Alqalam Journal of Medical and Applied Sciences. 2025;8(4):2158-2167
https://doi.org/10.54361/ajmas.258412

Original article

Awareness and Practice of Dental Stem Cells, Bio Banking, and Scaffolds Among Dentists in Tripoli, Libya: A Cross-Sectional Study

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Abstract
Dental stem cells (DSC) represent a new path to regeneration as they are readily accessible. Their collection is comparatively non-invasive and requires minimal resources. Knowledge of dental stem cells, their source types, preservation methods, ethical considerations, dental uses, preservation length, and so on is essential for their use in regenerative processes. The study sought to assess and compare dental professionals' knowledge, awareness, and practice of dental stem cells and tooth banking. A cross-sectional, questionnaire-based study. The study involved a total of 186 dentists from Tripoli /Libya, who took part in a cross-sectional questionnaire-based survey that assessed the level of knowledge, attitudes, and practices. The participants are dentists who have different academic and professional experiences and who have worked in public sectors such as healthcare centers, dental faculties, as well as private dental clinics. The study was carried out from July to September 2025. The study's findings showed that preserving DSCs for biobanking purposes was significantly more common among dentists with higher academic qualifications, with 82.8% supporting the practice ($p = 0.016$). When asked about scaffold-supported angiogenesis, academic qualification was significantly associated with beliefs regarding how these technologies improve outcomes ($p = 0.006$), while clinical experience was not ($p = 0.266$). When asked about the role of regenerative endodontic awareness, dentists with doctoral degrees (58.6%). This study suggested dental professionals had an acceptable level of understanding, but there is still a need to raise awareness of the current developments on methods of collection, ethical concerns, and guidelines regarding dental stem cells.
Keywords. Dental Stem Cell, Tooth Banking, Scaffold, Pulp Regeneration.

Introduction

Because hard tissue production by odontoblasts and pulp cells is a critical protective reaction to external stimuli, all efforts must be made to keep them vital and functioning. The dental pulp is divided into four separate zones based on histological analysis. The outermost covering of the pulp is known as the odontoblast layer, and it is composed of odontoblasts that create dentine under normal conditions. A cell-free zone (Weil's zone) is found underneath this layer, notably in the coronal pulp, and it connects to a cell-rich zone with high cell density. The sub-odontoblastic layer refers to both cell-free and cell-rich zones [1].
The pulp tissue also contains many undifferentiated cells that can develop into odontoblast-like cells. Many morphological investigations have revealed that the tooth pulp can generate hard tissues such as dentine and bone [2,3]. The dental pulp of human permanent teeth contains mesenchymal stem cells. They collected single-cell suspensions of dental pulp and then isolated DPSCs, discovering that their proliferation potential is greater than that of bone marrow-derived mesenchymal cells. These DPSCs also exhibit multipotency, with the ability to differentiate into osteoblasts, neuronal cells, and adipocytes [4,5].
Cell replacement therapy using undifferentiated cells be one of the most effective methods for cell and tissue regeneration. It is possible to collect stem cells from dental pulps extracted as pulp extirpation treatment or from a non-functional third molar. For cell replacement therapy, many stem cells would be required. Since stem cells in the dental pulp have higher proliferation ability than those in the other tissues [6,7,8].
Exfoliated deciduous tooth stem cells have been shown to have stronger differentiation potential than other dental stem cells [9,10]. Dental stem cells represent a new path to regeneration as they are easily obtained with minimal invasiveness and fewer resources required for collection. For utilization of dental stem cells in regenerative processes, the progress in dental stem cell applications is accelerating rapidly; therefore, it is essential to deepen our understanding of dental stem cell types, methods of preservation, ethical guidelines, application in dentistry, and so on is critical for their use in the regenerative process [11].
The range of use of biomaterials in regenerative dentistry keeps increasing. Biomaterials can enhance cell proliferation rates and viability. They can modify responses of cells, increase their surface adhesion, differentiation, osteoblastic and odontoblastic activity, osteo-conductivity, mineralization processes, antimicrobial effects, vascularization, and other mechanical and biological functions. These numerous effects determine the applications of biomaterials in regenerative dentistry. Biomaterials in the form of scaffolds have shown favorable properties in restorative dentistry, endodontics, implantology, and maxillofacial surgery. Scaffolds are generally considered as supporting pillars for stem cells that are to be grown. They can be fabricated from different materials, including biomaterials or their combinations. Material selection is crucial for proper in vivo functioning [12].

