# Encouraging Attitudes but Insufficient Knowledge of Stem Cell Applications and Banking Among Undergraduate Dental Students: Implications for Curriculum Reform.

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## ABSTRACT:

**Objective:** This study aimed to assess the knowledge and attitudes of undergraduate dental students regarding stem cells and their role in dentistry, including awareness of stem cell banking, and to examine their relationship with demographic characteristics.

**Methodology:** A descriptive cross-sectional survey was conducted among 130 undergraduate dental students at Baqai Medical University, Karachi, Pakistan, between February and May 2020. A validated questionnaire was used to collect demographic data, 15 items on knowledge, and 10 attitude statements measured on a Likert scale. Knowledge was categorized as poor (0–5), moderate (6–10), and good (11–15), while attitude was classified as poor (10–20), moderate (21–30), good (31–40), and excellent (41–50). Data were analyzed using SPSS version 26, with chi-square tests applied to assess associations at a significance level of $p < 0.05$.

**Results:** Students demonstrated a moderate level of knowledge, with 73.1% recognizing stem cells as undifferentiated cells capable of differentiation, though gaps remained regarding their specific role in dentistry. Attitudes were generally favorable: 72.3% expressed willingness to recommend stem cells to future patients, and 81.6% supported public education on the topic. However, only 53.8% felt the curriculum adequately addressed stem cells. No significant association was found between gender and knowledge ($p = 0.90$), but attitudes varied significantly by gender ($p = 0.04$).

**Conclusion:** Dental students exhibited positive attitudes toward stem cell applications in dentistry, yet knowledge gaps highlight the need to strengthen curricular content on regenerative dentistry and stem cell science.

**Keywords:** Stem Cells, Regenerative Endodontics, Dental Pulp, Dental Students, Tissue Engineering.

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## Introduction:

Stem cells are unspecialized cells that have self-renewal capacity and can differentiate into various cell lineages. Stem cell-based regenerative medicine has recently become one the most exciting fields in modern medicine and dentistry. Regeneration aims to repair and restore damaged tissues or to replace them to make dentistry more regenerative-driven.[1-3]

Dental stem cells of mesenchymal origin have shown potential for the regeneration of various dental tissues, especially the pulp-dentin complex, periodontal ligament, and apical papilla. Dental MSCs possess various differentiation potentials, including osteogenic, chondrogenic, adipogenic, and neurogenic lineages. Dental MSCs can be easily obtained from teeth that are extracted for medical reasons or naturally exfoliated from people, which can offer a non-invasive way compared to bone marrow MSCs. Moreover, dental MSCs have immune modulatory and anti-inflammatory characteristics that make them a potential cell resource in regeneration therapy and tissue engineering.[4] Regenerative endodontics may be the most promising aspect in the application of dental MSCs. Although the root canal treatment is successful in removing the infection in the root canal, the devitalized tooth is more susceptible to fracture. Regeneration attempts to restore vital pulp tissue in the root canal, which has the capacity for root development and further dentin deposition. Recent studies have demonstrated promising results on pulp regeneration using both dental pulp stem cells and apical papilla-derived stem cells with biomaterials and growth factors.[5,6] These protocols adopt a tissue engineering strategy comprising stem cells, scaffolds, and signaling molecules to regenerate the pulp-dentin complex and to achieve revascularization within the root canal system.

Beyond endodontics, the use of dental stem cells for regeneration purposes is investigated for periodontal regeneration, bone regeneration for alveolar bone defects, and reconstructive surgeries for craniofacial defects, and also for systemic disease therapy. Clinical trials on periodontal and bone regeneration using dental MSCs showed increased progress.[3] Clinical trials on periodontal and bone regeneration using dental MSCs have shown progressive advancement to translation, and studies show dental MSC-derived exosomes may have the capacity to replace direct

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stem cell transplantation by avoiding issues of potential transplantation-related complications.[7]

