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ORIGINAL ARTICLE

Assessment of knowledge and attitude toward stem cells and their implications in dentistry among recent graduates of dental schools in Saudi Arabia

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KEYWORDS

Stem cells;
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Abstract *Background:* To evaluate the knowledge and attitude level of recent dental graduates in Saudi Arabia toward stem cells and their potential therapeutic applications.

Methods: In this cross-sectional study, a questionnaire was distributed among 606 recent graduates from 14 dental schools in Saudi Arabia. Fifteen statements were formulated to address the knowledge component with "yes" or "no" or "I do not know" answer and 10 statements were designed to assess the attitude level with Likert 5-point response scale. The level of knowledge for each respondent was designated as poor if the score value is (0–5), moderate (6–10), and high (11–15). To evaluate the attitude level for each respondent, a score of (1) was assigned for extremely negative answer and (5) for extremely positive answer for each statement. Based on the total score, attitude level was considered poor when the score value is (10–29), moderately positive (30–39), good (40–44), or excellent (45–50).

Results: Significant difference was found in the knowledge score between males and females ($p = 0.004$). Both males and females showed poor knowledge with a mean score of 5.06 ± 2.5 and 5.63 ± 2.4, respectively. There was an overall moderately positive attitude of participants toward stem cells and their therapeutic applications with a mean value of 33.15 ± 5.92 with no significant difference between males and females ($p = 0.53$). A significant positive linear correlation

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was detected between knowledge and attitude for both males ($r = 0.323$, $p = 0.00$) and females ($r = 0.392$, $p = 0.00$).

Conclusion: Updating dental curricula with topics on stem cell research and potential future applications in dentistry is demanded.

1. Introduction

Stem cells are undifferentiated immature cells which have the ability to multiply and form a specific cell or tissue type (Nuti et al., 2016). The two main categories of stem cell are embryonic stem cells and adult stem cells (Nuti et al., 2016). Stem cells from dental origin are of adult type that can be derived from tooth structure (Ramamoorthi et al., 2015). Sources of postnatal dental stem cells include dental pulp, exfoliated primary teeth, periodontal ligament, apical papilla, and dental follicle progenitor cells (Gronthos et al., 2000).

Stem cell research is a promising branch of dental sciences. The possible applications of stem cells in dentistry are numerous, especially when considering that dental stem cells can be easily collected and saved for future use (Gronthos et al., 2000). For example, stem cells have been used for alveolar bone augmentation during dental implant insertion (Egusa et al., 2012). A tissue-engineered osteochondral construct using adult stems cells molded into the shape of a human mandibular condyle has been reported (Alhdlaq and Mao, 2005).

Dentists can play a significant role in collecting stem cells not only for dental applications but also for the potential treatment of medical illnesses. For example, stem cells of dental origin have shown potential use in treating heart diseases, regenerating neural tissue, and repairing cranial defects (Park et al., 2016). However, dentists are expected to possess the required knowledge about stem cells and have a positive attitude toward their applications in order to advance the utilization of stem cell in dentistry and medicine.

Previous reports have demonstrated variable levels of stem cell knowledge and attitude and their potential applications by health professionals and students of health science schools across various countries. For example, in India, there was a positive attitude towards use of stem cells in dentistry; however, their knowledge was inadequate (Katge et al., 2017). Students in other health disciplines, such as nursing students in Malaysia, showed a moderate knowledge and a positive attitude toward the therapeutic potential of stem cells (Lye et al., 2015). A recent study performed in Saudi Arabia indicated poor knowledge about stem cells in a sample of nursing students, along with a positive attitude toward stem cell therapy (Mohamed and Azzazy, 2016). Whereas, the same study showed a positive effect of educational intervention on the level of knowledge and attitude about stem cell therapy among nursing students and recommended updating the nursing curriculum with essential concepts about stem cell therapy.

To our knowledge, there are no published reports assessing knowledge and/or attitude regarding stem cells and their therapeutic potential applications among dentists in Saudi Arabia. Such assessment if performed among recent graduates may reflect the amount of exposure of dental students to the topic during their dental education and thus help in making any necessary recommendations. The current study aimed to assess the knowledge and attitude of recently graduated dentists in Saudi

Table 1 Sample distribution based on school and gender (n = 606).

		Male	Female	Total
Governmental	King Saud University	54	39	93
	King Saud Bin Abdulaziz University for Health Sciences	15	–	15
	King Abdulaziz University	47	48	95
	University of Dammam	24	–	24
	King Khalid University	31	23	54
	Umm Al QuraUniversity	3	7	10
	Jazan University	20	13	33
	Qassim University	–	8	8
	University of Hail	11	16	27
	Prince Sattam Bin Abdulaziz University	3	–	3
	AlJouf University	9	–	9
Total		217	154	371
Private	Riyadh Colleges of Dentistry and Pharmacy	41	49	90
	Al Farabi College for Dentistry and Nursing	41	70	111
	Qassim Private Colleges	20	14	34
Total		102	133	235
Grand total		319	287	606

Arabia toward stem cells and their potential therapeutic applications in dentistry.

