DOI: https://doi.org/10.54617/adoklinikbilimler.1431309

Review

Significance of Dental Stem Cells in Dentistry and Stem Cell Banking

Diş Hekimliğinde ve Kök Hücre Bankacılığında Dental Kök Hücrelerinin Önemi

Zeki Mert Çevik[1], Erkan Erkmen[2], Şule Kahraman[3]

ABSTRACT

Dentists play a crucial role in collecting stem cells for dental treatments and the potential treatment of medical diseases. Considering dental stem cells (DSCs) in terms of their increasing potential in medicine, adequate knowledge, and positive attitudes of dentists toward DSCs and their use in regenerative therapies are extremely important. The immense potential of DSCs in regenerative medicine applications for various treatments suggests their significant role in both dental treatments and innovative approaches to treating various diseases. “Dental banking” emerged as a result of the use of DSCs in medical applications and their numerous clinical advantages across regenerative medical domains. DSC banking is a service that makes it possible to store and utilize DSCs for potential medical applications. However, further clinical research is needed to advance the applications of DSCs in treatment. This review aims to summarize the current literature on dental stem cell banking applications and usage areas of DSCs in dentistry.

Keywords: Dental stem cells; Dental stem cell banking; Stem Cells; Stem cell banking

ÖZET

Diş hekimleri, yalnızca dental tedaviler için değil, aynı zamanda tıbbi hastalıkların potansiyel tedavisi için kök hücre toplamada önemli bir rol oynayabilir. Tıp alanında dental kök hücrelerin giderek artan potansiyeli göz önüne alındığında, diş hekimlerinin dental kök hücreler ve rejeneratif tedavilerde kullanımına yönelik yeterli bilgi ve olumlu tutumları son derece önemlidir. Dental kök hücrelerin çeşitli tedaviler için rejeneratif tıp uygulamalarında büyük bir potansiyele sahip olması, gelecekte yalnızca dental tedavilerde değil, çeşitli hastalıkların tedavisinde yenilikçi yaklaşımlarda önemli bir rol oynayabileceğini düşündürmektedir. Dental kök hücreler çeşitli klinik faydaları olduğundan ve rejeneratif tıbbın çeşitli alanlarında uygulandığından, dental kök hücrelerin tıbbi uygulamalar için korunması “diş bankası” kavramını oluşturmuştur. Dental kök hücre bankacılığı, dental kök hücrelerin saklanması ve gelecekte tıbbi tedaviler için kullanılabilmesini sağlayan bir hizmettir. Bununla birlikte, dental kök hücrelerin gelecekteki kullanım alanları ve bu hücrelerin potansiyel tedavi yöntemlerinin geliştirilebilmesi için çalışmaların devam etmesi ve klinik araştırmaların yapılması gerekmektedir. Bu derlemenin amacı diş hekimliğinde dental kök hücre bankacılığı uygulamalarına ve dental kök hücrelerin kullanım alanlarına dair mevcut literatürü özetlemektir.

Anahtar Kelimeler: Dental kök hücre; Dental kök hücre bankacılığı; Kök hücre; Kök hücre bankacılığı

Makale gönderiliş tarihi: 26.02.2024; Yayına kabul tarihi:7.03.2024
İletişim: Dt. Zeki Mert Çevik
Birlik Mahallesi Podgoritsa Caddesi 3/A Çankaya, Ankara, Turkiye
E-mail: zekimertcevik@gmail.com
[1] DDS, Gazi University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, Ankara, Turkiye
[2] Prof., Private Practice, Ankara, Turkiye
[3] DDS, PhD., Private Practice, Ankara, Turkiye

INTRODUCTION

Stem cells are the main cells in the body having the capacity to transform into different kinds of cells. They can self-renew and divide throughout life, replacing other cells. Stem cells are involved in the formation of many different tissues and organs in the body.[1]