Received: *30-07-2025* - ***Accepted***: *28-09-2025* - ***Published***: *05-10-2025*

Dental stem cells and tooth banking: knowledge, awareness, and practice. Most studies focused on dental stem cells and neglected stem cell banking [11]. Thus, there is a need to analyze Libyans' understanding of the utilization of dental stem cells and accessible tooth banking methods. The study sought to assess and compare dental professionals' knowledge, awareness, and practice of dental stem cells and tooth banking.

Methods

Study Design and duration

This study was designed as a cross-sectional, questionnaire-based survey that was prepared based on studies and validated by subject experts, and was conducted between July and September 2025.

Convenience Sampling and Participants

A total of 186 dentists were recruited using a convenience sampling technique. Participants included dentists with varying levels of clinical experience, working in the Libyan Ministry of Health's Oral and Dental Health Application and Research Centers in Tripoli, as well as those employed in private dental clinics and university faculties of dentistry. Dentists who failed to complete all sections of the questionnaire were excluded from the final analysis.

Data Collection

Data were collected through a self-administered, hand-delivered questionnaire consisting of 26 items. The instrument was developed after an extensive review of the multidisciplinary literature on dental stem cells (DSCs), including dentistry, cell biology, and regenerative medicine, and was further validated by subject experts to ensure clarity and relevance (11). To enhance participation, the questionnaire was distributed in both online and hard-copy formats.

The questionnaire was divided into two main parts. The first part took demographic characteristics of the participants, including gender, years of clinical experience, and highest academic qualification. The second part assesses knowledge of the existence of DSC, awareness of stem cell banks in Libya, recent advances in stem cell technology, sources of information on the topic, fundamental understanding of DSC, and applications in dental therapy.

Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics for Windows, Version 25.0. Descriptive statistics were used for frequency with percentages for categorized variables. Categorical variables were compared using Chi chi-square test, and a p-value of <0.05 was considered statistically significant.

Results

A total of 186 dentists participated in the study. As shown in (Table 1), the majority were females (58.1%), while males accounted for 41.9%. Regarding clinical experience, (16.7%) of participants had less than 5 years, (25.8%) had 6–10 years, and (57.5%) reported more than 10 years of practice. With respect to academic qualifications, (58.6%) held a Bachelor's degree, (25.8%) a Master's degree, and (15.6%) a Doctoral degree.

Awareness of Dental Stem Cell (DSC) Types

As presented in (Table 2), awareness of recognized DSC types varied significantly with academic qualifications. Overall, (52.2%) of respondents correctly identified "All of the above" as the recognized DSC types. Dentists with higher academic degrees were significantly more likely to select this response compared to those with only a Bachelor's degree ($p = 0.021$). In contrast, DPSCs were specifically identified by (18.2%) of respondents, SHED by 11.8%, and SCAP by (17.8%). No significant association was observed between clinical experience and DSC type recognition ($p = 0.498$).

Dental and Non-Dental Applications of DSCs

When asked about potential dental applications, most respondents (56.5%) selected "All of the above," while (32.3%) highlighted pulp/dentine regeneration specifically (Table 2). Respondents with Doctoral degrees were more likely to emphasize pulp/dentine regeneration compared to those with lower qualifications, though the differences were not statistically significant ($p = 0.257$). Similarly, clinical experience did not significantly influence responses ($p = 0.223$).

In terms of non-dental applications, awareness was generally lower. Only (45.2%) selected "All of the above" correctly. Dentists with more than 10 years of experience were significantly more likely to recognize all non-dental applications compared to those with fewer years of practice ($p = 0.044$). Among individual applications, bone regeneration (18.3%) was most frequently cited, followed by neural regeneration (12.4%), cardiac therapies (9.2%), and muscular dystrophy (2.6%) (Table 2). Academic qualification was not significantly associated with awareness of non-dental applications ($p=0.641$). Ethical concerns regarding DSC use were acknowledged by 54.3% of respondents. As shown in (Table 2), dentists with Master's and Doctoral degrees

Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

were significantly more likely to express ethical concerns compared to those with only a Bachelor's degree (p = 0.002). Approximately one-third of respondents reported being unaware of potential ethical issues.

