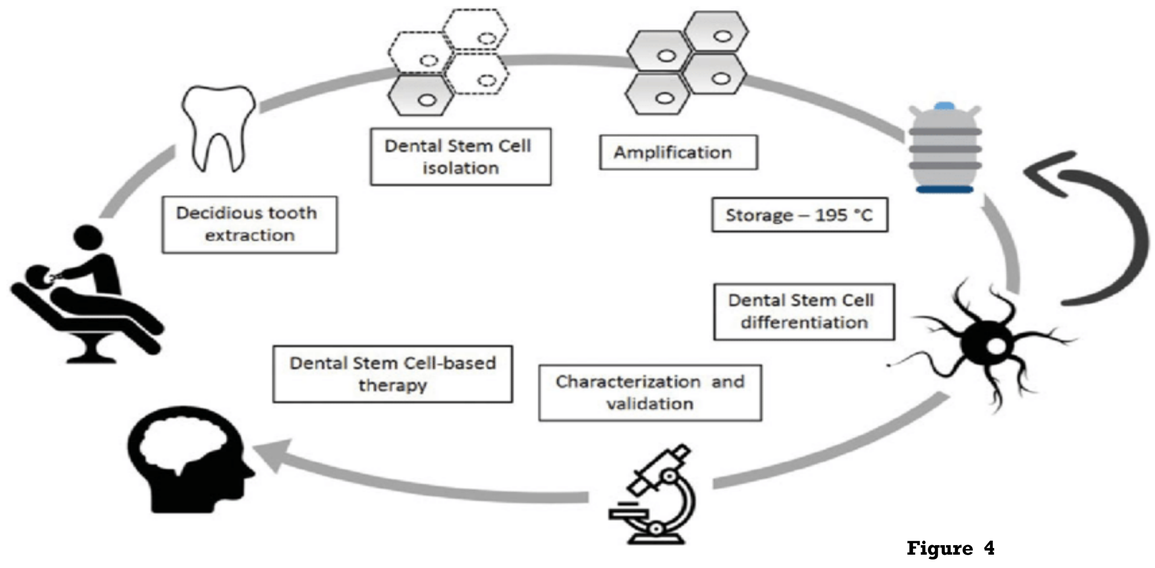


Figure 4

Looking to the Future

Many clinical trials are being conducted worldwide using dental stem cells. Outside of the U.S., several clinical trials have been completed. A study performed in Japan led to the formation of a fully developed tooth from dental stem cells in mice. The ability of the implant and bone to form an attachment was discovered by this clinical therapy (Majeski 2009, p. 26). Based on the results of the clinical trials that have already been performed, dental stem cells have shown exceptional capabilities. Research has indicated that pulp regeneration can be achieved, thus influencing the direction of endodontics in the near future (Majeski 2009, p. 26). Having a wide range of possible outcomes will expand the applications of dental stem cells in health care. There have been many clinical trials supporting the efficacy of dental stem cells since the discovery of stem cells in dental tissues. In the dental field, professionals have begun to recognize how important dental stem cells are, particularly when patients may require regenerative therapy in the future.

Teeth are a noninvasive source of stem cells, and right now, they are being discarded as medical waste. Dental stem cells are easy, convenient, and affordable to collect, hold promise for a range of very potential therapeutic applications. Although dental stem cell research and clinical utilizations are still in the initial stages, research strongly suggests its positive potential. These new sources of cells could be beneficial for cellular therapy and advancing the development of regenerative dentistry. In looking to the future of dentistry, dental stem cells will eventually play a significant role in restoring loss/and or damaged tissues.

References

Awais, S., Balouch, S. S., & Irum, S. (2021). Tissue Engineering With Dental Pulp Stem Cells. *Annals of King Edward Medical University*, *27*(2), 1–6.