2. Materials and methods

This study is a questionnaire-based cross-sectional study that was conducted in Saudi Arabia from July 2016 to April 2017. A paper-format questionnaire was distributed among all recent graduates in 2016 (dental interns) at 14 governmental and private dental schools. All dental schools in Saudi Arabia with at least one batch of dental graduates were included in this study. Approval to conduct this study was obtained from the Research Center at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia (CDRC application # IR 0185).

There were 14 dental schools included in this study; 11 governmental and 3 private. The number of questionnaires sent to each school and the number of respondents from each school are presented in Table 1.

The questionnaire was prepared in English language based on a review of the literature concerning stem cells and their applications in dentistry. An Arabic translation was prepared to assure full understanding of participants to the questions due to expected variability of English proficiency among participants. One dental intern at each dental school was assigned to handle the manual distribution and collection of the questionnaires. The questionnaire started with an informed consent from the participant, followed by collection of some demographic data including age, gender and University/College. This was followed by a group of twenty-five close-ended questions that were divided into two parts: the first was intended to assess dental interns' knowledge, while the second part aimed to investigate the attitude of participants toward stem cells and their potential applications in dentistry.

The knowledge portion of the questionnaire consisted of 15 statements with three possible responses: "Yes", "No" or "I don't know". Instructions were given to respondents to choose only one answer for each statement. The correct answer was

Please check (√) the appropriate box for each of the following statements:		Yes	No	I don't know
1.	Stem cells are unspecialized type of cells which are capable of forming any cell type.	✓		
2.	Human sperms and eggs are considered a source of adult stem cells.		✓	
3.	Stem cells obtained from adults are specialized cells that can form either bone or cartilage only .		✓	
4.	Embryonic stem cells can be obtained from umbilical cord .		✓	
5.	Stem cells obtained from dental tissues are considered adult stem cells .	✓		
6.	Dental pulp of exfoliated deciduous teeth is considered a useful source of stem cells.	✓		
7.	Dental stem cells can form neural cells.	✓		
8.	Dental stem cells can be retrieved from apical papilla of the tooth.	✓		
9.	One potential application of stem cells is to allow root formation to continue following trauma	✓		
10.	Adult bone marrow stem cells are usually taken from the spine		✓	
11.	Sound deciduous incisors and canines are better source of dental stem cells than deciduous molars .	✓		
12.	Autologous transplant of adult stem cells can fail mainly because of immunogenic reaction.		✓	
13.	Chondrocytes are considered one type of stem cells.		✓	
14.	Dental implants derived from stem cells are now available to replace missing teeth.		✓	
15.	Stem cell banks are now available in Saudi Arabia	✓		

Fig. 1 Answer key for knowledge part of the questionnaire.

given a score of (1) and the wrong answer was given a score of (0). The answer "I don't know" was also given a score of (0). The level of knowledge was divided into three categories based on the total score of each respondent: poor (0–5), moderate (6–10), and high (11–15). The portion of the questionnaire related to knowledge assessment, along with the expected correct answer for each statement is shown in Fig. 1.

The attitude portion of the questionnaire consisted of 10 statements that suggested the degree of agreement or disagreement with each statement using a 5-point Likert scale (Sullivan et al., 2013). Participants were instructed to choose only one answer for each statement. Score of (10) to (50) was given for the attitude section (a score of 1 for extremely negative answer and a score of 5 for extremely positive answer). Attitude level was divided into four categories based on the total score of each respondent: poor (10–29), moderate (30–39), good (40–44), and excellent (45–50) (Lye et al., 2015). The portion of the questionnaire related to attitude assessment is shown in Fig. 2.

After collection, the data were analyzed using the Statistical Package for the Social Sciences (Version 22.0, SPSS, Chicago, IL, USA). Independent sample *t*-test was used to assess the difference between males and females scores for both knowledge and attitude. Pearson correlation was used to determine the association between knowledge and attitude, while Chi-square test was used to determine the association between the variables of the study. The significance level for all tests was set at 95% confidence interval ($p < 0.05$).

3. Results

Of the 800 surveys that were distributed, 606 questionnaires were completed and collected from recent dental graduates of the 14 dental schools, yielding a response rate of 75.7%. The male-to-female ratio of the respondents was approximately 1:1, with 319 males and 287 females. Descriptive statistics of the sample are presented in Table1.