Awareness of Regenerative Endodontics

Overall, (58.0%) of dentists reported being familiar with regenerative endodontics (Table 3). Interestingly, dentists with less than 5 years of clinical experience demonstrated significantly greater familiarity compared to those with more than 10 years of practice (p = 0.012). However, academic qualifications were not significantly associated with awareness (p = 0.461).

When asked about the role of regenerative endodontics in periapical tissue healing, (67.8%) of respondents expressed positive expectations. Awareness of the Lesion Sterilization and Tissue Repair (LSTR) technique was moderate, with (41.9%) reporting familiarity. Although awareness was higher among dentists with Doctoral degrees (58.6%), the differences by clinical experience and qualification were not statistically significant (p = 0.794 and p = 0.125, respectively).

Awareness of 3D-Printed Scaffolds

As illustrated in (Table 4), awareness of 3D-printed scaffolds varied significantly with clinical experience. Only (14.0%) reported actively following current research, while (62.9%) were aware of the topic but expressed the need for additional training. Dentists with less than 5 years of experience were significantly less familiar compared to those with 6–10 years of practice (p = 0.001). Academic qualification did not significantly affect awareness (p = 0.606).

Regarding suitable scaffold materials, natural biomaterials (35.5%) and biodegradable hydrogels (22.0%) were most frequently selected, whereas (35.5%) admitted they were unsure. Knowledge gaps were evident, and recognition of appropriate scaffold types was significantly associated with clinical experience (p = 0.001) but not academic qualification (p = 0.109).

When evaluating scaffold characteristics, most dentists emphasized biocompatibility (83.3%) as essential, whereas fewer considered mechanical stability (25.3%) or drug-delivery capabilities (15.5%) to be important. No significant associations with either experience or qualification were observed (p > 0.05).

Dental Stem Cell Banking and Barriers to Use

As shown in (Table 5), (38.7%) of respondents stated that they would consider collecting or preserving DSCs for banking purposes. This was significantly more common among dentists with higher academic degrees, with (82.8%) of them supporting the practice (p = 0.016). Clinical experience, however, did not significantly influence attitudes toward banking (p = 0.068). Attendance at continuing education programs on DSCs or tooth banking was reported by (62.4%) of participants, with no significant associations with either experience or qualification.

Use of scaffolds in clinical practice was generally low, with (73.6%) reporting they had never used them. Notably, less experienced dentists (under five years of practice) were significantly more likely to report scaffold use (p = 0.001), while academic qualifications showed no significant effect (p = 0.536).

The most frequently reported barriers to DSC utilization included lack of training or knowledge (73.7%), regulatory restrictions (29.6%), high material costs (24.2%), and low patient acceptance (23.7%). These barriers were significantly associated with both clinical experience (p = 0.009) and academic qualification (p = 0.001).

When asked about scaffold-supported angiogenesis, 65.6% considered it to be "very important," with no significant variation by experience or academic level. Respondents also emphasized that combining stem cells with scaffolds could enhance pulp engineering outcomes, primarily through optimized growth factor delivery (31.7%), improved tissue integration (22.6%), and increased cell survival (17.2%). Interestingly, academic qualification was significantly associated with beliefs regarding how these technologies improve outcomes (p = 0.006), while clinical experience was not (p = 0.266).

Table 1. Demographic characteristics among participants

Variable		Frequency	Percentage
Gender:	Male	78	41.9%
	Female	108	58.1%
Years of Clinical Experience	< 5 years	31	16.7%
	6–10 years	48	25.8%
	> 10 years	107	57.5%
Highest Academic Qualification	Bachelor's Degree	109	58.6%
	Master's Degree	48	25.8%
	Doctoral Degree	29	15.6%

Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

https://doi.org/10.54361/ajmas.258412

Table 2. Knowledge, Applications, and Ethical Concerns of Dental Stem Cells by Clinical Experience and Academic Qualification

