

Dental Residents' Knowledge and Attitude towards Stem Cells and Regenerative Dentistry

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Abstract

Objectives: Success of regenerative dental procedures highly depends on their acceptance by the clinicians; yet, little is known about dental residents' attitudes regarding this new technology. The purpose of this study was to assess the knowledge and attitude of post-graduate dental students towards stem cells and regenerative dentistry as part of future dental treatments.

Methods: This cross-sectional survey was conducted on 84 third-year residents of various dental specialties. The questionnaire included demographics and professional status of the respondents, questions regarding their ethical beliefs and their clinical practice.

Results: Eighty-four completed questionnaires were returned anonymously. The majorities of the participants were female, and had practiced for ≤ 5 years. The survey showed that 76.2% of the participants had not received any continuing education or training courses on stem cells or regenerative dentistry. The majority of the participants (82.1%) believed that regenerative treatments should be included in dental practice. Of all, 76.2% had no umbilical cord or stem cell banking for themselves or a relative and 63.1% thought that dental pulp stem cell banking would be useful to regenerate dental tissues. Most of the participants (65.5%) had never performed regenerative therapy of any kind in their clinical practice and 51.2% of the participants were not sure whether regenerative procedures would be successful.

Conclusion: Although more evidence on the efficacy and safety of regenerative dentistry is required, postgraduate training in this regard seems necessary.

Key Words: Regenerative Medicine; Stem Cells; Tissue Engineering; Surveys and Questionnaires

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Introduction

Tissue engineering requires three key elements namely stem cells, scaffold and signaling molecules and refers to the application of biological therapeutic techniques with the aim of replacement, repair or preservation of tissue and improvement of its function (1,2). In general, stem cells are clonogenic cells capable of self-replication and multilineage differentiation. In dentistry, stem cells can be isolated from the dental pulp

of third molars, exfoliated deciduous teeth, apical papilla and tooth germs. Scaffolds are three-dimensional biomaterials providing a physicochemical environment for growth and differentiation of cells and enhancing their adhesion and migration. Scaffolds serve as an extracellular matrix and a carrier for morphogens. The third component of tissue engineering is the morphogenetic signaling molecules such as bone morphogenetic proteins and growth factors (3,4).

The field of regenerative dentistry is developing fast and may enable the

regeneration of tissues such as the alveolar bone, periodontal ligament, enamel, dentin and even a whole tooth in near future (5). This novel technology provides atraumatic and long-lasting results and could replace the tissues lost due to cancer or periodontal disease or those that were absent from the beginning due to congenital disorders (6,7). Absence of complications related to the biocompatibility of the currently used dental materials or problems due to the mismatch of physical or chemical properties of dental materials and tooth structure, which would result in mechanical failure, are other advantages of this new field of science (8). However, there are also some disadvantages such as high cost of isolation of stem cells, risk of tumorigenesis by these cells, risk of rejection of implanted cells or the scaffold by the host immune system, infection transmission, and mismatch of the biological properties of the implanted tissue with those of the surrounding tissue (9,10). Although the role of tissue engineered constructs in future dental treatment is huge (11), the transition of this new science from the research bench to the patient's chair-side requires high-quality research projects as well as a close cooperation between basic science scientists and dental clinicians (12,13). To achieve this goal, adequate knowledge and appropriate expertise are required in this regard. In consequence, knowledge of the clinicians about different products and their applications, and following the latest advances in this field are very important. At present, limited studies are available on the attitude of post-graduate students of endodontics towards tissue engineering (14,15); however, there is an obvious need to

assess the knowledge and attitude of residents in different dental specialties regarding the applications of tissue engineering in dentistry since acceptance of this new technology and delivery of regenerative procedures to dental patients are extremely important. This study aimed to assess the knowledge and attitude of post-graduate students of different dental specialties towards the applications of regenerative dentistry. The results would elucidate the educational shortcomings in this regard, clarify the acceptance of this treatment by the next generation of dental professionals, and besides, would be beneficial for setting ethical codes in this respect.