Stem cells are categorized into two groups based on their origin: embryonic and adult stem cells.[2] Embryonic stem cells are pluripotent, indicating their potential to develop into any kind of cell. These cells are seen in the early stages of embryo development and hold significant promise for generating new tissues and repairing damaged tissues.[1,3]

In contrast, adult stem cells have limited differentiation potential and are derived from various organs throughout an individual's life; in other words, they are multipotent stem cells.[4] These cells have been identified from relatively easily obtainable cell sources such as cord blood, adipose tissue, peripheral blood, and dental pulp since they were first obtained from bone marrow. When damage occurs to a particular tissue or organ, these cells proliferate in damaged tissue regions when appropriate conditions are provided to facilitate repair.[5,6] Adult stem cells' capacity for differentiation is referred to as "stem cell plasticity". The concept of stem cell plasticity underscores the capacity of adult stem cells to develop into diverse cell types. This offers immense potential for using stem cells to treat various diseases.[7]

Dental Stem Cells

The remarkable regenerative capacity of oral tissues after traumatic and pathological injuries has led researchers to explore the presence of cells with differentiation potential within these tissues. Further, studies have focused on isolating these cells.[8] Dental stem cells (DSCs) can be used in any part of the organism, and stem cells derived from extraoral sites can also be used in dental structures.[7] Like other stem cells, DSCs can only be explored provided that they are isolated, and their structures are well characterized.[9] Previous studies obtained DSCs from permanent dental pulp and deciduous teeth. Deciduous teeth, supernumerary teeth, impacted wisdom teeth, and teeth extracted for orthodontic purposes were frequently used in investigation.[10,11] However, it has become apparent over time that DSC sources are not limited, and many alternatives extend beyond these initial options. DSCs can also be obtained from dental follicles, dental germ, periodontal ligament, apical papilla, periosteum, oral mucosa, salivary gland, adipose tissue, maxillary sinus membrane, and alveolar bone tissue.[10,12,13] Among these sources, dental pulp is extremely significant due to its ease of accessibility, lack of ethical concerns, and patient tolerance.[14]

Uses of DSCs in dentistry

DSCs can be used for regenerating pulp, repairing damaged dentin, and treating periodontal diseases. The combined application of DSCs and current filling materials may allow us to achieve the objective of creating oral tissues in the near future. Understanding the molecular principles of tooth development and repair is the foundation of regenerative dentistry, leveraging developing technologies in tissue engineering and biomaterials. DSCs play a crucial role in creating complex dental tissues. The availability of regenerative tooth treatments through tissue engineering can alleviate challenges associated with current dental procedures such as endodontic prosthodontic treatments, as well as implant surgery.[15]

1. Periodontal Regeneration Applications

The periodontium is a collection of specialized tissues that surround and support the teeth. Periodontitis is an inflammatory condition affecting the periodontium and causing the permanent loss of connective tissue attachment and alveolar bone support. The problem for cell-based replacement of the functional periodontium is forming new ligaments and bone and ensuring proper connections between ligament and bone tissues, besides the connection between bone and tooth root. One aim of the present study was to employ different populations of DSCs to replicate critical events in periodontal development temporally and regionally. This approach facilitates sequential regeneration of the periodontium.[16]

Theoretically, in periodontal regeneration methods, the periodontal ligament should contain organized cell sheets to facilitate human periodontal ligament (HPDL) cell transplantation.[17] Periodontal ligament cells were isolated from 3rd molars in humans and cultured on poly (N-isopropylacrylamide) graft fields,

which induced spontaneous detachment of the ligament as appropriate cell sheets during low-temperature treatment of the cells. HPDL cell sheets were implanted in athymic mice in which the periodontium and cementum were removed from 1st molars. It was presumed that natural periodontal ligament fibrils and a noncellular cement-like layer might make this technique suitable for future periodontal regenerations. This approach seems promising; however, it does not consider any necessary bone replacement.[18]