Survey Item	Response	Total (n, %)	Clinical Experience			p-value	Academic qualification			p-value
			<5 years (n, %)	6–10 years (n, %)	>10 years (n, %)		Bachelor's (n, %)	Master's (n, %)	Doctoral (n, %)	
Recognized Types of DSCs	DPSCs	34 (18.2)	6 (19.4)	9 (18.8)	19 (17.8)	0.498[C]	25 (22.9)	8 (16.7)	1 (3.4)	**0.021[C]**
	SHED	22 (11.8)	6 (19.4)	6 (12.5)	10 (9.3)		13 (11.9)	6 (12.5)	3 (10.3)	
	SCAP	33 (17.8)	4 (12.9)	12 (25.0)	17 (15.9)		29 (26.6)	2 (4.2)	2 (6.9)	
	All of the above	97 (52.2)	15 (48.4)	21 (43.8)	61 (57.0)		42 (38.5)	32 (66.7)	23 (79.3)	
	Not aware	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Potential Dental Applications	Whole-tooth regeneration	8 (4.3)	1 (3.2)	1 (2.1)	6 (5.6)	0.223[C]	3 (2.8)	4 (8.3)	1 (3.4)	0.257[C]
	Periodontal/Alveolar regeneration	13 (6.8)	2 (6.5)	3 (6.3)	8 (7.5)		7 (6.4)	6 (12.5)	0 (0.0)	
	Pulp/Dentine regeneration	60 (32.3)	5 (16.1)	14 (29.2)	41 (38.3)		28 (25.7)	15 (31.3)	17 (58.6)	
	All of the above	105 (56.5)	23 (74.2)	30 (62.5)	52 (48.6)		71 (65.1)	23 (47.9)	11 (37.9)	
	Not aware	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	0 (0.0)	
Non-Dental Applications	Cardiac therapies	17 (9.2)	4 (12.9)	2 (4.2)	11 (10.3)	**0.044[C]**	9 (8.3)	4 (8.3)	4 (13.8)	0.641[C]
	Neural regeneration	23 (12.4)	2 (6.5)	3 (6.3)	18 (16.8)		8 (7.3)	4 (8.3)	11 (37.9)	
	Muscular dystrophy	5 (2.6)	3 (9.7)	0 (0.0)	2 (1.9)		4 (3.7)	0 (0.0)	1 (3.4)	
	Bone regeneration	34 (18.3)	7 (22.6)	10 (20.8)	17 (15.9)		18 (16.5)	11 (22.9)	5 (17.2)	
	All of the above	84 (45.2)	12 (38.7)	29 (60.4)	43 (40.2)		54 (49.5)	23 (47.9)	7 (24.1)	
	None of the above	23 (12.4)	3 (9.7)	4 (8.3)	16 (15.0)		16 (14.7)	6 (12.5)	1 (3.4)	
Ethical Concerns in DSC Use	Yes	101 (54.3)	14 (45.2)	32 (66.7)	55 (51.4)	0.357[C]	47 (43.1)	32 (66.7)	22 (75.9)	**0.002[C]**
	No	21 (11.3)	4 (12.9)	4 (8.3)	13 (12.1)		13 (11.9)	6 (12.5)	2 (6.9)	
	Not aware	64 (34.4)	13 (41.9)	12 (25.0)	39 (36.4)		49 (45.0)	10 (20.8)	5 (17.2)	

C: Chi-square test. P < 0.05 is statistically significant

Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

https://doi.org/10.54361/ajmas.258412

Table 3. Awareness and Perceptions of Regenerative Endodontics by Clinical Experience and Academic Qualification