Bhat, M., Shetty, P., Shetty, S., Khan, F. A., Rahman, S., & Ragher, M. (2019). Stem Cells and Their Application in Dentistry: A Review. *Journal of Pharmacy & Bioallied Sciences*, *11*, S82–S84. https://hs1.farmingdale.edu:2258/10.4103/jpbs.JPBS_288_18

Ilhazzazi, T., & Alghamdi, F. (2021). Clinical applications of dental stem cells in modern regenerative medicine: A systematic review with updates. *Nigerian Journal of Clinical Practice*, *24*(4), 457https://link.gale.com/apps/doc/A658484691/HRCA?u=sunyfarm_main&sid=bookmark-HRCA&xid=7f76e968.

Lei, T., Zhang, X., & Du, H. (2021). Characteristics, Classification, and Application of Stem Cells Derived from Human Teeth. *Stem Cells International*, 1–11. https://hs1.farmingdale.edu:2258/10.1155/2021/8886854

Madhavi, N., Nalla, S., Thandu, A., Sameer, S., Lakshmi, P., & Puvvati, R. L. (2018). A review on oral mesenchymal stem cells and tissue engineering, prospects of stem cell-based regenerative dentistry. *International Archives of Integrated Medicine*, *5*(1), 152–158.

Majeski, J. (2009). Dental Stem Cells in Research and Practice. *Access*, *23*(8), 24–26.

Nakahara, T. (2011). Potential feasibility of dental stem cells for regenerative therapies: stem cell transplantation and whole-tooth engineering: Official Journal of the Society of the Nippon Dental University. *Odontology*, *99*(2), 105-11. http://hs1.farmingdale.edu:2098/10.1007/s10266-011-0037-y.

Narwal, A., Gupta, S., & Hooda, A. (2019). Dental stem cells - Sources and identification methods. *Chrismed Journal of Health and Research*, *6*(1), 1–6. https://doi.org/10.4103/cjhr.cjhr_110_18.

Paz, A. G., Maghaireh, H., & Mangano, F. G. (2018). Stem Cells in Dentistry: Types of Intra- and Extraoral Tissue-Derived Stem Cells and Clinical Applications. *Stem Cells International*, 1–14. https://hs1.farmingdale.edu:2258/10.1155/2018/4313610.

Yoshida, S., Tomokiyo, A., Hasegawa, D., Hamano, S., Sugii, H., & Maeda, H. (2020). Insight into the Role of Dental Pulp Stem Cells in Regenerative Therapy. *Biology*, *9*(7), 160. https://doi.org/10.3390/biology9070160a, S., Tomokiyo, A., Hasegawa, D., Hamano, S., Sugii, H., & Maeda, H. (2020). Insight into the Role of Dental Pulp Stem Cells in Regenerative Therapy. *Biology*, *9*(7), 160. https://doi.org/10.3390/biology9070160.

Figure 1: Bonaventura, G., Incontro, S., Iemmolo, R., La Cognata, V., Barbagallo, I., Costanzo, E., Barcellona, M. L., Pellitteri, R., & Cavallaro, S. (2019, November 27). *Dental mesenchymal stem cells and neuro-regeneration: A focus on spinal cord injury*. Cell and Tissue Research. https://link.springer.com/article/10.1007/s00441-019-03109-4.

Figure 2: Lee, S.-M., Zhang, Q., & Le, A. D. (2014, January 30). *Dental stem CELLS: Sources and potential applications*. Current Oral Health Reports. https://link.springer.com/article/10.1007/s40496-014-0012-0.

Figure 3: Foothills. (2020, January 20). *Stem cells for joint pain*. Foothills Orthopedic & Sport Therapy. https://www.foothillstherapy.com/2020/01/20/stem-cells-for-joint-pain/

Figure 4: Hirtz, C. (2019). Dental stem cells as a promising source for cell therapies in neurological diseases. https://doi.org/http://dx.doi.org/10.1080/10408363.2019.1571478

Presented at the 97th Annual Session of the Greater New York Dental Meeting in 2021