Seo *et al*.[19] examined whether HPDL tissue contained stem cells that might be employed to regenerate periodontal tissue. The periodontal ligament tissue obtained from impacted 3rd molars contained clonogenic, quickly proliferating cells that might express antigens specific to some mesenchymal stem cells. They also reported the formation of cement/periodontal ligament-like structures resembling the natural periodontal ligament, with a thin layer of cement adjacent to dense collagen fibers resembling Sharpey fibers when the aforementioned cells were mixed with hydroxyapatite/tricalcium phosphate powder as a carrier matrix and implanted into immunocompromised mice.[19] The major issue with these methods is the extent to which any revitalized periodontium sustains its integrity and function over long periods during mastication. Currently available treatments for severe periodontitis are inadequate, and in spite of their shortcomings, they are likely to remain a significant focus of studies in the near future, particularly in the context of new therapies based on DSC.[18]

2. Regenerative Endodontic Treatment Applications

Irreversible pulp damage results in pulp necrosis, often causing endodontic infection. Some vital pulp tissue may remain, allowing for continued root formation in young patients. In cases where the pulp is devitalized in an early stage, the traditional solution is to remove the damaged pulp tissue and fill the root canal with a synthetic material.

The primary aim of pulp tissue engineering is to replace inflamed or necrotic pulp with new, healthy, and functional tissue that is capable of forming dentin. In this technique, undifferentiated cells are seeded on a resorbable scaffold *in vitro*. Thus, proliferation, migration, and differentiation of the cells are induced, leading them to transform into specialized cells. The resulting structure is implanted *in vivo*, and it is ensured that the shaping and maturation process takes place to form functional tissue.[20] Dentin regeneration is achieved in a necrotic tooth as an alternative to traditional endodontic treatment in pulp tissue engineering.[21] Therefore, the morphogenetic signals, scaffold development, and identification of appropriate cells to induce stem cells in the regeneration of lost tissues need to be understood.[22]

A previous study revealed de novo pulp regeneration using DSCs in the evacuated root canal cavity. Dental pulp stem cells (DPSCs) and stem cells from the apical papilla were isolated from 3rd molars in humans, seeded on poly(D, L lactide-co-glycolide) scaffold, and introduced into the root canal cavity. The histological examination of the tooth fragments 3–4 months postoperatively demonstrated that the root canal cavity had been completely filled with well-established, vascularized, pulp-like tissue. In addition, a layer of dentin resembling mineralized tissue was located on the canal's dentinal walls.[23]

3. Biological tooth formation applications

The structure formed after differentiation and recombination of embryonic DSCs by placing them on top of each other and obtaining a new tooth in a special environment or a dental socket is called a "biological tooth."

Dualibi *et al*.[24] multiplied the germs they obtained from 3- to 7-day-old mouse embryos in a culture medium, placed them in polyglycolate-based envelopes, and implanted them into the omentum of 6- to 12-month-old animals of the same sex. Mature dental tissues were found in the implants removed at the end of 12 weeks. This study, which demonstrated that germs obtained from 4-day-old embryos reproduced easily in a culture medium, was also significant as it marked the first transplantation procedure performed between different individuals of the same species. Further, despite the success achieved in the formation of mineralized structures resembling dental tissues in these studies, the aforementioned method still may lead to many problems.

Gronthos *et al*.[25] isolated highly proliferative cells from mature human dental pulp, forming an immunophenotype similar to mesenchymal stem cells generated from bone marrow. When these cells were cultured, they showed high alkaline phosphatase activity and were dense calcified masses. *In vivo* transplantation experiments have shown that these cells can form dentin-like structures.