Survey Item	Response	Total (n, %)	Clinical Experience			p-value	Academic qualification			p-value
			<5 years (n, %)	6–10 years (n, %)	>10 years (n, %)		Bachelor's (n, %)	Master's (n, %)	Doctoral (n, %)	
Are you familiar with regenerative endodontics?	Yes	108 (58.0)	24 (77.4)	31 (64.6)	53 (49.5)	**0.012**[C]	64 (58.7)	30 (62.5)	14 (48.3)	0.461[C]
	No	78 (42.0)	7 (22.6)	17 (35.4)	54 (50.5)		45 (41.3)	18 (37.5)	15 (51.7)	
Can regenerative endodontics enhance the healing of periapical tissues?	Yes	126 (67.8)	23 (74.2)	31 (64.6)	72 (67.3)	0.221[C]	69 (63.3)	36 (75.0)	21 (72.4)	0.556[C]
	No	4 (2.1)	0 (0.0)	3 (6.3)	1 (0.9)		3 (2.8)	1 (2.1)	0 (0.0)	
	Unsure	56 (30.1)	8 (25.8)	14 (29.2)	34 (31.8)		37 (33.9)	11 (22.9)	8 (27.6)	
Are you aware of the LSTR technique?	Yes	78 (41.1)	12 (38.7)	22 (45.8)	44 (41.1)	0.794[C]	41 (37.6)	20 (41.7)	17 (58.6)	0.125[C]
	No	108 (58.9)	19 (61.3)	26 (54.2)	63 (58.9)		68 (62.4)	28 (58.3)	12 (41.4)	

C: Chi-square test. P < 0.05 is statistically significant

Table 4. Awareness and Perceptions of 3D-Printed Scaffolds by Clinical Experience and Academic Qualification

Survey Item	Response	Total (n, %)	Clinical Experience			p-value	Academic qualification			p-value
			<5 years (n, %)	6–10 years (n, %)	>10 years (n, %)		Bachelor's (n, %)	Master's (n, %)	Doctoral (n, %)	
Awareness of 3D-printed scaffolds	Yes, I follow current research	26 (14.0)	3 (9.7)	15 (31.3)	8 (7.5)	**0.001**[C]	16 (14.7)	6 (12.5)	4 (13.8)	0.606[C]
	Yes, but I require further training	117 (62.9)	20 (64.5)	19 (39.6)	78 (72.9)		64 (58.7)	32 (66.7)	21 (72.4)	
	No	43 (23.1)	8 (25.8)	14 (29.2)	21 (19.6)		29 (26.6)	10 (20.8)	4 (13.8)	
Suitable scaffold type for pulp tissue engineering	Biodegradable hydrogels	41 (22.0)	8 (25.8)	16 (33.3)	17 (15.9)	**0.001**[C]	21 (19.3)	14 (29.2)	6 (20.7)	0.109[C]
	Synthetic polymers	13 (6.9)	1 (3.2)	9 (18.8)	3 (2.8)		10 (9.2)	2 (4.2)	1 (3.4)	
	Natural biomaterials	66 (35.5)	12 (38.7)	11 (22.9)	43 (40.2)		33 (30.3)	17 (35.4)	16 (55.2)	
	I do not know	66 (35.5)	10 (32.3)	12 (25.0)	44 (41.1)		45 (41.3)	15 (31.3)	6 (20.7)	
Essential attributes of an ideal scaffold	Biocompatibility	155 (83.3)	26 (89.7)	41 (85.4)	88 (88.9)	0.647[C]	86 (84.3)	42 (93.3)	27 (93.1)	0.671[C]
	Mechanical stability	47 (25.3)	8 (27.6)	11 (22.9)	28 (28.3)		28 (27.5)	13 (28.9)	6 (20.7)	
	Drug-delivery capability	29 (15.5)	8 (27.6)	6 (12.5)	15 (15.2)		16 (15.7)	8 (17.8)	5 (17.2)	

C: Chi-square test. P < 0.05 is statistically significant

Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

https://doi.org/10.54361/ajmas.258412

Table 5. Responses on Dental Stem Cell (DSC) Banking and Scaffold Use According to Clinical Experience and Academic Qualification

