Dental Stem Cells and Their Utilization In Regenerative Medicine: A Cross Sectional Study Among Healthcare Professionals

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Abstract

Introduction: Regenerative medicine has been recognized as a trailblazing field that aims to repair, replace, and regenerate damaged tissues and organs to restore their normal function.

Objective: Regenerative medicine is gaining clinical application for treating bone and cartilage injuries, burn victims, heart disease, and neurodegenerative disorders. This research seeks to identify the level of awareness, the perceived benefits and challenges, and the readiness of healthcare professionals to integrate DSC-based therapies into their clinical practice. It aims to identify educational gaps and challenges in adopting DSC-based therapies.

Materials and Methods: A cross-sectional, questionnaire-based study was conducted among health professionals to assess their understanding, awareness, and attitudes regarding dental stem cells and their therapeutic roles in regenerative therapy. A sample of 176 participants from various cities in Punjab was surveyed, and the data was analyzed using SPSS version 25.0 for statistical analysis.

Results: The study surveyed 176 participants (88 dental surgeons, 88 medical doctors), revealing comprehensive awareness of stem cells (96%) and 77% participants considered dental stem cells' regenerative abilities. Dental surgeons demonstrated greater familiarity with dental stem cells' self-renewal and proliferation, while both groups strongly supported increased government awareness campaigns.

Conclusion: Healthcare professionals demonstrated high awareness of dental stem cells, with dental surgeons exhibiting greater knowledge of regenerative capabilities. These findings highlight the need for targeted educational initiatives to enhance clinical integration.

Key Words: Regenerative Medicine, Stem Cells, healthcare, surgeons

Introduction

Regenerative medicine has been recognized as a trailblazing field that aims to repair, replace, and regenerate damaged tissues and organs to restore their normal function. Stem cells, biomaterials, and bioengineering techniques are used to achieve this. [1] Regenerative medicine provides personalized treatments using a patient's or genetically matched cells, reducing immune rejection and improving outcomes.[2] Stem cell therapy, which harnesses stem cells' distinct properties—such as their ability to self-replicate and specialize into a diverse range of cell types—to promote tissue regeneration and healing, is at the forefront of regenerative medicine. Stem cells are categorized based on origin and potency, with various types including embryonic stem cells, perinatal stem cells, induced pluripotent stem cells, and dental stem cells. These sources are regarded as critical for personalized medicine, regenerative medicine, and therapeutic applications.[3]

Dental stem cells (DSCs) have garnered considerable interest due to their ease of access, multipotency, and potential applications in regenerative medicine among the different types of stem cells. These cells are sourced from different dental tissues, including dental pulp, periodontal ligament, dental follicle, and exfoliated deciduous teeth. Stem cells have the capacity to regenerate damaged organs, repair bone and cartilage, facilitate wound healing, and treat neurological disorders. “Immense promise” is held by this technology for treating conditions with limited therapeutic options, such as spinal cord injuries, heart disease, bone degenerative diseases, diabetes, and neurodegenerative diseases.[4]

Research has demonstrated that stem cells, sourced from the dental pulp of adult teeth, exhibit the capacity for dentin-pulp regeneration, illustrating their contribution to dental tissue repair and regeneration.[5] Furthermore, multiple studies have revealed that stem cells obtained from exfoliated deciduous teeth (SHED) have been observed to display higher proliferative rates and increased differentiation potential into various cell types, as opposed to other dental stem cells.[6]

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The potential of SHED in treating neurological disorders, bone defects, and immune-related conditions has been explored by studies, underscoring the versatility and clinical relevance of these cells. Preclinical studies have demonstrated that osteoblast differentiation and bone formation can effectively be contributed to by DPSCs and SHED when conducted with animal models. Cases of fractures, non-union fractures, craniofacial bone reconstruction, cartilage regeneration, osteonecrosis, and bone defects resulting from trauma or disease can be addressed with this approach. [7,8] Moreover, periodontal ligament stem cells (PDLSCs) exhibit significant potential in regenerating periodontal tissues, which is essential in the treatment of periodontal diseases and the maintenance of oral health. [9]