Methods

The questionnaire used in this study was designed according to a questionnaire used by Epelman et al, (14) in their study in 2009 on residents of endodontics. Some of the professional questions purely related to endodontics were eliminated and a few questions were modified considering our study population. The face validity, content validity and reliability of the Persian version of the questionnaire were assessed.

For assessing face validity, we used qualitative and quantitative methods. In qualitative assessment, 10 specialists were interviewed and asked to rate the questionnaire in terms of level of difficulty, irrelevancy and ambiguity; the questionnaire was slightly modified according to their opinions. In quantitative assessment, the impact score of each question was calculated by scoring all items of the questionnaire using

a five-point Likert scale of very high (5 points), high (4 points), moderate (3 points), low (2 points) and very low (1 point). Then, for assessment of validity, the questionnaire was completed by 20 residents. Using the impact score formula [impact score=frequency (%) × importance], the face validity was calculated. If this index was ≥ 1.5 , the item would be qualified for further analyses and would remain in the questionnaire.

To determine the content validity of the questionnaire, quantitative and qualitative methods were used. In qualitative assessment, 10 experts in the field of dental education were requested to review the questionnaire and express their opinions as written with special attention to the grammar, choice of words, significance of questions, order of questions and time required to fill out the questionnaire. To ensure that the most important and the most accurate content has been chosen (necessity of each question), the content validity ratio (CVR) was calculated. The content validity index (CVI) was also calculated to ensure that the questions had been designed in the most appropriate method for measurement of the content. To determine the CVR, 15 experts in dental education were requested to assess the questionnaire and assign each item to one of the three groups of essential, necessary but not essential, and unnecessary. The CVR was calculated based on their responses using the formula below:

$$\text{CVR} = (A - n/2) / (n/2)$$

Where A was the number of experts who believed that the item was essential and n was the total number of experts. The obtained values were assessed using the Lawshe's table. The CVI was then calculated according

to Waltz and Bausell index (16). To calculate CVI, 15 dental specialists were requested to rate each question in terms of relevance, simplicity and clarity using a 4-point Likert scale (1: irrelevant, 2: somehow relevant, 3: relevant, 4: completely relevant). For this purpose, CVI was calculated by summing the positive scores for each item acquiring a score of 3 and 4 (highest score) divided by the total number of experts. Items were qualified if scored $\text{CVI} > 0.79$.

To assess the reliability of the tool and internal consistency of the questionnaire, the Cronbach's alpha was used. The Persian version of the questionnaire was pretested in Shahid Beheshti University, School of Dentistry for assessment of validity (20 residents). Using the data obtained from the questionnaire, the Cronbach's alpha coefficient of reliability was calculated to be 0.94 using SPSS software (SPSS Inc., IL, USA).

Finally, a questionnaire was designed with 37 questions in four categories: three questions asked for demographics of the respondents, six questions were about the resident's professional status, 14 questions asked for their ethical beliefs and attitude, and the remaining questions were about the clinical practice of regenerative dentistry by the participants.

The questionnaires were then administered among dental residents studying in different dental schools of Tehran. Senior residents were briefed about tissue engineering and the objective of the study. The questionnaires were collected after a specified time point and the data were analyzed by calculating the percentage of different responses out of the total responses.

Results

The impact score results indicated that all questions except for seven questions gained a score of ≥ 1.5 ; thus, only seven questions were modified.

The results of CVI indicated that all questions except for question 2 had a CVI of higher than 0.79; thus, they were found to be appropriate. Question 2 had a CVI score of 0.70-0.79,

indicating that it required some revisions. This item (question #2) was corrected and its CVI increased from 0.75 to 0.97. The results indicated that all questions had a CVR of ≥ 0.62 (according to the Lawshe's table). It indicated that the presence of statistically acceptable items ($P < 0.05$) in this tool was necessary. Finally, the questionnaire was designed with 37 questions. The results of the survey questions are shown in Table 1.