A significant difference was noted between males and females in the knowledge score using independent sample *t*-test ($p = 0.004$), with a mean knowledge score of 5.06 ± 2.5 for males and 5.63 ± 2.4 for females (Table 7). Accordingly, all data related to knowledge score for males and females was segregated for any further analysis. The number and

Please rate your level of agreement with the following statements by checking (√) the appropriate box:		Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
1.	I am aware of stem cell research and potential applications of stem cells in dentistry					
2.	I will you recommend treatment with stem cells if it is available					
3.	The curriculum that I have studied contained good amount of information about stem cells and their potential applications in dentistry					
4.	Adding a special course concerning stem cells to the dental curriculum is advisable					
5.	I have attended scientific activities related to stem cells outside the curriculum					
6.	I am interested in attending advanced training course about stem cells and their applications in dentistry					
7.	Use of stem cells in dentistry contradicts ethical and religious principles					
8.	Use of embryonic stem cells should be prohibited as they are taken from embryo or aborted fetus					
9.	There should be more public awareness programs about stem cells and their therapeutic applications					
10.	I will consider specializing in dental treatment with stem cells if it becomes a recognized dental specialty in the future?					

Fig. 2 Attitude assessment statements.

Table 2 Number and percentage of correct/incorrect responses to knowledge statements mong dental interns (n = 606).

Knowledge statement	No. of correct responses (%)	No. of incorrect responses (%)	Total	*p*-value
1. Stem cells are unspecialized type of cells which are capable of forming any cell type.	432 (71.3)	174 (28.7)	606 (100)	<0.001
2. Human sperms and eggs are considered a source of adult stem cells.	222 (36.6)	384 (63.4)	606 (100)	<0.001
3. Stem cells obtained from adults are specialized cells that can form either bone or cartilage only.	233 (38.4)	373 (61.6)	606 (100)	<0.001
4. Embryonic stem cells can be obtained from umbilical cord.	84 (13.9)	522 (86.1)	606 (100)	<0.001
5. Stem cells obtained from dental tissues are considered adult stem cells.	296 (48.8)	310 (51.2)	606 (100)	0.448
6. Dental pulp of exfoliated deciduous teeth is considered a useful source of stem cells.	263 (43.4)	343 (56.6)	606 (100)	0.001
7. Dental stem cells can form neural cells.	243 (40.1)	363 (59.9)	606 (100)	<0.001
8. Dental stem cells can be retrieved from apical papilla of the tooth.	237 (39.1)	369 (60.9)	606 (100)	<0.001
9. One potential application of stem cells is to allow root formation to continue following trauma.	409 (67.5)	197 (32.5)	606 (100)	<0.001
10. Adult bone marrow stem cells are usually taken from the spine.	104 (17.2)	502 (82.8)	606 (100)	<0.001
11. Sound deciduous incisors and canines are better source of dental stem cells than deciduous molars.	177 (29.2)	429 (70.8)	606 (100)	<0.001
12. Autologous transplant of adult stem cells can fail mainly because of immunogenic reaction.	98 (16.2)	508 (83.8)	606 (100)	<0.001
13. Chondrocytes are considered one type of stem cells.	120 (19.8)	486 (80.2)	606 (100)	<0.001
14. Dental implants derived from stem cells are now available to replace missing teeth.	171 (28.2)	435 (71.8)	606 (100)	<0.001
15. Stem cell banks are now available in Saudi Arabia.	176 (29.0)	430 (71.0)	606 (100)	<0.001

percentage of correct and incorrect responses to knowledge statements are shown in Table 2.

The individual question's analysis showed poor knowledge related to Q4: "Embryonic stem cells can be obtained from the umbilical cord," where 522 participants (86.1%) had the wrong answer, while Q1: "Stem cells are unspecialized type of cells that are capable of forming any cell type" had the highest correct response rate of 432 respondents (71.3%). The number and percentage of respondents representing each category of knowledge level are presented in Table 3.

Male graduates from private dental schools showed higher level of knowledge (5.34 ± 2.68) with significant difference ($p = 0.09$) compared to males graduated from governmental dental schools (4.87 ± 2.38). Female graduates from private dental schools showed no significant difference ($p = 0.43$) in the level of knowledge to female graduates from governmental dental schools (5.74 ± 2.56 and 5.52 ± 2.38, respectively). The mean knowledge scores among males and females from various dental schools are represented in Fig. 3.

Male graduates of King Saud Bin Abdulaziz University for Health Sciences showed the highest percentage of moderate knowledge level with 92.9% compared to other governmental schools. Among the private schools, Al Qassim Private College showed the highest percentage (65%) of moderate knowledge level, followed by Al Farabi College for Dentistry and Nursing (63.4%).

For female graduates, Al Qassem University showed the highest percentage of stem cell knowledge (75%), followed by Jazan University and King Saud University (69.2% and 59%, respectively).

No significant difference between males and females was noted in regards to the attitude score (33.30 ± 5.94 for males, 32.99 ± 5.89 for females) using independent sample *t*-test ($p = 0.53$). A significant difference in attitude score was found between governmental (32.37 ± 5.69) and private schools (34.38 ± 6.07) ($p = 0.01$). The mean attitude score among graduates of various dental schools is represented in Fig. 4. The number and percentage of responses to attitude statements among dental graduates are presented in Table 4.