Ikea *et al*.[26] determined the development of a fully functional tooth in an adult mouse, which was achieved by transplanting biologically regulated tooth germ in the laboratory into the alveolar bone at the site of a missing tooth. Although dental tissues were regenerated, the success rate for correct tooth rearrangement was only 15%–20%. This suggested that more extensive studies were needed to obtain structurally sound teeth.[27]

Use of DSCs in systemic diseases

The findings of several *in vivo* and *in vitro* investigations provided hope for future uses of DSCs in regenerative dentistry and the treatment of systemic degenerative diseases.[28] Studies showed that these dental tissue-derived cells not only exhibited the potential for self-renewal and multiple differentiation but also possessed immunomodulatory functions and potent tissue regenerative properties.[29] Studies have shown that DSCs may play an important role in a variety of diseases such as spinal cord injuries, Parkinson's disease, Alzheimer's disease, myocardial infarction, cerebral ischemia, muscular dystrophy, liver diseases, diabetes, eye diseases, and so forth.[30]

Further studies are needed to confirm the regenerative abilities of DSCs as investigating these abilities seems quite promising for a wide range of diseases.[31]

DSC Banking

DSC banking provides a valuable tool to effectively advance research and clinical practice in dentistry on oral and systemic disorders. This approach can also contribute to the emergence of therapeutic advantages and represent a significant step forward in the field of personalized medicine.[32] Stem cell banks that collect bone marrow and placental cord blood have been operating for many years; however, specialized banks focusing on DSCs have only recently been developed in this field. The number of DSC banks has increased, particularly in India, North America, and the United Kingdom.[33]

DSC banking has so far centered on cells found in the pulp of human deciduous and permanent teeth, especially wisdom teeth.[34] However, not every extracted tooth is equally suitable for stem cell harvesting. To achieve a successful outcome, the extracted teeth must have a bleeding pulp, indicating cell viability. In addition, the signs of disease, such as tumors, apical lesions, or cysts, reduce the efficiency of stem cell harvesting.[35] Therefore, stem cells should preferably be obtained from extracted, uninfected teeth. However, they can also be isolated from carious teeth, albeit with slower cell regeneration and increased expression of inflammatory molecules.[32,36] DSC banking companies hold differing opinions about accepting decayed and infected teeth; also, the scientific literature reflects a similar division. Werle *et al*.[37] reported that stem cells from both decayed and healthy deciduous teeth had the same capacity for tissue differentiation. Tsai *et al*.[38] evaluated the effectiveness of obtaining stem cells from deciduous teeth with increasing levels of disease severity or the presence or absence of caries. The study showed that stem cells could also be isolated from decayed teeth, but their numbers were inversely correlated with the clinical severity of caries. Furthermore, the results of the study indicated that DSCs from healthy teeth were four times more successful than those from decayed teeth. Werle *et al.*[37] recorded only a 10% difference in successful stem cell isolation from decayed versus healthy teeth. Other studies on adult stem cells from healthy teeth and teeth with caries with inflamed pulp confirmed that cell regeneration was lower in diseased teeth; however, both stem cell sources had similar differentiation capacities.[37,39,40] Tsai *et al*.[38] found an increase in inflammatory mediator expression and the number of innate immune system molecules in stem cells from diseased teeth compared with healthy ones. How these differences affect the long-term application of DSCs in biobanks is unclear; however, it is recommended to be cautious. The questions about decayed teeth clearly demonstrate the lack of knowledge about teeth as a source of stem cells in DSC banking. Regarding biobanks in dentistry, some as-

pects require further examination. Currently, not all biological materials available in dentistry are stored in banks. The chance to get more data and valuable samples can be increased by developing new DSC banks to collect biological samples that are not common, such as periodontal ligament, alveolar bone, oral mucosa, and maxillary sinus membrane. The cells obtained from these tissues may carry the potential to be applied in not only bone and periodontal regeneration but also the treatment of various systemic diseases.[41] In addition, it is essential to emphasize that the acquisition or use of samples from biobanks in everyday clinical trials is still not possible due to certain unresolved issues. For instance, how long oral specimens should be stored is unclear and ethical regulations on the use of biospecimens are needed (especially DSCs). It is important to clarify these points so that the biobanking applications can be used more effectively in everyday clinical work. Biobanking may be certified for long-term preservation, but the properties of samples may change over time and the analysis results at the time of collection may not accurately reflect their true state. Whether stem cells can still be used effectively after extended cryopreservation is not fully established.[42,43]