Table 1- Survey results of attitude of dental residents training in different dental schools of Tehran towards regenerative dental treatments

Category of questions	Questions	Responses
Demographic information	1. What is your sex?	
	a. Male	32.1% (n = 27)
	b. Female	67.9% (n = 57)
	2. How old are you?	Average: 28.17
	3. Indicate the location of your postgraduate study.	
	a. Tehran University of Medical Sciences	25% (n=21)
	b. Shahid Beheshti University of Medical Sciences	29.8% (n=25)
	c. Islamic Azad University Tehran Dental Branch	22.6% (n=19)
	d. Shahed University of Medical Sciences	22.6% (n=19)
	4. Which is your field in dentistry?	
a. Endodontics	9.5% (n=8)	
b. Pediatric Dentistry	14.3% (n=12)	
c. Orthodontics	14.3% (n=12)	
d. Periodontics	14.3% (n=12)	
e. Prosthodontics	11.9% (n=10)	
f. Restorative Dentistry	16.7% (n=14)	
g. Maxillofacial Surgery	9.5% (n=8)	
h. Oral Pathology	9.5% (n=8)	
Professional status	5. How many years have you been in practice?	
	a. 0-5 years	81% (n=68)
	b. 5-10 years	19% (n=16)
	c. More than 10 years	0.0% (n=0)
	6. Where was your primary place of practice?	
	a. Public health service center	44.0% (n=37)
	b. Private health service center	25.0% (n=21)
	c. Never had a practice (strict admission to postgraduate study)	31.0% (n=26)
	7. Where was your primary place of practice located?	
	a. Capital	21.4% (n=18)
b. Urban	38.1% (n=32)	
c. Rural	9.5% (n=8)	
d. Academic Environment	0.0% (n=0)	
e. Military Environment	0.0% (n=0)	
f. Never had a practice (strict admission to postgraduate study)	31.0% (n=26)	

	8. How frequently do you read scientific dental journals?	
	a. Everyday	14.3% (n = 12)
	b. Every week	28.6% (n = 24)
	c. Every month	21.4% (n = 18)
	d. Every year	17.9% (n = 15)
	e. Never	17.9% (n = 15)
	9. Have you ever received continuing education in stem cells and/or regenerative dental treatments?	
	a. Yes	23.8% (n = 20)
	b. No	76.2% (n = 64)
	10. Should regenerative therapy be incorporated into dentistry?	82.1% (n = 69)
	a. Yes	17.9% (n = 15)
	b. No	0.0% (n = 0)
	c. Maybe	
	11. Have you or any of your relatives used umbilical cord or other types of stem cell banking?	
	a. Yes	16.7% (n = 14)
	b. No	76.2% (n = 64)
	c. Unsure	7.1% (n = 6)
	12. Do you think dental stem cell banking will be useful to regenerate dental tissues?	
	a. Yes	63.1% (n = 53)
	b. No	9.5% (n = 8)
	c. Unsure	27.4% (n = 23)
	13. How many years do you think it will take for some regenerative stem cell therapies to be used in dentistry?	
	a. 0-10 years	28.6% (n = 24)
	b. 11-20 years	45.2% (n = 38)
	c. More than 21 years	26.2% (n = 22)
	14. How many years do you think it will take before dentists are able to implant new teeth grown in a laboratory?	
	a. 0-10 years	17.9% (n = 15)
	b. 11-20 years	42.9% (n = 36)
	c. More than 21 years	39.3% (n = 33)
Ethical perspectives	15. Would you be willing to attend a training course and/or continuing education courses to apply regenerative dental treatments?	
	a. Yes	48.8% (n = 41)
	b. No	23.8% (n = 20)
	c. Unsure	27.4% (n = 23)
	16. What do you think would be the biggest obstacle to a patient accepting regenerative dental treatment?	
	a. Higher cost	67.9% (n = 57)
	b. Fear of stem cells	32.1% (n = 27)
	c. Other reasons	0.0% (n = 0)
	17. Would you be willing to save teeth and dental tissue for future regenerative dental treatment?	
	a. Yes	57.1% (n = 48)
	b. No	22.6% (n = 19)
	c. Unsure	20.2% (n = 17)
	18. Do you think that regenerative dental treatment will be a better treatment option than implant placement?	
	a. Yes	59.5% (n = 50)
	b. No	17.9% (n = 15)
	c. Unsure	22.6% (n=19)