Majority of the participants (81.9%) agreed to recommend more public awareness programs about stem cells and their therapeutic applications. More than half of the respondents (61.3%) were willing to recommend stem cell therapy if it becomes available. Also, high percentage of participants (53.1%) believed that the use of stem cells in dentistry did not contradict ethical and religious principles.

Interestingly, high percentage of participants (68.3%) considered specializing in dental treatment with stem cells if it becomes a recognized dental specialty in the future. However, 47.5% of the respondents reported not having been exposed to a sufficient amount of information about stem cells and their potential application in dentistry. The attitude level across various dental schools are shown in Table 5.

The mean value for the knowledge and attitude scores across governmental and private schools are represented in Table 6, while the mean value for the knowledge and attitude

Table 3 Number and percentage of respondents in each category of knowledge level based on gender and school distribution (n = 606).

Gender		School	Poor N (%)	Moderate N (%)	High N (%)	Total N (%)	*p*-value
Male	**Governmental**	1-King Saud University	31 (57.4)	23 (42.6)	0 (0.0)	54 (100.0)	< 0.0001
		2- King Saud Bin Abdulaziz University for Health Sciences	1 (7.1)	14 (92.9)	0 (0.0)	15 (100.0)	< 0.0001
		3- King Abdulaziz University	32 (68.1)	15 (31.9)	0 (0.0)	47 (100.0)	< 0.0001
		4- University of Dammam	13 (54.2)	11 (45.8)	0 (0.0)	24 (100.0)	< 0.0001
		5- King Khalid University	29 (93.5)	2 (6.5)	0 (0.0)	31 (100.0)	< 0.0001
		6- Umm Al Qura University	1 (33.3)	2 (66.7)	0 (0.0)	3 (100.0)	< 0.0001
		7- Jazan University	8 (40)	12 (60)	0 (0.0)	20 (100)	< 0.0001
		8- University of Hail	5 (45.5)	6 (54.5)	0 (0.0)	11 (100)	< 0.0001
		9- Prince Sattam Bin Abdulaziz University	3 (100)	0 (0.0)	0 (0.0)	3 (100)	< 0.0001
		10- AlJouf University	9 (100)	0 (0.0)	0 (0.0)	9 (100)	< 0.0001
		Total	132 (60.8)	85 (39.2)	0 (0.0)	217 (100.0)	< 0.0001
	Private	**1-** Riyadh Colleges of Dentistry and Pharmacy	24 (58.5)	17 (41.5)	0 (0.0)	41 (100)	< 0.0001
		2- Al Farabi College for Dentistry and Nursing	14 (34.1)	26 (63.4)	1 (2.4)	41 (100)	< 0.0001
		3- Qassim Private Colleges	7 (35)	13 (65)	0 (0.0)	20 (100)	< 0.0001
		Total	45 (44.1)	56 (54.9)	1 (0.8)	102 (100.0)	< 0.0001
		Grand Total	**177 (55.5)**	**141 (44.2)**	**1 (0.3)**	**319 (100.0)**	< 0.0001
Female	**Governmental**	1-King Saud University	16 (41)	23 (59)	0 (0.0)	39 (100.0)	< 0.0001
		2- King Abdulaziz University	36 (75)	12 (25)	0 (0.0)	48 (100.0)	< 0.0001
		3- King Khalid University	13 (56.5)	10 (43.5)	0 (0.0)	23 (100.0)	< 0.0001
		4- Umm Al Qura University	3 (42.9)	4 (57.1)	0 (0.0)	7 (100.0)	< 0.0001
		5- Jazan University	4 (30.8)	9 (69.2)	0 (0.0)	13 (100.0)	< 0.0001
		6- Qassim University	2 (25)	6 (75)	0 (0.0)	8 (100.0)	< 0.0001
		7- University of Hail	8 (50)	8 (50)	0 (0.0)	16 (100.0)	< 0.0001
		Total	82 (53.2)	72 (46.8)	0 (0.0)	154 (100.0)	< 0.0001
	Private	1- Riyadh Colleges of Dentistry and Pharmacy	29 (59.2)	20 (40.8)	0 (0.0)	49 (100.0)	< 0.0001
		2- Al Farabi College for Dentistry and Nursing	24 (34.3)	44 (62.9)	2 (2.9)	70 (100.0)	< 0.0001
		3- Qassim Private Colleges	7 (50)	7 (50)	0 (0.0)	14 (100.0)	< 0.0001
		Total	60 (45.1)	71 (53.4)	2 (1.5)	133 (100.0)	< 0.0001
		Grand Total	**142 (49.5)**	**143 (49.8)**	**2 (0.7)**	**287 (100.0)**	< 0.0001