Survey Item	Response	Total (n, %)	Clinical Experience			p-value	Academic qualification			p-value
			<5 years (n, %)	6–10 years (n, %)	>10 years (n, %)		Bachelor's (n, %)	Master's (n, %)	Doctoral (n, %)	
Would you collect/preserve DSCs for banking?	Yes	72 (38.7)	16 (51.6)	22 (45.8)	34 (31.8)	0.068[C]	50 (45.9)	17 (35.4)	5 (17.2)	**0.016[C]**
	No	114 (61.3)	15 (48.4)	26 (54.2)	73 (68.2)		59 (54.1)	31 (64.6)	24 (82.8)	
Would you attend continuing education on DSCs/tooth banking?	Yes	116 (62.4)	20 (64.5)	28 (58.3)	68 (63.6)	0.795[C]	64 (58.7)	35 (72.9)	17 (58.6)	0.216[C]
	No	70 (37.6)	11 (35.5)	20 (41.7)	39 (36.4)		45 (41.3)	13 (27.1)	12 (41.4)	
How often do you use scaffolds with stem cells in practice?	Frequently	8 (4.3)	6 (19.4)	2 (4.2)	0 (0.0)	**0.001[C]**	7 (6.4)	1 (2.1)	0 (0.0)	0.536[C]
	Occasionally	8 (4.3)	2 (6.5)	1 (2.1)	5 (4.7)		6 (5.5)	2 (4.2)	0 (0.0)	
	Rarely	33 (17.7)	5 (16.1)	15 (31.3)	13 (12.1)		19 (17.4)	9 (18.8)	5 (17.2)	
	Never	137 (73.6)	18 (58.1)	30 (62.5)	89 (83.2)		77 (70.6)	36 (75.0)	24 (82.8)	
What challenges hinder DSC use in practice?	Lack of training/knowledge	137 (73.7)	23 (74.2)	29 (63.0)	85 (81.7)	**0.009[C]**	70 (66.7)	42 (89.4)	25 (86.2)	**0.001[C]**
	Regulatory restrictions	53 (28.4)	9 (29.0)	15 (32.6)	21 (20.2)		33 (31.4)	11 (23.4)	1 (3.4)	
	High material costs	45 (24.2)	12 (38.7)	10 (21.7)	23 (22.1)		30 (28.6)	11 (23.4)	4 (13.8)	
	Low patient acceptance	44 (23.7)	13 (41.9)	12 (26.1)	19 (18.3)		32 (30.5)	7 (14.9)	5 (17.2)	
Essential attributes of an ideal scaffold	Biocompatibility	155 (83.3)	26 (89.7)	41 (85.4)	88 (88.9)	0.647[C]	86 (84.3)	42 (93.3)	27 (93.1)	0.671[C]
	Mechanical stability	47 (25.3)	8 (27.6)	11 (22.9)	28 (28.3)		28 (27.5)	13 (28.9)	6 (20.7)	
	Drug-delivery capability	29 (15.6)	8 (27.6)	6 (12.5)	15 (15.2)		16 (15.7)	8 (17.8)	5 (17.2)	

Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

Discussion

Advances in stem cell research hold promising potential to repair and regenerate dental tissues, including pulp, dentine, and periodontium, as well as broader medical applications such as bone and neural tissue repair [10,11]. Regenerative dentistry relies on stem cells, gene therapy, and other approaches, but clinical use is limited and raises ethical considerations [13]. Adequate knowledge and positive attitudes among dentists are essential for the implementation of these therapies. In Tripoli, limited curriculum coverage and few specialized centers may contribute to gaps in awareness, highlighting the need to assess dentists' knowledge, attitudes, and perceptions regarding stem cell applications.

In the present study, dentists' understanding of dental stem cell (DSC) types was significantly associated with academic qualifications, with 52.2% correctly identifying multiple DSC types ($p = 0.021$). Similarly, Nagappan et al. reported universal awareness of stem cells among dentists, with most recognizing their differentiation potential and applications in dentistry, though a notable proportion expressed uncertainty about specific functions [14].

In the present study, 54.3% of respondents reported ethical concerns regarding the use of dental stem cells (DSCs). Dentists with master's and doctoral degrees were significantly more likely to express such concerns compared to those holding only a bachelor's degree ($p = 0.002$). These results are in agreement with Katge et al. [15], who reported that Indian dentists recognize ethical challenges associated with DSC use. Similarly, Sede et al. [11] emphasized that, despite advances in stem cell research, both practitioners and patients face obstacles such as limited awareness, high costs, and ethical considerations in dental applications. Dental stem cells (DSCs) are considered among the safest sources of stem cells and possess diverse regenerative potentials, making their storage essential [16]. The importance of dental stem cell banking has been emphasized by Davies and Scheven, who described it as a form of biological insurance that preserves cells with the same genetic composition for potential future therapeutic use [17]. In the present study, participants across all groups demonstrated limited knowledge regarding methods for DSC preservation and the ethical standards governing their clinical application, consistent with the findings of Katge et al. [15].