The varying levels of awareness and understanding of dental stem cells' potential applications among healthcare professionals is also addressed in the literature. Studies have shown that in-depth knowledge and confidence in using these cells in clinical practice are lacking in health professionals. Insufficient exposure to stem cell biology in medical and dental education, combined with the rapid advancements in the field that may not be fully incorporated into the curricula, could be attributed to this knowledge gap. [10] Interest in regenerative medicine in Pakistan is rising, however, its integration is still limited due to a lack of awareness, infrastructure, and research. Dental stem cells offer a promising yet underutilized resource in healthcare. [11,12]

This study intends to address the gaps identified in the literature by assessing the current state of knowledge, attitudes, and practices among healthcare professionals about the application of dental stem cells in regenerative medicine. The findings will inform educational interventions and policy recommendations for enhancing DSC integration into clinical practice.

Materials and Methods

A cross-sectional, questionnaire-based study was conducted to explore healthcare practitioners' understanding, awareness, and attitudes toward the utilization of dental stem cells in regenerative therapy. Participation was voluntary and included licensed dentists and medical doctors. The Institutional Research and Ethics Committee provided ethical approval (ERC APPROVAL NO: UCD/ERCA/24/589). Data were gathered over four months, from June 2024 to September 2024, across various cities of Punjab. Participants included in this research were sampled using a non-probability convenience sampling technique for data collection. The sample size of 176 participants (88 in each group) is calculated with 95% power of the test and 5.8% level of significance and by taking the expected percentage of response of dental and medical doctors towards knowledge regarding stem cells (Dental stem cells may be extracted from the tissues of dental pulp and periodontal ligaments) 50% and 24.60%. The following formula was used to calculate sample size

$$n = \frac{\left\{ z_{1-\alpha/2}\sqrt{2\bar{P}(1-\bar{P})} + z_{1-\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)} \right\}^2}{\left(P_1 - P_2\right)^2}$$

Data entry and analysis were performed using SPSS version 25 software.

A pre-validated self-administered questionnaire was used without any modifications, as originally developed and validated in a previous study. [13] There was a total of 20 closed questions spread throughout two sections of the self-administered survey. General information, such as gender, age, occupation, and level of education, was covered in the first section. In the second section, participants were asked to share details on their understanding, knowledge, and attitudes regarding dental stem cells, and their potential uses in regenerative therapies. Regarding the perception questions, each respondent was asked to indicate their level of agreement with the statement by selecting one of the following options: strongly disagree, disagree, unsure, agree, or strongly agree. The questionnaire was distributed simultaneously through Google Forms. The study's participants were made aware of the objective, the anonymous involvement.

Data Analysis

Data entry and analysis were performed using SPSS version 25. Qualitative variables were presented with frequency and percentage. The Chi-square or Fisher Exact Test was employed to assess the association between qualitative variables, with a P-value of ≤ 0.05 regarded as statistically significant.

Results

This study involved 176 participants, equally split between dental surgeons (n=88) and medical doctors (n=88). Among dental surgeons, 60.2% were male and 39.8% female, while the medical doctors were mostly female (60.2%). Most dental surgeons (77.3%) were aged 20–29, with smaller groups in the 30–39 (20.5%) and 40–49 (2.3%) ranges. For medical doctors, 62.5% were aged 20–29, 27.3% were 30–39, 8.0% were 40–49, and 2.3% were over 50. (Table I)

Table I. Demographic Characteristics of Study Participants

		N(%)	N(%)
Gender	Male	53 (60.2%)	35 (39.8%)
	Female	35 (39.8%)	53 (60.2%)
Age	20–29 years	68 (77.3%)	55 (62.5%)
	30–39 years	18 (20.4%)	24 (27.2%)
	40–49 years	2 (2.3%)	7 (8%)
	>50 years	–	2 (2.3%)