Besides, dental stem cell banking also develops along with the rapid progress in regenerative research. Dental stem cell banking contains isolation, manipulation, and cryopreservation of stem cells derived from exfoliated deciduous teeth and impacted or extracted permanent teeth to keep them for future therapy. With advances in cryobiology development, many private and public tooth banks are being built around the world.[8,9]

Ethical and social aspects have also played a crucial role in embracing therapy with stem cells. Although adult dental stem cells can overcome some ethical issues and controversies related to embryonic stem cells, misunderstandings towards ethical permissibility and religious concerns still exist. Education of dental stem cells is of great significance in influencing healthcare professionals' attitudes and knowledge, and their intention to recommend them to patients. There are studies evaluating the knowledge and attitudes of both dental graduates and practitioners, which generally indicate that the respondents possessed moderate awareness but not a thorough understanding of the details and clinical application of dental stem cells.[10]

Despite tremendous progress in the field of dental stem cell research and regenerative medicine, limited information is available concerning knowledge and attitudes towards it among undergraduate dental students in Pakistan, especially for those involving stem cell banking and ethical aspects in recent studies. With the widespread application of dental stem cells and the growing number of stem cell banking facilities in dentistry, it is essential to determine if future dentists are well-informed and possess an appropriate attitude towards it.

This study aimed to investigate undergraduate dental students' knowledge and attitudes towards stem cells in dentistry, including awareness of dental stem cell banking and the relationship between demographics and both parameters.

## Methodology:

Ethical approval was obtained from the Ethics Review Board, Baqai Medical University, Karachi, Pakistan. (BDC/ERB/2019/014). A descriptive cross-sectional survey was conducted to explore dental students' knowledge and attitudes towards stem cells and their use in dentistry at Baqai Medical University, Karachi, Pakistan. Procedures conducted adhered to the Declaration of Helsinki. The survey was conducted from February to May 2020. The study was conducted using a convenience sampling method. All dental students present during the period of data collection who agreed to participate were included, while absent students or unwilling students were excluded from the study. Informed verbal consent was obtained from all students before filling in the questionnaire. The sample size was calculated by OpenEpi software (Version 3.01) based on a prior study on the knowledge of dental students about stem cells.[10] With a population proportion of 50%, at a 95% confidence level and 5% error margin, the calculated required sample size was 120 participants. However, with a 10% expected non-response rate, the sample size was set as 130 participants. Data was collected through a standardized pre-tested questionnaire adapted from other similar studies investigating knowledge and attitude toward stem cells in dentistry.[11] The questionnaire consisted of three sections. Section A had three questions and included the demographic details of the students, i.e., age, sex, and year of study. Section B had fifteen multiple true/false statements and an extra 'I don't know' choice to measure students' knowledge regarding the nature, origin, and possible applications of stem cells in dentistry. Correct answers scored one mark, while wrong or "I don't know" scored zero. A knowledge score was derived for each student (Maximum score 15), which was classified as: poor knowledge (0-5), moderate knowledge (6-10), and high knowledge (11-15). Section C measured Attitude, it comprised of ten statements using a 5-point Likert Scale: strongly agree (5), agree (4), unsure (3), disagree (2), and strongly disagree (1) to assess students awareness, opinions regarding adequacy of curriculum, learning experience, interest in learning and future career choice and other concerns like ethical view regarding stem cell therapy in dentistry. For positively worded statements, the scoring range was from 5 to 1 (strongly agree to strongly disagree). However, for negatively worded statements (Q7 & Q8 about ethics), the scoring was reversed to allow for consistency. An attitude score was derived for each student (Maximum score 50), classified as: poor attitude (10-20), moderate attitude (21-30), good attitude (31-40), excellent attitude (41-50). Statistical analysis was done by using SPSS software (Version 26.0, IBM Corp., Armonk, NY, USA). The demographic data and distribution of the individual knowledge and attitude statements were presented as frequencies and percentages. Chi-square test of independence was utilized to assess the association between categorical independent variables and the dependent variable. The p-value < 0.05 was considered to be statistically significant.