With the Regulation on Cord Blood Banking issued by the Ministry of Health of the Republic of Turkey on July 5, 2005, the establishment of stem cell banks in Turkey has started and the activities in this field have expanded over time. In particular, the future storage of deciduous teeth as a source of stem cells has gained widespread interest. Studies have proven the capacity of DSCs to differentiate into adipocytes, neural cells, osteocytes, chondrocytes, and myocytes. Also, preserved DSCs offer potential use for the donor and other family members.[40,44]

The stem cells obtained from baby teeth can be stored in banks for 20–25 years. These cells can be used for organ plantation and potentially, for treatment of diseases such as cancer; heart, skin, muscle, bone, and blood diseases; genetic and metabolic diseases; and Alzheimer's and Parkinson's diseases. However, to use a deciduous tooth as a source of stem cells, the tooth must not be necrotic, that is, it must be alive. Milk teeth that fall out spontaneously usually do not bleed and the pulp of the teeth has lost its vitality. Hence, in terms of stem cell harvesting, it may be healthier and more efficient to remove the deciduous tooth while it still retains its vitality, for example, when new mobility begins. While the deciduous tooth is extracted, it is transferred into a special solution, and simultaneously, the blood taken from the patient must also be sent to the bank.[43,44]

Patients who want to store their DSCs should contact their dentists, as dentists need to know the procedures involved. In addition, the family considering storing the stem cells should contact the bank to find out the details of the storage conditions and cost. The cell banks in Turkey usually offer payment packages for 1, 5, 10, and 15 years.[44]

CONCLUSIONS

DPSCs have the potential to easily reach sufficient cell numbers for cellular therapy by showing a high degree of population growth besides the advantages of easy availability. In today's dental practice, the damaged tissue is restored using various synthetic materials. However, recent studies on DPSCs and tissue engineering techniques have sparked hope for the development of a new treatment concept in these areas.

Thanks to the establishment and expansion of DSC banks, DSCs with their wide differentiation capacity have an extremely promising therapeutic potential, especially in regenerative therapies. With the widespread adoption of DSC banks and the reduced costs of DSC banking, DSC applications will become a more accessible treatment option for patients in the future.

REFERENCES

1. Casagrande L, Grando Mattuella L, Borba de Araujo F, Eduardo J. Stem cells in dental practice: perspectives in conservative pulp therapies. J Clin Pediatr Dent 2007;31:25-7.

2. Zhang H, Wang ZZ. Mechanisms that mediate stem cell self-renewal and differentiation. J Cell Biochem 2008;103:709-18.

3. Delilbaşı L. *İn vitro* fertilizasyon (IVF) laboratuvar yöntemleri. In: Delilbaşı L (eds) Ankara: Öncü Basımevi 2008:1-31.

4. Rai S, Kaur M, Kaur S. Applications of stem cells in interdisciplinary dentistry and beyond: an overview. Ann Med Health Sci Res 2013;3:245.

5. Coulombel L. Adult tissue stem cells: definition, identification and therapeutic use. Journ Annu Diabetol Hotel Dieu 2003:1-16.

6. Ferrari G, Cusella– G, Angelis D, Coletta M, Paolucci E, Stornaiuolo A, *et al*. Muscle regeneration by bone marrow-derived

myogenic progenitors. Science 1998;279:1528-0

7. Majeski J. Dental stem cells in research and practice. Access 2009;26:24-6.

8. Glick M. Stem cell research and oral health. J Am Dent Assoc 2009;140:514.

9. Suzergoz F, Erdem A, Sepet E, Bektas M, Yalman N, Gurol A. A pilot study on the isolation of dental pulp stem cells, potential of forming colonies and defining the content of stem cells. Turkiye Klinikleri J Med Sci 2009;29.