Most respondents (96.0%) were aware of stem cells, and 54.0% believed dental stem cells could potentially replace missing teeth, though 38.6% were unsure. A large majority (77.3%) recognized that dental stem cells can self-renew and differentiate, while 69.3% acknowledged their ability to proliferate. Many also understood their role in neural regeneration (64.2%). However, there was some uncertainty about whether stem cells could cause cancer (40.9%) or if dental stem cells exhibit similar traits to bone marrow stem cells (51.7%). A strong sentiment (72.9%) supported more government campaigns to raise awareness about dental stem cell research. (Table II)

Table II. Awareness and Perceptions of Dental Stem Cells Among Participants

Have you heard about stem cells?	No	7	4.0%
	Yes	169	96.0%
Replacement of missing teeth with stem cell-derived dental implants	No	13	7.4%
	Not sure	68	38.6%
	Yes	95	54.0%
DSCs exhibit self-renewal and multipotent differentiation properties.	No	8	4.5%
	Not sure	32	18.2%
	Yes	136	77.3%
DSCs undergo proliferation via cell division.	Not sure	43	24.4%
	No	11	6.3%
	Yes	122	69.3%
DPSCs exhibit neuro-regenerative and reparative properties.	No	10	5.7%
	Not sure	53	30.1%
	Yes	113	64.2%
Stem cells can contribute to cancer development.	No	43	24.4%
	Not sure	72	40.9%
	Yes	61	34.7%

DSCs differ from bone marrow-derived mesenchymal stem cells in characteristics.	No	30	17.0%
	Not sure	91	51.7%
	Yes	55	31.3%
Dental tissue-derived stem cells classified as adult stem cells.	No	19	10.8%
	Not sure	72	40.9%
	Yes	85	48.3%
Adult stem cells can be sourced from sperm, eggs, and various somatic tissues.	No	56	31.8%
	Not Sure	67	38.1%
	Yes	53	30.1%
MSCs are derived from bone marrow, placenta, umbilical cord, adipose tissue, and dental tissues.	No	19	10.8%
	Not Sure	44	25.0%
	Yes	113	64.2%
DSCs sourced from dental pulp and periodontal ligament tissues.	No	17	9.7%
	Not sure	56	31.8%
	Yes	103	58.5%
DSCs research holds promising potential.	Agree	67	38.1%
	Disagree	3	1.7%
	Neutral	33	18.8%
	Strongly agree	61	34.7%
	Strongly disagree	12	6.8%
I would like to contribute my extracted teeth for use in research and therapy.	Agree	59	33.5%
	Disagree	21	11.9%
	Neutral	42	23.9%
	Strongly agree	41	23.3%
	Strongly disagree	13	7.4%
I would like to preserve my DSCs for personal purposes.	Agree	69	39.2%
	Disagree	11	6.3%
	Neutral	54	30.7%
	Strongly agree	32	18.2%
	Strongly disagree	10	5.7%
Investing in dental stem cell banking and products is lucrative.	Agree	63	35.8%
	Disagree	3	1.7%
	Neutral	67	38.1%
	Strongly agree	35	19.9%
	Strongly disagree	8	4.5%
Governments should promote awareness of dental stem cell research.	Agree	76	43.2%
	Disagree	2	1.1%
	Neutral	25	14.2%
	Strongly agree	67	38.1%
	Strongly disagree	6	3.4%

In comparison between dentists and medical doctors on dental stem cells (Table III), both groups were largely familiar with stem cells (94.3% vs. 97.7%, p=0.444). More dentists recognized the self-renewal abilities of dental stem cells (83.0% vs. 71.6%, p=0.001). Dentists were also more certain regarding the capability of dental pulp stem cells for neural regeneration (70.5% vs. 58.0%, p=0.090) and their ability to proliferate (77.3% vs. 61.4%, p=0.052). Notably, doctors were more likely to believe that stem cells could be derived from sperm and eggs (38.6% vs. 21.6%, p=0.042). Both groups supported further awareness campaigns (44.3% vs. 42.0%, p=0.467).