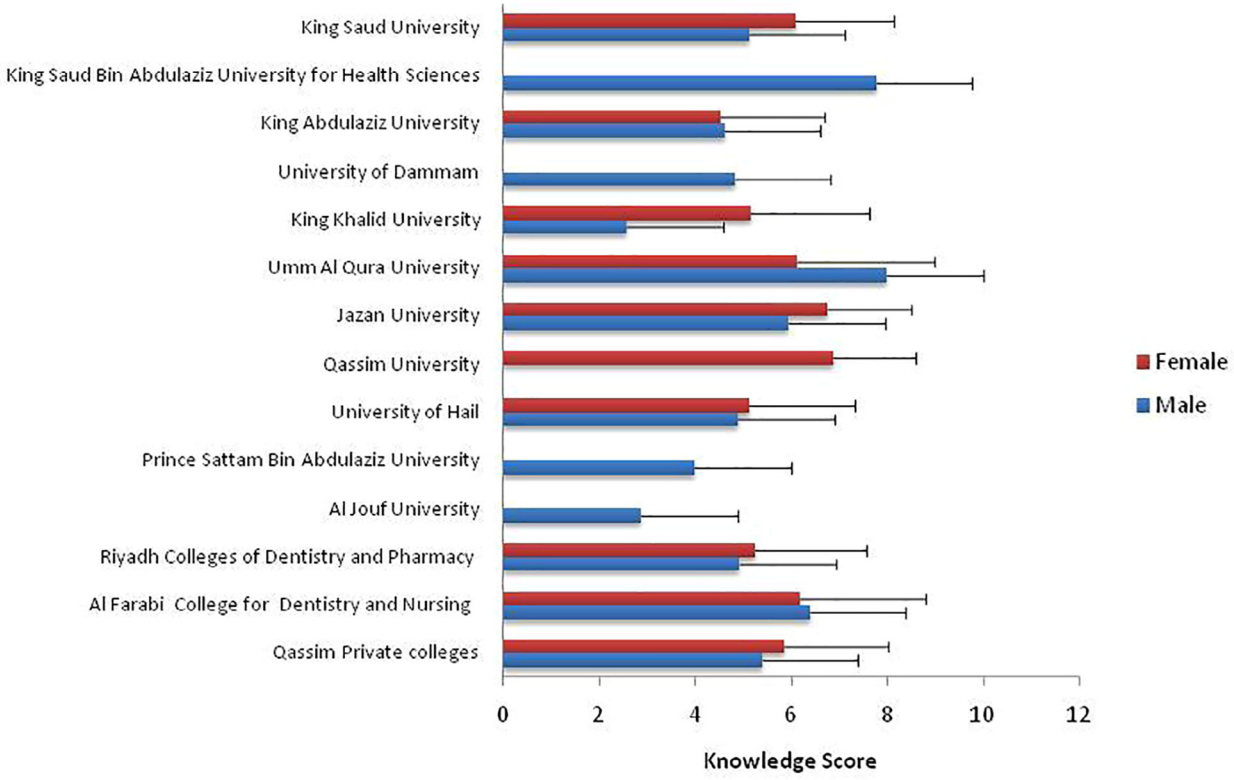

Fig. 3 Mean (±SD) knowledge score among dental schools for male and female.