	19. Do you think stem cells and regenerate treatments should be tested on animals prior to clinical testing?	
	a. Yes	96.4% (n = 81)
	b. No	0.0% (n = 0)
	c. Unsure	3.6% (n = 3)
	20. Would you be willing to deliver dental treatments that involve embryonic stem cells sourced from a human fetus?	69.0% (n = 58)
	a. Yes	17.9% (n = 15)
	b. No	13.1% (n = 11)
	c. Unsure	
	21. Are you concerned about any potential health hazards regarding the use of stem cells as part of regenerative dentistry?	77.4% (n = 65)
	a. Yes	17.9% (n = 15)
	b. No	4.8% (n = 4)
	c. Unsure	
	22. Do you believe there is a risk that stem cell clinics will deliver future dental treatments?	63.1% (n = 53)
	a. Yes	19.0% (n = 16)
	b. No	17.9% (n = 15)
	c. Unsure	
	23. Do you believe that dental professional associations should regulate the use of stem cell and regenerative dentistry?	88.0% (n = 74)
	a. Yes	6.0% (n = 5)
	b. No	6.0% (n = 5)
	c. Unsure	
	24. Do you use any type of regenerative procedures in your practice, such as membranes, scaffolds, bioactive materials, Emdogain or grafts?	
	a. Yes	34.5% (n = 29)
	b. No	65.5% (n = 55)
	25. In case of using materials derived from a human corpse or animal, do you explain it to your patients?	
	a. Yes	45.2% (n = 38)
	b. No	38.1% (n = 32)
	c. Unsure	16.7% (n = 14)
	26. When was the last time you invested in the new technology (digital radiography, patient record keeping software, cone beam CT, CAD/CAM) in your practice?	
Clinical practice	a. Last year	77.4% (n = 65)
	b. Last 5 years	2.4% (n = 2)
	c. More than 5 years	20.2% (n = 17)
	d. Never	0% (n = 0)
	27. What is your assessment of regenerative dental treatment outcomes?	
	a. Successful	38.1% (n = 32)
	b. Unsuccessful	10.7% (n = 9)
	c. Don't know	51.2% (n = 43)
	28. After nonsurgical treatments, would the healing of periapical tissues and periodontium be enhanced by tissue engineering?	66.7% (n = 56)
	a. Yes	4.8% (n = 4)
	b. No	28.6% (n = 24)
	c. Don't know	

29. Would you be willing to collect dental tissue for stem cell banks?	67.9% (n = 38)
a. Yes	34.5% (n=29)
b. No	20.2% (n = 17)
c. Unsure	
30. In a case where you can't provide a regenerative treatment, would you be willing to refer your patient to a stem cell treatment center?	76.2% (n = 64)
a. Yes	9.5% (n = 8)
b. No	14.3% (n = 12)
c. Unsure	
31. What would make you most likely to recommend stem cell and regenerative dental treatments to your patients?	
a. If it is the most effective treatment option	53.6% (n = 45)
b. It is safe and reliable	31.0% (n = 26)
c. If it is the most cost-effective option	15.5% (n = 13)
d. I would never recommend it	0% (n = 0)
32. Using which payment plan would you be most willing to deliver stem cell and regenerative dental treatment?	
a. Fee for service	22.6% (n = 19)
b. Dental insurance	57.1% (n = 48)
c. Not important	20.2% (n = 17)
33. Would you only provide regenerative dental treatment if you are able to increase your income?	
a. Yes	10.7% (n = 9)
b. No	69% (n = 58)
c. Unsure	20.2% (n = 17)
34. What should your fee be for collecting dental tissues for stem cell banking?	
a. Nothing	23.8% (n = 20)
b. Less than \$100	9.5% (n = 8)
c. More than \$100	66.7% (n = 56)
d. Unsure	0.0% (n = 0)
35. How much do you think your patients be willing to pay for stem cell banking?	
a. Nothing	39.3% (n = 33)
b. \$100 per year	27.4% (n = 23)
c. \$101-\$200 per year	23.8% (n = 20)
d. More than \$200 per year	9.5% (n = 8)
e. Unsure	0.0% (n = 0)
36. What should be the cost for regenerative dentistry?	
a. Equal to current treatment	27.4% (n = 23)
b. More than current treatment	42.9% (n = 36)
c. Less than current treatment	19% (n = 16)
d. Unsure	10.7% (n = 9)
37. Please write here any comments you wish to make related to the survey.	