Table III. Comparison of Stem Cell Awareness Among Professional Groups

Questions	Options	Dentists	Medical Doctor	p-value
		n (%)	n (%)	
Have you heard about stem cells?	No	5(5.7%)	2(2.3%)	**0.444**(F)
	Yes	83(94.3%)	89(97.7%)	
Replacement of missing teeth with stem cell-derived dental implants	No	10(11.4%)	3(3.4%)	**0.064**(C/F)
	Not sure	29(33.0%)	39(44.3%)	
	Yes	49(55.7%)	46(52.3%)	
DSCs exhibit self-renewal and multipotent differentiation properties.	No	7(8.0%)	1(1.1%)	**0.001**(F)
	Not sure	8(9.1%)	24(27.3%)	
	Yes	73(83.0%)	63(71.6%)	
DSCs undergo proliferation via cell division.	Maybe	15(17.0%)	28(31.8%)	**0.052**(C/F) *
	No	5(5.7%)	6(6.8%)	
	Yes	68(77.3%)	54(61.4%)	
DPSCs exhibit neuro-regenerative and reparative properties.	No	6(6.8%)	4(4.5%)	**0.090**(C/F)
	Not sure	20(22.7%)	33(37.5%)	
	Yes	62(70.5%)	51(58.0%)	
Stem cells can contribute to cancer development	No	19(21.6%)	24(27.3%)	**0.106**(C/F)
	Not sure	43(48.9%)	29(33.0%)	
	Yes	26(29.5%)	35(39.8%)	
DSCs differ from bone marrow-derived mesenchymal stem cells in characteristics.	No	18(20.5%)	12(13.6%)	**0.162**(C/F)
	Not sure	48(54.5%)	43(48.9%)	
	Yes	22(25.0%)	33(37.5%)	
Dental tissue-derived stem cells classified as adult stem cells.	No	10(11.4%)	9(10.2%)	**0.863**(C/F)
	Not sure	34(38.6%)	38(43.2%)	
	Yes	44(50.0%)	41(46.6%)	
Adult stem cells can be sourced from sperm, eggs, and various somatic tissues	No	33(37.5%)	23(26.1%)	**0.042***
	Not Sure	36(40.9%)	31(35.2%)	
	Yes	19(21.6%)	34(38.6%)	
MSCs are derived from bone marrow, placenta, umbilical cord, adipose tissue, and dental tissues.	No	13(14.8%)	6(6.8%)	**0.186**(C/F)
	Not Sure	23(26.1%)	21(23.9%)	
	Yes	52(59.1%)	61(69.3%)	
DSCs sourced from dental pulp and periodontal ligament tissues.	No	11(12.5%)	6(6.8%)	**0.004***
	Not sure	18(20.5%)	38(43.2%)	
	Yes	59(67.0%)	44(50.0%)	
DSCs research holds promising potential.	Agree	29(33.0%)	38(43.2%)	**0.298**(C/F)
	Disagree	2(2.3%)	1(1.1%)	
	Neutral	18(20.5%)	15(17.0%)	
	Strongly agree	30(34.1%)	31(35.2%)	
	Strongly disagree	9(10.2%)	3(3.4%)	
I would like to contribute my extracted teeth for use in research and therapy.	Agree	32(36.4%)	27(30.7%)	**0.922**(C/F)
	Disagree	10)11.4%)	11(12.5%)	
	Neutral	19(21.6%)	23(26.1%)	
	Strongly agree	20(22.7%)	21(23.9%)	
	Strongly disagree	7(8.0%)	6(6.8%)	
Would like to preserve my DSCs for personal purposes.	Agree	38(43.2%)	31(35.2%)	**0.688**(C/F)
	Disagree	4(4.5%)	7(8.0%)	
	Neutral	25(28.4%)	29(33.0%)	
	Strongly agree	15(17.0%)	17(19.3%)	
	Strongly disagree	6(6.8%)	4(4.5%)	
Investing in dental stem cell banking and products is lucrative.	Agree	31(35.2%)	32(36.4%)	**0.188**(C/F)
	Disagree	3(3.4%)	0(0.0%)	
	Neutral	34(38.6%)	33(37.5%)	
	Strongly agree	14(15.9%)	21(23.9%)	
	Strongly disagree	6(6.8%)	2(2.3%)	
Governments should promote awareness of dental stem cell research.	Agree	39(44.3%)	37(42.0%)	**0.467**(C/F)