## Result:

Table 1 shows an assessment of the level of knowledge among the 130 dental students. A good proportion (73.1%) knew the basic definition of stem cells, but a large number of knowledge gaps were common. For example, a majority of them (65.4%) think that the stem cells taken from adult bone marrow usually come from the spine, and 51.5% of them think chondrocytes are a type of stem cell. Importantly, there was a substantial degree of uncertainty with over 40% responding 'I don't know' to questions about stem cells taken from dental tissues, stem cell banks available in Pakistan, and the potential for stem cells to continue root formation after injury. Table 2 shows Attitude of the students towards the use of stem cells in dentistry was positive. Majority (72.3%) were positive about using stem cell treatment if available, and even more students agreed (81.6%) to increase public awareness of stem cells. 72.3% of students agree on a separate course for stem cells, but only 53.8% felt that they learned enough about the topic in their current curriculum. While 40% were not confident about moral and religious issues related to the topic, 47.7% were uncertain whether the use of embryonic stem cells should be banned. Table 3 shows Analysis of the relationship between gender and knowledge reported that gender has no significant relation with the level of knowledge (p=0.90) but showed a relationship with the level of attitude (p=0.04). The majority of students reported a moderate level of attitude, where most students were females, but in the "good" level of attitude, male students (54.2%) were greater than females (45.8%).

Table No 1: Assessment of the knowledge depth.

| No | Questions | Responses; n (%) | | |
|---|---|---|---|---|
| | | Yes | No | I don't know |
| 1 | Stem cells are unspecialized type of cells which are capable of forming any cell type. | 95 (73.1%) | 14 (10.8%) | 21 (16.2%) |
| 2 | Human sperms and eggs considered a source of adult stem cells | 76 (58.5%) | 27 (20.8%) | 27 (20.8%) |
| 3 | Stem cells obtained from adult are specialized cells that can form either bone or cartilage only | 59 (45.4%) | 36 (27.7%) | 35 (26.9%) |
| 4 | Embryonic stem cells can be obtained from umbilical cord | 71 (54.6%) | 17 (13.1%) | 42 (32.3%) |
| 5 | Stem cells obtained from dental tissues are considered adult stem cells | 53 (40.8%) | 25 (19.2%) | 52 (40%) |
| 6 | Dental pulp of exfoliated deciduous teeth is considered a useful source of stem cells. | 61 (46.9%) | 22 (16.9%) | 47 (36.2%) |
| 7 | Dental stem cells can form neural cells | 61 (46.9%) | 28 (21.5%) | 41 (31.5%) |
| 8 | Dental stem cells can be retrieved from apical papilla of the tooth | 59 (45.4%) | 20 (15.4%) | 51 (39.2%) |
| 9 | One potential application of stem cells is to allow root formation to continue following trauma | 47 (36.2%) | 23 (17.7%) | 60 (46.2%) |
| 10 | Adult bone marrow stem cells are usually taken from the spine | 85 (65.4%) | 21 (16.2%) | 24 (18.5%) |
| 11 | Sound deciduous incisors and canines are better source of dental stem cells than deciduous molars | 50 (38.5%) | 34 (26.2%) | 46 (35.4%) |
| 12 | Autologous transplant of adult stem cells can fail mainly because of immunogenic reaction | 58 (44.6%) | 25 (19.2%) | 47 (36.2%) |
| 13 | Chondrocytes are considered one type of stem cells | 67 (51.5%) | 31 (23.8%) | 32 (24.6%) |
| 14 | Dental implants derived from stem cells are now available to replace missing teeth | 61 (46.9) | 26 (20) | 43 (33.1) |
| 15 | Stem cell banks are now available in Pakistan | 38 (29.2) | 26 (20) | 66 (50.80) |

Table No 2: Attitude towards use of stem cell.