Demographic information:

A total of 84 subjects participated in this study; out of which, 27 (32.1%) were males and 57 (67.9%) were females. The mean age of participants was 28.17 years.

Professional status:

Figure 1 shows the percentage of different specialties among the participants. Most participants had less than five years of work experience (81%); 38.1% had started working after graduation and most of them (44%) were working in public (governmental) clinics;

28.6% reported weekly review of scientific dental journals and more than half the study population (76.2%) had not participated in

any continuing education course on stem cells or dental regenerative treatments.

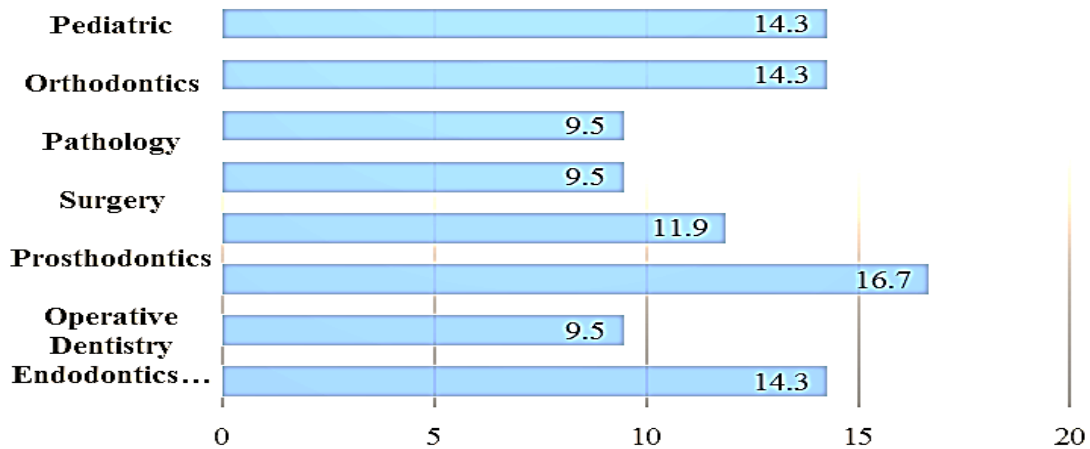


Figure 1- The frequency percentage of participants' specialty

Ethical perspectives:

More than half of the study population (82.1%) believed that tissue engineering and regenerative treatments must be included in dental practice. However, the majority of respondents (76.2%) had never used stem cells from the umbilical cord or other sources; about two-thirds (63.1%) believed that dental pulp stem cell banking would be useful for dental regenerative purposes.

About half of the participants (45.2%) estimated that it would take 11-20 years until some regenerative treatments become a common practice in dentistry. Also, 42.9% predicted that in the next 11-20 years, dentists would be able to implant a whole tooth formed by tissue engineering techniques.

Approximately half of the participants (48.8%) were willing to participate in workshops or continuing education courses on tissue engineering applications in dentistry. The main barriers mentioned by participants against the acceptance of this novel treatment modality are shown in Figure 2.