C= Chi square test, F= Fisher exact test

Discussion

The domain of stem cell research has gained significant traction. It presents many applications in medicine and dentistry, primarily due to its prospects for regenerating and repairing damaged tissues. As a result, healthcare professionals are primed to advance stem cell research and guide and implement innovative stem cell therapies within their practice.[14]

The findings of this study illustrate a significant awareness of stem cells among dental surgeons and medical doctors, with an overall awareness rate of 96.0% among the participants. The high overall familiarity with the subject indicates a growing recognition of stem cells' role in modern medicine. This aligns with recent global studies, such as a study conducted in Malaysia, which reports similar high levels of awareness and knowledge about stem cells among healthcare professionals.[13] Furthermore, most participants recognized the potential of dental stem cells for applications in dental implants (54.0%) and their ability to self-renew (77.3%). The application of dental stem cells in tissue engineering and regenerative dental medicine has been well-documented in the literature, and these insights support the feasibility of utilizing these cells in clinical settings.[15] This awareness is crucial, considering the growing emphasis on regenerative medicine and the applications of stem cells in clinical settings. Interestingly, the derivation of adult stem cells from sperm and eggs, where a higher percentage of medical doctors (38.6%) agreed compared to dental surgeons (21.6%), may be explained by the greater exposure of medical professionals to diverse sources of stem cells during their training. This disparity highlights the need for improved interdisciplinary education that includes comprehensive coverage of stem cell sources, characteristics, and applications.

A key therapeutic feature of dental stem cells is their self-renewal ability, recognized by 77.3% of respondents. This, along with their potential for trilineage differentiation,

highlights their value in regenerative medicine. [16] The greater awareness among dental surgeons (83.0%) compared to medical doctors (71.6%) may be attributed to the focus on dental applications of stem cells in their curriculum and clinical training. However, concerns remain about the potential cancer risks of stem cell therapies. While 34.7% believed stem cells could lead to cancer, 40.9% were uncertain, reflecting ongoing debates about their oncogenic potential.[16] These concerns underscore the importance of strict regulation and thorough risk assessment in stem cell applications.

The promising future for dental stem cell research is highlighted by the study's results, with optimism being expressed by 72.8% of respondents. The accelerating pace of advancements in regenerative medicine and tissue engineering, as reflected in recent literature, aligns with this enthusiasm. [3,17] Breakthroughs in regenerative therapies through dental stem cell research have potential benefits beyond dentistry. A significant portion of participants expressed willingness to donate extracted teeth for research (33.5%) and preserve dental stem cells for personal use (39.2%), reflecting growing public acceptance of stem cell banking. This aligns with trends in countries like China, where interest in biobanking and personalized medicine is rising. [18] Additionally, 55.7% viewed the dental stem cell industry as a promising investment, highlighting its potential for growth. Similar positive attitudes have been reported globally, including in Saudi Arabia and Malaysia, despite limited public knowledge.[19,20]

Conclusion

In conclusion, this study offers valuable insight into the awareness and perceptions of dental stem cells among dental surgeons and medical doctors. While both groups show strong overall familiarity, notable differences in specific knowledge areas highlight the need for targeted curriculum enhancements and continuing education programs. Strengthening healthcare professionals' understanding of dental stem cells can support more informed clinical decisions and accelerate progress in regenerative therapies. To fully realize the benefits of this emerging field, curriculum developers and policymakers should prioritize integrated training and interprofessional collaboration, while addressing existing clinical, safety, and ethical challenges.

Disclosure/Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study, which was conducted solely for academic purposes to contribute to the body of knowledge on dental stem cells in regenerative medicine.

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Author's Contributions

TB, as the corresponding author, conceived the idea, examined cases. AC interpreted data and contributed to manuscript writing. IAS was responsible for results interpretation and manuscript writing. MAA examined cases and assisted in manuscript writing, while RSN also examined cases and entered data into SPSS. NA and MA contributed to manuscript writing.

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