Furthermore, the study identified the primary barriers to pursuing dental stem cell therapy as lack of training or knowledge (73.7%), regulatory restrictions (29.6%), high material costs (24.2%), and low patient acceptance (23.7%). These barriers were significantly associated with both clinical experience ($p = 0.009$) and academic qualification ($p = 0.001$), in line with the observations reported by Katge et al. [15].

The term "regenerative endodontics" was adopted by the American Association of Endodontics in 2007. Revascularization and revitalization—two other similar concepts—are used interchangeably. All techniques aimed at restoring and repairing the affected tissue's physiological shape is included in the category of regenerative endodontic procedures. Over half of the participants in this survey (58%) were aware of regenerative endodontics (RE). Like the findings by Devika B, J, and Mahalakshmi [18], it's noteworthy that dentists with less than five years of clinical experience were much more familiar than dentists with more than 10 years of practice [19]. These positive results regarding recent graduates can be attributed to major advancements in all aspects of dentistry in Tripoli, Libya, as well as increased awareness of the field through forums such as meetings and conferences on stem cell therapies and continuing dental education programmes, as well as improved knowledge of the subject through scientific journals. This finding is consistent with Epelman et al.'s study [20], which examined how enthusiastic dental professionals were about regenerative endodontics. Different results were seen in the study by Goyal A R et al. [21], in which most of the study participants had poor knowledge regarding regenerative endodontics.

Whenever participants asked about the importance of regenerative endodontics in periapical tissue repair, 67.8% of respondents had positive expectations. These findings are consistent with the research undertaken by Mohamed Jamal et al. [22] and Subba, T.A. et al. [23].

This finding lines up with previously published work that delves deeper into the subject, with the majority of successful instances conducted on necrotic immature teeth [24]. Furthermore, current information and research data on RE in mature teeth demonstrate that it heals periapical lesions but does not restore tooth life [25]. As a result, in older teeth, RE is unlikely to give a meaningful advantage over current conventional endodontic treatment techniques with a high success rate.

In the present study, 41.9% of respondents indicated that the Lesion Sterilization and Tissue Repair (LSTR) process was moderately well known. Awareness of this regenerative endodontic procedure did not differ significantly across dentists' clinical experience or professional qualifications, although those holding doctoral degrees demonstrated a higher level of familiarity. These findings are consistent with those reported by Mahalakshmi [18], who observed similar trends in knowledge and perceptions among dental practitioners. Overall, the results suggest that participants in this study maintained a responsible approach toward regenerative endodontic procedures and possessed a generally thorough understanding of regenerative endodontic therapy, reflecting a positive orientation toward adopting contemporary dental innovations.

Tissue engineering is a rapidly growing area of practice in regenerative dentistry that involves developing biological substitutes to restore the function of damaged tissues (for example, the nerve of a tooth or dental pulp). By employing regenerative endodontic approaches, clinicians can address the following important principles of regeneration: disinfection, a supportive scaffold, and growth and chemotactic factors to direct stem cell behavior [26].

Received: *30-07-2025* - ***Accepted***: *28-09-2025* - ***Published***: *05-10-2025*

In the present study, a significant variation in practitioners' awareness of scaffold materials was observed. While 35.5% of respondents recognized natural biomaterials and 22.0% acknowledged biodegradable hydrogels as suitable scaffold materials, the largest proportion (35.5%) expressed uncertainty. This finding highlights a notable knowledge gap within the dental community regarding this emerging field, consistent with the results of a survey conducted by Naika et al. in India in 2023, which similarly reported limited awareness of current regenerative endodontic protocols and scaffold materials among practicing dentists [27].

Clinician familiarity with scaffold type also had a strong association with clinical experience ($p = 0.001$), which suggested that hands-on practice was a more important factor in knowledge than having an academic qualification at this level ($p = 0.109$). In terms of scaffold properties, practitioners indicated they prioritized biocompatibility most (83.3% of respondents), demonstrating their predominant concern around patient safety and tissue integration. Only 25.3% indicated mechanical stability would be important, and 15.5% indicated importance placed on drug-delivery capabilities. This may have indicated a lack of awareness of these properties; however, the difference in knowledge may signify a lack of understanding of the importance of these properties. Mechanical stability supports the structural integrity of the scaffold when subjected to physiological forces, and drug-delivery stability is required so that bioactive molecules can be released for regulatory purposes [28].