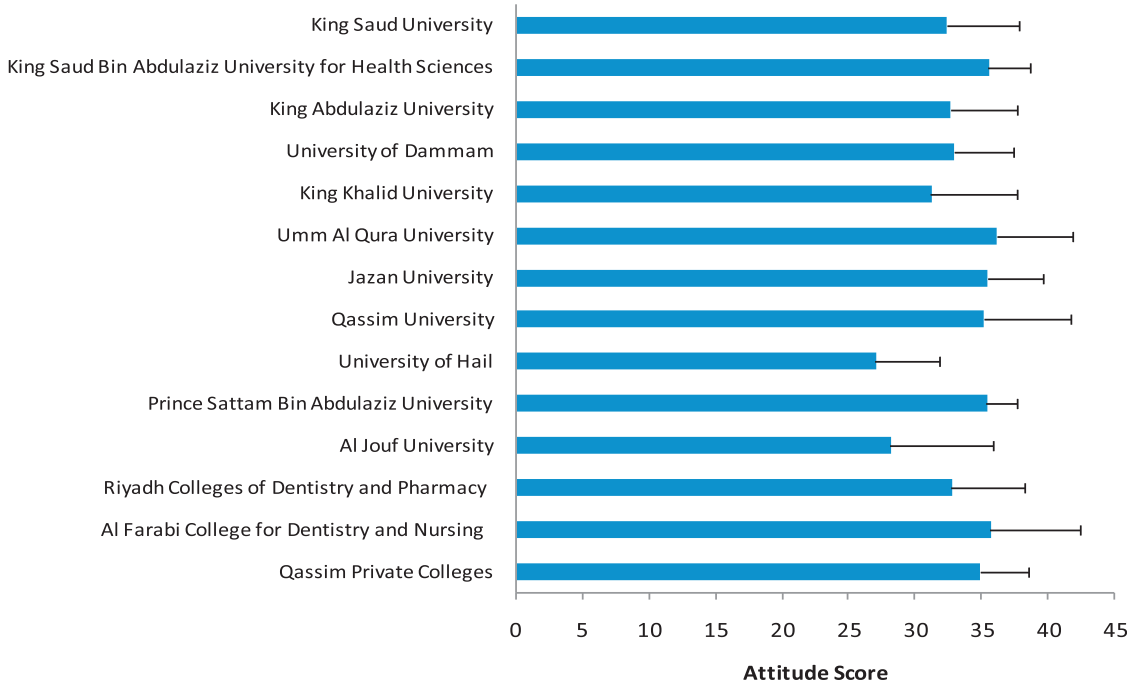

Fig. 4 Mean (±SD) attitude score of dental interns among dental schools.

Table 4 Number and percentage of responses to attitude statements among dental interns (n = 606).

Attitude statement	Strongly agree N (%)	Agree N (%)	Unsure N (%)	Disagree N (%)	Strongly disagree N (%)	Total	*p*-value
1. I am aware of stem cell research and potential applications of stem cells in dentistry.	62 (10.2)	145 (23.9)	194 (32.0)	140 (23.1)	65 (10.7)	606 (99.9)	< 0.001
2. I will recommend treatment with stem cells if it is available.	139 (22.9)	233 (38.4)	168 (27.7)	38 (6.3)	28 (4.6)	606 (100)	< 0.001
3. The curriculum that I have studied contained good amount of information about stem cells and their potential applications in dentistry.	54 (8.9)	143 (23.6)	121 (20)	157 (25.9)	131 (21.6)	606 (100)	< 0.001
4. Adding a special course concerning stem cells to the dental curriculum is advisable.	206 (34.0)	213 (35.1)	99 (16.3)	54 (8.9)	34 (5.6)	606 (100)	< 0.001
5. I have attended scientific activities related to stem cells outside the curriculum.	82 (13.5)	107 (17.7)	90 (14.9)	193 (31.8)	134 (22.1)	606 (100)	< 0.001
6. I am interested in attending advanced training course about stem cells and their applications in dentistry.	229 (37.8)	197 (32.5)	97 (16.0)	39 (6.4)	44 (7.3)	606 (100)	< 0.001
7. Use of stem cells in dentistry contradicts ethical and religious principles.	52 (8.6)	78 (12.9)	154 (25.4)	108 (17.8)	214 (35.3)	606 (100)	< 0.001
8. Use of embryonic stem cells should be prohibited as they are taken from embryo or aborted fetus.	73 (12)	92 (15.2)	213 (35.1)	103 (17.0)	125 (20.6)	606 (100)	< 0.001
9. There should be more public awareness programs about stem cells and their therapeutic applications.	258 (42.6)	238 (39.3)	81 (13.4)	15 (2.5)	14 (2.3)	606 (100)	< 0.001
10. I will consider specializing in dental treatment with stem cells if it becomes a recognized dental specialty in the future.	232 (38.3)	182 (30.0)	145 (23.9)	28 (4.6)	19 (3.1)	606 (100)	< 0.001

scores based on gender are shown in Table 7. The correlation between knowledge and attitude revealed significant positive linear relationship for both males ($r = 0.323$, $p = 0.00$) and females ($r = 0.392$, $p = 0.00$).

4. Discussion

Field of stem cell research has emerged with numerous applications in medicine and dentistry due to potential ability to regenerate and repair damaged tissue (Lymperi et al., 2013). Dentists are expected to play a major role not only in advancing the field of stem cell research but also in directing and implementing future stem cell therapies in dentistry. Accordingly, a good basic knowledge and a positive attitude toward stem cells and their potential applications is essential among future dentists.

The current study investigated the level of knowledge and attitude regarding stem cells among recent graduates of dental schools in Saudi Arabia. This is a crucial step to explore the current exposure of dental students to the topic of stem cells during their dental education.

In general, both male and female dental interns showed poor to moderate knowledge level, with higher percentage of male interns showing poor knowledge (55.7%). Inadequate knowledge about stem cells among various health professional groups has been reported in different regions of the world. For example, a study conducted in Nigeria reported that majority of dentists had inadequate knowledge of stem cell use in dentistry (Sede et al., 2016). In addition, a study conducted in Italy concluded that two-thirds of participated physicians had no specific knowledge about stem cells (Frati et al., 2014).