10. Gronthos S, Mankani M, Brahim J, Robey PG, Shi S. Postnatal human dental pulp stem cells (DPSCs) *in vitro* and *in vivo*. Proc Natl Acad Sci U S A 2000;97:13625-30.

11. Miura M, Gronthos S, Zhao M, Lu B, Fisher LW, Robey PG, *et al*. SHED: stem cells from human exfoliated deciduous teeth. Proc Natl Acad Sci U S A 2003;100:5807-12.

12. Han J, Okada H, Takai H, Nakayama Y, Maeda T, Ogata Y. Collection and culture of alveolar bone marrow multipotent mesenchymal stromal cells from older individuals. J Cell Biochem 2009;107:1198-204.

13. Guo J, Weng J, Rong Q, Zhang X, Zhu S, Huang D, *et al*. Investigation of multipotent postnatal stem cells from human maxillary sinus membrane. Sci Rep. 2015;5:11660.

14. Karaöz E, Demircan PC, Sağlam Ö, Aksoy A, Kaymaz F, Duruksu G. Human dental pulp stem cells demonstrate better neural and epithelial stem cell properties than bone marrow-derived mesenchymal stem cells. Histochem Cell Biol 2011;136:455-73.

15. Sharpe PT. Dental mesenchymal stem cells. Development 2016;143:2273-80.

16. Lin NH, Gronthos S, Bartold P. Stem cells, tissue engineering and periodontal regeneration. Aus Dent J 2008;53:108-21.

17. Hasegawa M, Yamato M, Kikuchi A, Okano T, Ishikawa I. Human periodontal ligament cell sheets can regenerate periodontal ligament tissue in an athymic rat model. Tissue Eng 2005;11:469-78.

18. Volponi AA, Pang Y, Sharpe PT. Stem cell-based biological tooth repair and regeneration. Trends Cell Biol 2010;20:715-22.

19. Seo B-M, Miura M, Gronthos S, Bartold PM, Batouli S, Brahim J, *et al*. Investigation of multipotent postnatal stem cells from human periodontal ligament. Lancet 2004;364:149-55.

20. Tziafas D. The future role of a molecular approach to pulp-dentinal regeneration. Caries Res 2004;38:314-20.

21. Miyagi SPH, Kerkis I, da Costa Maranduba CM, Gomes CM, Martins MD, Marques MM. Expression of extracellular matrix proteins in human dental pulp stem cells depends on the donor tooth conditions. J Endod 2010;36:826-31.

22. Morsczeck C, Frerich B, Driemel O. Dental stem cell patents. Recent Patents on DNA & Gene Sequences. Recent Pat DNA Gene Seq 2009;3:39-43.

23. Huang GT-J, Yamaza T, Shea LD, Djouad F, Kuhn NZ, Tuan RS, *et al*. Stem/progenitor cell–mediated de novo regeneration of dental pulp with newly deposited continuous layer of dentin in an *in vivo* model. Tissue Eng Part A 2010;16:605-15.

24. Duailibi M, Duailibi S, Young C, Bartlett J, Vacanti J, Yelick P. Bioengineered teeth from cultured rat tooth bud cells. J Dent Res 2004;83:523-8.

25. Gronthos S, Simmons PJ. The growth factor requirements of STRO-1-positive human bone marrow stromal precursors under serum-deprived conditions *in vitro*. Blood 1995.

26. Ikeda E, Morita R, Nakao K, Ishida K, Nakamura T, Takano-Yamamoto T, *et al*. Fully functional bioengineered tooth replacement as an organ replacement therapy. Proc Natl Acad Sci U S A 2009;106:13475-80.

27. Hall PA, Watt FM. Stem cells: the generation and maintenance of cellular diversity. Development 1989;106:619-33.

28. Lee S-M, Zhang Q, Le AD. Dental stem cells: sources and potential applications. Current Oral Health Reports 2014;1:34-42.