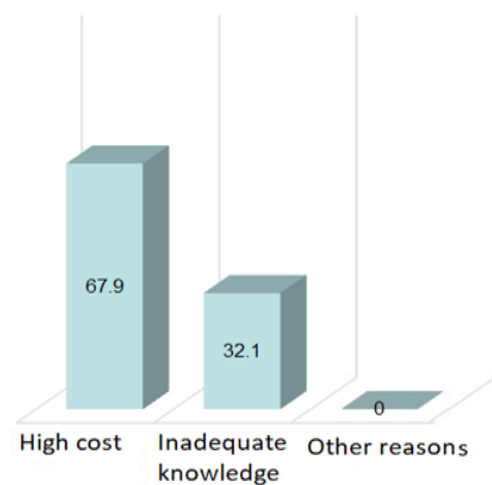


Figure 2- Main barriers against the acceptance of tissue engineering in dentistry

More than half of the respondents (57.1%) were interested in storing teeth and dental tissues for future use in dental regenerative procedures and 59.5% believed that dental regenerative treatments were superior to dental implant therapy. Also, 96.4% stated that regenerative treatments with the use of stem cells must be tested on animals prior to use in the clinical setting on humans and 69% were interested in performing dental

regenerative treatments with the use of stem cells isolated from human fetus.

Regarding the future of regenerative treatments, most participants (77.4%) were concerned about the potential health risks of using stem cells as part of regenerative dentistry and about two-thirds (63.1%) considered the possibility of stem cell clinics providing patients with dental regenerative treatments in the future. Moreover, 88.1% expressed the need for rules and regulations regarding the use of stem cells in regenerative dentistry to be set by dental associations.

Clinical practice:

More than half of the participants (65.5%) had not performed any regenerative treatment (such as use of membrane, scaffold, etc.) in their clinical practice. About half of the participants (45.2%) mentioned that in case of using materials derived from a human corpse or animal, they would explain it to the patient and obtain consent prior to the procedure. Most participants (77.4%) had used new technologies (such as digital radiography, data registry software, etc.) in their practice in the past year. As shown in Figure 3, most participants made no comment regarding the success of regenerative treatments in the future (51.2%). The majority of participants (66.7%) believed that the healing of periapical and periodontal tissues would be greatly enhanced by non-surgical regenerative treatments; 45.2% of the participants were interested in collecting and storing dental tissues for stem cell banking.

Regarding the financial issues related to regenerative treatments, most participants (76.2%) mentioned that if they are not capable of performing a regenerative treatment, they will refer the patient to a stem cell treatment

center; 53.6% of participants stated that they would recommend regenerative treatment to their patients only if it is the most efficient treatment option; 31% of participants would use these treatments only if they are safe, 15.5% stated that they would recommend these treatments only if they are the most cost-effective option. Most participants (57.1%) preferred payments via dental insurance for regenerative treatments. The majority of participants (69%) did not agree to perform regenerative treatments only to increase their income. The suggested price by 66.7% of participants for collection and storage of dental tissues for stem cell banking was \$100; 9.5% suggested a price less than \$100 and 23.8% were willing to do it for free. The majority of participants (39.3%) believed that patients would not be willing to pay any price for banking their stem cells. Also, about half of the participants (42.9%) believed that the cost of dental regenerative treatments must be higher than that of conventional treatment procedures.

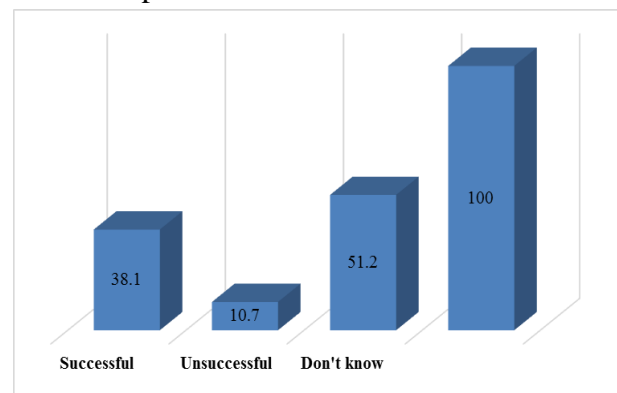


Figure 3- success rate estimate of regenerative dental treatments

Discussion

By use of tissue engineering in dentistry, tissues such as the alveolar bone, periodontal

ligament, enamel, dentin and even a whole tooth can be regenerated in near future (6). A recent survey reported that the possibility of adopting new technologies by general practitioners graduated recently (in the past 10 years) is more than that by practitioners who have practiced for >20 years (17). However, the willingness of dental clinicians to perform a regenerative treatment or recommend it to their patients is still questionable. Moreover, specific ethical codes are not available in this regard and the safety of these treatments is still a matter of concern for many clinicians. Also, the cost of treatment plays an important role in its acceptance by the patients and the cost of these types of treatments has not yet been determined by clinicians. Therefore, a survey on the knowledge and attitude of the next generation of dental professionals may help elucidate these issues.