In Saudi Arabia, two public centers for cord blood banks were subject to a fatwa (Islamic legal ruling) issued by the Muslim World League's Islamic Jurisprudential Council (Fadel et al., 2007). First, a public bank was created in 2006 at King Faisal Specialist Hospital and Research Center, which now stores over 4600 units. A second cord blood bank is King Abdullah International Medical Research Center (KAIMRC), which was established in 2009 and is operated by the National Guard Health Affairs. The KAIMRC Umbilical Cord Blood Bank is a non-profit public bank that provides hematological stem cells for patients who are in need or for research (Abumaree et al., 2014). Notably, the National Guard Health Affairs established the first stem cell donor registry in the region in an effort to increase matching rates among the Arab citizenry and now lists over 5000 donors (Matsumoto et al., 2015). However, more than two-thirds of the respondents in our study were unaware of the availability of stem cell banks in Saudi Arabia.

Regenerative dentistry has been recently recognized as a treatment option for immature teeth following trauma, anatomical anomalies, and caries (Murray et al., 2007). In the present study, more than two-thirds of participants were familiar with the concept of using stem cells to continue root formation following trauma. This finding is consistent with a relevant study performed on dentists in South Africa (Basson et al., 2016).

In the present study, more than half of dental interns did not think that the use of stem cells in dentistry contradicted ethical and religious principles. This is in contrast to a previous study which found that many nursing students were worried about the use of stem cells being unethical (Lye et al., 2015).

Overall, the level of knowledge and attitude of recently graduated dentists in Saudi Arabia toward stem cells and their potential therapeutic applications in dentistry can be interpreted as being inadequate.

Limitations of this study include the fact that the collected data was self-reported by participants through a questionnaire. Usually, self-reported data can not be independently verified and may be prone to bias such as exaggerated or lessened

Table 5 Attitude level based on dental schools distribution (n = 606).

School name	Poor N(%)	Moderate N(%)	Good N(%)	Excellent N(%)	Total N(%)	*p*-value
Governmental						
1- King Saud University	25 (26.9)	61 (65.6)	3 (3.2)	4 (4.3)	93 (100)	< 0.0001
2- King Saud Bin Abdulaziz University for Health Sciences	0 (0.0)	15 (100.0)	0 (0.0)	0 (0.0)	15 (100.0)	< 0.0001
3- King Abdulaziz University	17 (17.9)	67 (70.5)	10 (10.5)	1 (1.1)	95 (100.0)	< 0.0001
4- University of Dammam	6 (25.0)	16 (66.7)	2 (8.3)	0 0.0%	24 (100.0)	< 0.0001
5-King Khalid University	21 (38.9)	29 (53.7)	4 (7.4)	0 (0.0)	54 (100.0)	< 0.0001
6- Umm Al Qura University	0 (0.0)	7 (70.0)	1 (10.0)	2 (20.0)	10 (100.0)	< 0.0001
7- Jazan University	3 (9.1)	23 (69.7)	6 (18.2)	1 (3.0)	33 (100.0)	< 0.0001
8- Qassim University	2 (25.0)	5 (62.5)	0 (0.0)	1 (12.5)	8 (100.0)	< 0.0001
9- University of Hail	17 63.0%	10 37.0%	0 0.0%	0 0.0%	27 (100.0)	< 0.0001
10-Prince Sattam Bin Abdulaziz University	0 (0.0)	3 (100.0)	0 (0.0)	0 (0.0)	3 (100.0)	< 0.0001
11-Al Jouf University	5 (55.6)	4 (44.4)	0 (0.0)	0 (0.0)	9 (100.0)	< 0.0001
Total	**96 (25.9)**	**240 (64.7)**	**26 (7.0)**	**9 (2.4)**	**371 (100.0)**	< 0.0001
Private						
1-Riyadh Colleges of Dentistry and Pharmacy	22 (24.4)	56 (62.2)	9 (10.0)	3 (3.3)	90 (100.0)	< 0.0001
2- Al Farabi Collage for Dentistry and Nursing	14 (12.6)	69 (62.2)	20 (18.0)	8 (7.2)	111 (100.0)	< 0.0001
3- Qassim Private colleges	2 (5.9)	27 (79.4)	4 (11.8)	1 (2.9)	34 (100.0)	< 0.0001
Total	**38 (16.2)**	**152 (64.7)**	**33 (14.0)**	**12 (5.1)**	**235 (100.0)**	< 0.0001
Grand total	**134 (22.1)**	**392 (64.7)**	**59 (9.7)**	**21 (3.5)**	**606 (100.0)**	< 0.0001

Table 6 Mean score of knowledge and attitude in governmental and private schools.

College		Frequency	Mean ± SD
Knowledge	Government	371	5.08 ± 2.38
	Private	235	5.72 ± 2.54
Attitude	Government	371	32.37 ± 5.69
	Private	235	34.38 ± 6.07

Table 7 Mean score of knowledge and attitude among male and female respondents.

Gender		Frequency	Mean ± SD
Knowledge	Male	319	5.06 ± 2.51
	Female	287	5.63 ± 2.38
Attitude	Male	319	33.30 ± 5.94
	Female	287	32.99 ± 5.89

response by individuals. The validity of the arabic translation of the questionnaire was not tested due to time constrain, which may be considered another limitation of this study. Generalizability and applicability of the study is limited by the geographic representation of the study and the rate of response. Although all available dental schools in Saudi Arabia with at least one batch of graduates were approached, not all graduates completed and submitted the questionnaire. Also, findings of this study are confined to recent dental graduates in Saudi Arabia and cannot be generalized to represent detists and dental graduates in other geographic regions.