| No | Questions | Responses; n (%) | | | | |
|---|---|---|---|---|---|---|
| | | Strongly Agree | Agree | unsure | Disagree | Strongly Disagree |
| 1 | I am aware of stem cell research and potential applications of stem cells in dentistry | 26(20) | 51(39.2) | 33(25.4) | 11(8.5) | 9(6.9) |
| 2 | I will recommend treatment with stem cells if it is available | 32(24.6) | 62(47.7) | 29(22.3) | 5(3.8) | 2(1.8) |
| 3 | The curriculum that I have studied contained good amount of information about stem cells and their potential applications in dentistry | 18(13.8) | 52(40) | 37(28.5) | 17(13.1) | 6(4.6) |
| 4 | Adding a special course concerning stem cells to the dental curriculum is advisable | 36(27.7) | 48(44.6) | 27(20.8) | 7(5.4) | 2(1.5) |
| 5 | I have attended scientific activities related to stem cells outside the curriculum | 18(13.8) | 26(20) | 42(32.3) | 33(25.4) | 11(8.5) |
| 6 | I am interested in attending advanced training course about stem cells and their applications in dentistry | 33(25.4) | 47(36.2) | 32(24.6) | 13(10) | 5(3.8) |
| 7 | Use of stem cells in dentistry contradicts ethical and religious principles | 10(7.7) | 34(26.2) | 52(40) | 18(13.8) | 16(12.3) |
| 8 | Use of embryonic stem cells should be prohibited as they are taken from embryo or aborted fetus | 20(15.4) | 30(23.1) | 62(47.7) | 13(10) | 5(39.2) |
| 9 | There should be more public awareness programs about stem cell and their therapeutic applications | 46(35.4) | 47(36.2) | 30(23.1) | 5(3.8) | 2(1.5) |
| 10 | I will consider specializing in dental treatment with stem cells if it becomes a recognized dental specialty in the future | 27(20.8) | 50(38.5) | 36(27.7) | 12(9.2) | 5(3.8) |

**Table No 3: Relationship between gender and knowledge.**

| Variables | Categories | Gender; n (%) | | Total N (%) | p-value |
|---|---|---|---|---|---|
| | | Male | Female | | |
| Knowledge score | Poor | 12(30) | 28(70) | 40(100) | |
| | Moderate | 20(29.9) | 47(70.1) | 67(100) | |
| | High | 8(34.8) | 15(65.2) | 23(100) | 0.90 |
| Attitude score | Poor | 4(28.6) | 10(71.4) | 14(100) | |
| | Moderate | 21(24.4) | 65(75.6) | 86(100) | |
| | Good | 13(54.2) | 11(45.8) | 24(100) | 0.04 |
| | Excellent | 2(33.3) | 4(66.7) | 6(100) | |

## Discussion:

This study assessed dental students' knowledge and attitudes regarding the application and potential role of stem cells in dentistry. Knowledge of stem cells among dental students is relevant since they are most likely the future practitioners to utilize new stem cell therapies in their clinical practice.[11,12] While our results showed moderate knowledge, there were notable gaps in understanding the application of dental stem cells among dental students. In this study, 73.1% of dental students were able to correctly define stem cells as an unspecialized cell that may differentiate into any kind of cell. These findings were similar to studies on dental undergraduates regarding awareness that have been carried out in other regions, where they found that dental undergraduates generally possess adequate but limited knowledge of the details regarding the application of stem cells in dentistry.[13] In our study, only 40.8% of dental students were aware that dental pulp stem cells can be retrieved from the apical papilla, and just 36.2% recognized their role in facilitating root formation after trauma. These knowledge gaps underscore the urgent need to revise dental curricula to incorporate fundamental concepts of stem cell biology and their clinical applications in dentistry.