29. Liu J, Yu F, Sun Y, Jiang B, Zhang W, Yang J, *et al*. Concise reviews: Characteristics and potential applications of human dental tissue-derived mesenchymal stem cells. Stem cells 2015;33:627-38.

30. Yamada Y, Nakamura-Yamada S, Kusano K, Baba S. Clinical potential and current progress of dental pulp stem cells for various systemic diseases in regenerative medicine: a concise review. Int J Mol Sci 2019;20:1132.

31. Botelho J, Cavacas MA, Machado V, Mendes JJ. Dental stem cells: recent progresses in tissue engineering and regenerative medicine. Ann Med 2017;49:644-51.

32. Dickinson BP, Ashley RK, Wasson KL, O'Hara C, Gabbay J, Heller JB, *et al*. Reduced morbidity and improved healing with bone morphogenic protein-2 in older patients with alveolar cleft defects. Plastic Recontr Surg 2008;121:209-17.

33. Alonso N, Tanikawa DYS, Freitas RdS, Canan Jr L, Ozawa TO, Rocha DL. Evaluation of maxillary alveolar reconstruction using a resorbable collagen sponge with recombinant human bone morphogenetic protein-2 in cleft lip and palate patients. Tissue Eng Part C Methods 2010;16:1183-9.

34. Pradel W, Eckelt U, Lauer G. Bone regeneration after enucleation of mandibular cysts: comparing autogenous grafts from tissue-engineered bone and iliac bone. Oral Surgery, Oral Medicine, Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:285-90.

35. Tanikawa D, Pinheiro CC, Almeida MCA, Oliveira CR, Coudry RdA, Rocha DL, *et al*. Deciduous dental pulp stem cells for maxillary alveolar reconstruction in cleft lip and palate patients. Stem Cells Int 2020;2020:6234167

36. d'Aquino R, De Rosa A, Lanza V, Tirino V, Laino L, Graziano A, *et al*. Human mandible bone defect repair by the grafting of dental pulp stem/progenitor cells and collagen sponge biocomplexes. Eur Cell Mater 2009;18:75-83.

37. Werle SB, Lindemann D, Steffens D, Demarco FF, de Araujo FB, Pranke P, *et al*. Carious deciduous teeth are a potential source for dental pulp stem cells. Clin Oral Investig 2016;20:75-81.

38. Tsai AI, Hong H-H, Lin W-R, Fu J-F, Chang C-C, Wang I, *et al*. Isolation of mesenchymal stem cells from human deciduous teeth pulp Biomed Res Int. 2017;2017.

39. Pereira L, Rubini M, Silva J, Oliveira D, Silva I, Poças-Fonseca M, *et al*. Comparison of stem cell properties of cells isolated from normal and inflamed dental pulps. Int Endod J 2012;45:1080-90.

40. Malekfar A, Valli KS, Kanafi MM, Bhonde RR. Isolation and characterization of human dental pulp stem cells from cryopreserved pulp tissues obtained from teeth with irreversible pulpitis. J Endod 2016;42:76-81.

41. Yamada Y, Nakamura-Yamada S, Konoki R, Baba S. Promising advances in clinical trials of dental tissue-derived cell-based regenerative medicine. Stem Cell Res Ther 2020;11:1-10.

42. Sivolella S, Scanu A, Xie Z, Vianello S, Stellini E. Biobanking in dentistry: A review. Jpn Dent Sci Rev 2022;58:31-40.

43. Eklund N, Andrianarisoa NH, van Enckevort E, Anton G, Debucquoy A, Müller H, *et al*. Extending the minimum information about biobank data sharing terminology to describe samples, sample donors, and events. Biopreserv Biobank 2020;18:155-64.

44. Kahraman Ş, Delilbaşı E. Uses of stem cells in dentistry and awareness of dental stem cells. ADO Klinik Bilimler Dergisi 2022;11:65-70.