In this study, the questionnaire was very similar to that used previously by Epelman *et al.* (14); however, we assessed the validity and reliability of the questionnaire and modified some items based on the results of these assessments.

The current study was the first to collect and assess the opinions and perspectives of dental residents in Tehran regarding tissue engineering and regenerative treatments. Most participants in this study had insignificant clinical experience (0 to 5 years); this indicates that our study population would constitute the next generation of dentists. In contrast, those evaluated in the study by Epelman *et al.* (14) had over 21 years of clinical experience.

Although the percentage of subjects who reported reviewing scientific dental journals

in our study was similar to that in the study by Epelman *et al.* (14), most participants in our study had not participated in any continuing education course on stem cells or regenerative treatments. One reason may be that our participants were mostly recent graduates and they might not have gotten a chance to participate in these classes. These findings are in agreement with those of Manguno *et al.* (18). Subjects in their study had a work experience similar to that in our study. Sede *et al.* (19) reported higher awareness about stem cell use in dentistry among older participants (aged >35 years), males, and more experienced participants in terms of years of practice (>5 years). The number of residents interested in participation in workshops or continuing education courses in our study was less compared to almost 100% reported in other studies (14,15,18). Lower number of individuals interested in participating in such courses in our study may be due to lack of adequate knowledge and insufficient instruction of residents regarding stem cells and dental regenerative treatments and elucidates the educational shortcomings in our dental schools. Sede *et al.* (19) also showed poor knowledge about the use of stem cells in dentistry among a group of Nigerian dentists. Most residents in our study believed that tissue engineering and regenerative treatments must be included in dental practice and stated that it would be beneficial to have stem cell banks. They mostly believed that the healing of periapical tissues and periodontium would be greatly enhanced by non-surgical tissue engineering treatment modalities; these results were in line with previous findings (14,15,18). These opinions may reflect the increasing number of research projects and papers on

tissue engineering and regenerative dentistry. On the other hand, although the demand for dental implants has greatly increased, more than half of the participants believed that regenerative treatments are superior to dental implant therapy. Considering the fact that the success of dental implants is over 90%, such high expectations of tissue engineering would be a great challenge for specialists in this novel field of science. High expectation was also revealed in a study on insights about the advantages of stem cell research, which were far greater than insights about its risks (20,21).

Similar to the studies by Epelman et al, (14) and Maguno et al, (18) most residents in our study believed that regenerative treatments have a promising future in dentistry and will have extensive dental applications in the next two decades. However, subjects in the study by Utneja et al. (15) believed that regenerative treatments would have extensive applications in dentistry in the next one decade. Moreover, about two-thirds of our study subjects had not performed any regenerative treatment in their clinical practice while in studies by Epelman et al, (14) and Utneja et al, (15) half of the participants reported practicing dental regenerative procedures. The study by Naylor et al. (22) showed that only 40% of respondents were using these techniques. Such a controversy in the results may be due to the fact that these studies were conducted on a specific group of professionals i.e. endodontists; whereas, our study was conducted on residents of all dental specialties. In a recent study, Lin et al. (23) showed that half of the endodontists surveyed had performed regenerative procedures. The American Association of Endodontists

released a position statement in 2013 stating that “revascularization or pulpal regeneration is within the scope of practice of endodontics” (24). These kinds of statements have a real impact on revision of specialty education programs and should be considered for performing this type of procedure in all dental specialties.

In our study, half of the participants stated that they would recommend dental regenerative treatment to their patients only if it is the most effective treatment option; 31% reported that they would recommend these treatments to their patients only if they are safe. This finding indicates that clinicians and patients need more evidence-based documents regarding the safety of these procedures and their higher efficacy than the conventional treatments.