With regards to the source of dental stem cells, 46.9% knew that dental pulp extracted from shed primary teeth is an important source of stem cells. Stem cells from human exfoliated deciduous teeth (SHED) and other dental mesenchymal stem cells (DMSCs) show great promise for regenerative medicine and tissue engineering applications due to their potent regenerative and immunomodulatory properties.[14,15] Moreover stem cells isolated from apical papilla have the unique properties that make them relevant for root canal therapies.[16] Current regenerative endodontics studies demonstrate that pulp derived stem cell population may aid in pulp-dentin complex regeneration and contribute to further root formation in a correct biological environment.[17] With regards to the students' attitude towards stem cells and their applications, 72.3% were willing to recommend stem cells for patients, and 61.5% are keen to learn about this new technology. However, only 53.8% of the students reported being aware that their dental school provided teaching on stem cells and their applications in dentistry. Similar educational gaps have also been found in recent cross-sectional studies evaluating dental students' readiness regarding regenerative medicine and the curriculum.[18] These findings highlight persistent gaps between scientific advancement and dental undergraduate education.

One of the major prerequisites for the acceptance of stem cell research is that it does not contravene any ethical or religious belief; 53.1% of the participants were able to acknowledge this, while 40% seemed uncertain. Obtaining stem cells from adult dental sources is considered a highly desirable prospect, as it circumvents many of the ethical concerns that are related to embryonic stem cells, and the procedure can be easily performed non-invasively.[14] Yet it seems that some doubt over the ethical and legal implications still surrounds this technology among dental students.[19]

The introduction of a dental stem cell banking service represents a significant step in translational regenerative medicine. Tooth banking, also referred to as cryopreservation of dental stem cells from teeth to provide therapeutic sources in the future, has recently been reviewed and highlighted the need for standardized methods for stem cell isolation, viability testing, and long-term storage to meet their clinical applications.[20] Even with these advancements, the knowledge of the existence of stem cell banking services is low among dental students. In our study, only 29.2% were aware of stem cell banking in Pakistan, which is consistent with reports from low and middle-income countries.[21] It implies that it is necessary to update the curriculum of dentistry across Pakistan as well as to raise public awareness of the new technology.

A noteworthy and statistically significant finding was the association between gender and attitude, with male students being disproportionately represented in the moderate and good attitude categories compared to female students ($p = 0.04$). Gender association with attitudes toward regenerative therapies is inconsistent; some authors have reported the presence of a significant relationship, while others deny a relationship between them.[13,18] In contrast, no significant association was observed with knowledge ($p = 0.90$), indicating that male and female students had same exposure to the theoretical aspects of the subject.

This study carries important implications for curriculum policy across dental colleges, as a substantial proportion of students expressed interest in specialized courses on stem cells, highlighting the demand for formal integration of this subject into dental education. Professional training in dentistry should encompass modules on stem cell biology, regenerative endodontics, principles of tissue engineering, ethical considerations, and stem cell banking technologies.[17,20] Furthermore, hands-on experiences through workshops, seminar presentations, and research activities will enhance the competence and preparedness of future dentists to apply these concepts in clinical practice.

Several limitations should be acknowledged. First, the cross-sectional study design restricts the ability to draw causal inferences. Second, reliance on a self-administered questionnaire introduces the possibility of subjective bias. Third, as all participants were drawn from a single dental school, the findings cannot be generalized to other institutions. Future multicenter studies involving larger student populations would provide stronger evidence regarding dental students' knowledge and attitudes toward stem cells. In addition, longitudinal research is recommended to capture changes over time and to better understand the evolving impact of curricular interventions.

## Conclusion:

Undergraduate dental students demonstrated generally positive attitudes toward stem cell applications in dentistry, yet their knowledge remained moderate with clear gaps in clinical applications and stem cell banking. While most supported stem cell therapies and curricular inclusion, many reported insufficient educational exposure. Knowledge did

not differ significantly by gender, though attitudes varied. These findings underscore the need to integrate regenerative dentistry and stem cell education more effectively into undergraduate curricula to better prepare future dental professionals.

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| Authors' contribution | |
|---|---|
| Arsalan Mirza | Conceived, Literature review, manuscript writing |
| Aisha Wali | Literature review, introduction writing |
| Shakila Nazir | Developed proforma |
| Aisha Kiran | Data analysis |
| Rehana Farooqi | Data Collection |
| Faiza Alavi | Data Collection |