5. Conclusion

Among recent dental graduates in Saudi Arabia, there was moderate to positive attitude toward stem cells and their therapeutic applications in dentistry; however, knowledge was inadequate. It is recommended that dental students should be more exposed and motivated about the principles of regenerative dentistry during their dental education in order to be prepared for future practice utilizing stem cells. Thus, modifi-

cation of the current dental curriculum of dental schools in Saudi Arabia is recommended to equip dental graduates with the required knowledge about stems cells and to enhance their attitude toward potential utilization of stem cells in medicine and dentistry.

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Conflicts of interest

The authors declare no conflict of interest.

References:

Abumaree, M.H., Al Askar, A.S., Kalionis, B., Abomaray, F.M., Jawdat, D., Hajeer, A.H., Fakhoury, H., Al Jumah, M.A., 2014. Stem cell research and regenerative medicine at King Abdullah International Medical Research Center. Stem Cells Dev. 23 (S1), 12–16.

Alhadlaq, A., Mao, J., 2005. Tissue-engineered osteochondral constructs in the shape of an articular condyle. J. Bone Joint Surg. 87 (5), 936–944.

Basson, R.A., Moodley, D.S., Oliviera, A., Basson, N.J., 2016. A survey of the opinions of Dentists regarding stem cells in Dentistry. S. Afr. Dent. J. 71 (8), 351–355.

Egusa, H., Sonoyama, W., Nishimura, M., Atsuta, I., Akiyama, K., 2012. Stem cells in dentistry–Part II: Clinical applications. J. Prosthodont. Res. 56 (4), 229–248.

Fadel, H.E., 2007. Prospects and ethics of stem cell research: an Islamic perspective. J. IMA, 39.

Frati, P., Gulino, M., Pacchiarotti, A., D'Errico, S., Sicuro, L., Fineschi, V., 2014. A survey of Italian physicians' opinion about stem cells research: what doctors prefer and what the law requires. Biomed. ResInt., 9

Gronthos, S., Mankani, M., Brahim, J., Robey, P., Shi, S., 2000. Postnatal human dental pulp stem cells (DPSCs) in vitro and invivo. PNAS 97 (25), 13625–13630.

Katge, F., Shetty, A.J., Rusawat, B., Vamsi, K.C., 2017. Knowledge and attitude of Indian dentists regarding dental stem cells: a cross-sectional descriptive survey. Indian J. Dent. Res. 28 (4), 367.

Lye, J., Soon, L., Nizam, W., Ahmad, W., Tan, S., 2015. Knowledge and attitude about stem cells and their application in medicine among nursing students in UniversitiSains Malaysia, Malaysia. Malays. J. Med. Sci. 22 (4), 23–31.

Lymperi, S., Ligoudistianou, C., Taraslia, V., Kontakiotis, E., Anastasiadou, E., 2013. Dental stem cells and their applications in dental tissue engineering. Open Dent. J. 7, 76.

Matsumoto, M.M., Dajani, R., Matthews, K.R., 2015. Cord blood banking in the Arab World: current status and future developments. Biol. Blood Marrow Transplant. 21 (7), 1188–1194.

Mohamed, H., Azzazy, H., 2016. Effect of educational intervention on knowledge and attitude of nursing students regarding stem cells therapy. J. Nurs. Care 5 (8), 75–80.

Murray, P.E., Garcia-Godoy, F., Hargreaves, K.M., 2007. Regenerative endodontics: a review of current status and a call for action. J. Endod. 33 (4), 377–390.

Nuti, N., Corallo, C., Chan, B., Ferrari, M., Gerami-Naini, B., 2016. Multipotent differentiation of human dental pulp stem cells: a literature review. Stem Cell Rev. 12 (5), 511–523.

Park, Y., Cha, S., Park, Y., 2016. Regenerative applications using tooth derived stem cells in other than tooth regeneration: a literature review. Stem Cells Int., 1–12

Ramamoorthi, M., Bakkar, M., Jordan, J., Tran, S., 2015. Osteogenic potential of dental mesenchymal stem cells in preclinical studies: a systematic review using modified ARRIVE and CONSORT guidelines. Stem Cells Int., 1–28

Sede, M.A., Audu, O., Azodo, C.C., 2016. Nigerian dental students' permissive tendency to the proposed organized incorporation of stem cells application into dental curriculum: a cross-sectional study. J. Oral Res. Rev. 8 (2), 72.

Sullivan, G.M., Artino, A.R., 2013. Analyzing and interpreting data from Likert-type scales. J. Grad. Med. Educ. 5, 541–542.