Our participants believed that the high cost of such regenerative treatments could be the main obstacle against their acceptance. Our results in this regard are similar to other studies (14,15,18). Participants in our study preferred dental insurance coverage for regenerative treatments. However, subjects in studies by Epelman et al, (14) and Manguno et al. (18) preferred fee for service; this indicates that the next generation of Iranian dental specialists are more concerned about their patients and expect the insurance systems to cover patient expenses of regenerative treatments. By doing so, the demand for such treatments will increase as well. Most participants in our study believed that patients are willing to pay nothing for stem cell banking; while in the study by Manguno et al, (18) half of the participants stated that patients would pay approximately \$100 per year for stem cell banking; this

difference may be due to the different levels of income of patients residing in different countries.

Certainly, the cost of regenerative dentistry is one of the key considerations in predicting the impact of tissue engineering on the future of dentistry. The cost of treatment itself, as well as cumulative costs of translational approaches towards clinical application and constructing services for dental stem cell obtaining and banking or producing scaffolds at reasonable prices have a real impact on popularity of this technology. Similar to earlier studies, most participants in our study stated that the cost of regenerative treatments must be higher than that of conventional treatments; which may be due to the novelty of this modality and high cost of procurement of stem cells and regenerative procedures.

Most subjects in our study were not interested in providing patients with regenerative treatments only for the purpose of increasing their income, which highlights the ethical obligations of the future dental professionals. Three challenging questions were also included in our questionnaire. Two questions were about the conduction of tests on animals prior to clinical application in humans and the ethics of using human embryonic stem cells. At present, communities are mainly against the use of animals for research purposes, and potential treatments with the use of human embryonic stem cells are still a highly debated topic in many countries worldwide. However, most participants in our study agreed with the use of animals for experimental purposes and also the use of human embryonic stem cells; besides, they were mainly concerned about the potential health hazards regarding the use of stem cells as part of regenerative dentistry.

These findings were also in accordance with previous studies (14,15,18). In the 3rd question regarding explanation to patients about the source of materials derived from a human corpse or animal, the favorable and opposed responses were approximately equal. However, respect for patient autonomy is very important in clinical ethical decision making (25). It seems that there is a definite need to educate dental residents beyond the context of general ethical obligations.

In the studies by Epelman *et al.* (14) and Manguno *et al.* (18) only one-third of subjects were concerned about stem cell clinics providing dental services. But, our participants were more concerned in this regard and for this reason, most participants supported setting of relevant rules and regulations for use of stem cells in dental regenerative treatments. At present, the American Food and Drug Administration (FDA) has set three essential rules for the companies manufacturing any sort of human cells or tissues. These companies must register with the FDA before beginning these activities, they must meet the donor eligibility requirements and they should comply with the Current Good Tissue Practice requirements. These three criteria were set aiming to ensure the safety of biological products (26,27). Setting ethical codes along with thorough implementation of laws can ensure patients and clinicians regarding the safety of such regenerative treatments.

Finally, it should be noted that most of the participants in our study were females and the reported male preference for rational evaluation and logical learning style compared to females could explain some controversial results (28). Further studies in

different and larger communities are required to obtain more information on the acceptance of dental regenerative treatments by dentists. These data can help standardize the reconstructive and regenerative dental treatments.

Conclusion

This study provided a valuable insight into the ethical beliefs and judgments of dental residents regarding tissue engineering. Our study results showed the acceptance of regenerative treatments by dental residents in Tehran. However, this study also indicated the need for reassuring the clinicians regarding the efficacy and safety of these treatments. Thus:

- 1- Further scientific evidence is required to confirm the efficacy of regenerative treatments.
- 2- It seems that the current instruction on new treatment modalities such as tissue engineering is inadequate for dental residents and these topics must be included in continuing education courses and workshops.
- 3- Ethical codes must be updated, and clinicians and patients should be provided with information regarding new treatment modalities such as stem cell treatments.
- 4- Some rules and regulations must be set to ensure the safety of regenerative treatments.

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