The adoption of emerging technologies, such as 3D-printed scaffolds, also varied considerably among participants. Only 14.0% of respondents reported actively following research on this topic, whereas a majority (62.9%) indicated a need for additional training. Dentists with five years or less of clinical experience exhibited a more pronounced knowledge gap compared to more experienced practitioners. This is particularly relevant given the rapidly advancing field of three-dimensional (3D) printing, or additive manufacturing, which holds substantial potential for tissue and organ regeneration. 3D printing enables the precise, layer-by-layer deposition of cells, biomaterials, and bioactive molecules to fabricate complex structures that closely mimic the natural extracellular matrix. Customized scaffolds produced through this technology offer high accuracy and precision, enhancing their potential for clinical applications in regenerative dentistry [29].

The critical role of vascularization in tissue regeneration was highlighted in the present study, with 65.6% of respondents rating scaffold-based angiogenesis as "very important." This aligns with existing literature, which emphasizes that the formation of new blood vessels supplies essential oxygen and nutrients to cells, a key factor in effective tissue healing. Contemporary tissue engineering strategies increasingly advocate the use of scaffolds incorporated with angiogenic factors to promote and sustain vascularization [30].

Additionally, respondents noted the demonstrated value in combining scaffold technologies with stem cells, particularly to enhance growth factor delivery (31.7%) and facilitate tissue integration (22.6%). The strong association between academic qualifications and beliefs regarding scaffold technologies ($p = 0.006$) implies that having more formal education has influenced clinician perception about the potential of these technologies, demonstrating similar research advances that have been discussed in the literature recently regarding tissue engineering strategies. The importance of this approach becomes clear since the scaffold would serve as the vehicle for growth factors and integration necessary to tackle challenges associated with pulp regeneration [31].

Although the potential for scaffolds has been established, it is notable that only 26.4% of dentists reported using scaffolds in their clinical practice. This suggests a clear disconnect between knowledge acquired through education and clinical implementation. Conclusion: These findings suggest the need for specific educational programs and continuing educational initiatives to address identified knowledge gaps, including aspects related to material characteristics of scaffolds, and next-level fabrication technologies such as 3D printing, to facilitate the promise of pulp tissue engineering becoming a clinical reality.

This study has several limitations. The sample included fewer dental specialists compared to general practitioners, which may have influenced the overall level of knowledge reported. Moreover, the limited availability of specialized centers for stem cell banking and regenerative procedures in Tripoli limited participants' practical exposure. Lastly, the current dental curriculum in the region offers minimal coverage of stem cell biology and tissue engineering, contributing to knowledge gaps among practitioners. These issues should be considered when interpreting the results.

Conclusion

This study suggested that there was awareness among dental professionals regarding dental stem cells, but still, there was still a lack of knowledge on the method of collection, ethical concerns, and guidelines regarding dental stem cells. It was found that there are many obstacles, like high cost, patient acceptance, ethical issues, and insufficient knowledge among patients and professionals. There is a need for increasing the horizon of dental stem cells and make professionals skilled and patients aware of it so that these can be used for regeneration. The dental curriculum and educational programmes should include details regarding dental stem cells, storage techniques, and time. Therefore, it will open new ways for dental stem cell therapy in the field of dentistry. There is a need for future vivo research and increased applicability of dental stem cells in treatment in the field of dentistry. These findings highlight a pressing need for targeted educational

Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

initiatives and professional training programmes. Bridging the identified knowledge gaps, particularly concerning scaffold characteristics and advanced fabrication techniques like 3D printing, is essential for translating the promise of pulp tissue engineering into widespread clinical reality.

Disclaimer
The article has not been previously presented or published and is not part of a thesis project.

Conflict of Interest
There are no financial, personal, or professional conflicts of interest to declare.

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Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*

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Received*: 30-07-2025 -* ***Accepted****: 28-09-2025 -* ***Published****: 05-10-2025*