Republic of Iraq
Ministry of Higher Education
and Scientific Research
University of Baghdad
College of Dentistry

Awareness of Iraqi dental students toward The application of stem cells in dentistry and orthodontics.

A project submitted to College of Dentistry, University of Baghdad, Department of Orthodontics in partial fulfillment for the Bachelor in Dental Surgery.

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Certification of the Supervisor

I certify that this project entitled "Awareness of Iraqi dental students toward the application of stem cells in dentistry and orthodontics" was prepared by the fifth-year student May Mahmoud Yahya under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name

Prof. Dr. Mushriq Fawzi

Date

Dedication

I dedicated this project to my family for their endless love, support, and encouragement

Acknowledgment

First and Foremost praise is to ALLAH. I would like to thank Allah for giving me opportunity, and strength to do my project. His continuous grace and mercy was with me throughout my life and ever more during the tenure of my project.

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I owe everything to my parents who encouraged and helped me at every stage of my personal and academic life and longed to see this achievement come true.

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List of abbreviations

Abbreviation	Description
AECs	Amniotic epithelial cells
DFCs	Dental follicle cells
DO	Distraction osteogenesis
DPSCs	Dental pulp stem cells
ERR	External root resorption
ESCs	Epithelial stem cells
FSCs	Fetal stem cells
GTR	Guided tissue regeneration
iPS	Induced pluripotent stem
MDSCs	Mesenchymal dental stem cells
MSCs	Mesenchymal stem cells
OTM	Orthodontic tooth movement
PDL	Periodontal ligament
PDLSCs	Periodontal ligament stem cells
RME	Rapid maxillary expansion
SCAP	Stem cells from apical papilla
SCs	Stem cell
SHED	stem cells from human exfoliated deciduous teeth
TMJ	Temporo-mandibular joint
UCE	Umbilical cord epithelium

Introduction

Orthodontics involves treatment of dental malocclusions and correction of dentofacial deformities. The aim of orthodontic treatment is to achieve facial aesthetics and improve oral health related quality of life. Orthodontic treatment of malocclusions has several shortcomings such as prolonged treatment time, apical root resorption, tooth movement limited to alveolar bone and difficulties to overcome periodontal defects **(Silvola *et al.*, 2014).**

Stem cells are primitive cells found in all multi-cellular organisms that are characterized by self-renewal and the capacity to differentiate into any mature cell type. These stem cells have the awesome potential for regeneration and may be used to replace or repair damaged cells, and have the potential to drastically change the treatment of conditions like cancer, Alzheimer's and Parkinson's disease and even paralysis. There are 2 main types of stem cells – embryonic stem cells and adult stem cells – which are classified according to their origin and differentiation potential **(Narang and Sehgal, 2012).**

In the field of dentistry, adult mesenchymal stem cells (MSCs) have been identified in several oral and maxillofacial tissues, which suggest that the oral tissues are a rich source of stem cells, and oral stem and mucosal cells are expected to provide an ideal source for genetically reprogrammed cells such as induced pluripotent stem (iPS) cells. Furthermore, oral tissues are expected to be not only a source but also a therapeutic target for stem cells, as stem cell and tissue engineering therapies in dentistry continue to attract increasing clinical interest. **(Egusa *et al.*, 2012)**

Dental stem cells in Iraq are still at the budding stage, and there seems to be limited awareness regarding dental stem cells. Therefore, this study aimed to assess the awareness of stem cells among the dental students.

Aim of study

To our knowledge, no previous study was performed to assess the awareness regarding stem cells and their therapeutic potential applications among dental students in Iraq. Such assessment if performed among the students may reflect the amount of exposure of dental students and recent graduates to the topic during their dental education and thus help in making any necessary recommendations.

Therefore, the current study was set out to assess the awareness of dental students about stem cells application in dentistry and orthodontics.

Chapter one: Review of literature

1.1 Definition

Stem cells (SCs) are undifferentiated cells that are capable of self-renewal and differentiation into multiple functional cell types **(Hassouna *et al.*, 2018).** Stem cells have the remarkable properties of developing into a variety of cell types in the human body. They serve as a repair system by the ability to divide without limit to replace other cells. When a stem cells divides, each new cell has the potential to either remain as a stem cell or become another cell type with special functions, such as blood cells, brain cells, etc **(Nguyen *et al.*, 2014).**

1.1.1 Stem cell can be isolated from these sources

- Embryonic stem cells (ESCs) are isolated from the internal cell mass of the blastocyst. They consist of populations of pluripotent cells that can produce the primitive ectoderm during embryogenesis **(Boroviak and Nichols, 2014; Kusena *et al.*, 2021).**
- Amniotic epithelial cells (AECs) arise from the amniotic membrane of the human placenta. They express multivalent ESC markers (such as oct-4, Nanog, and alkaline phosphatase), do not express telomerase, and do not form teratomas in vivo after transplantation **(Ballini *et al.*, 2019).**
- Fetal stem cells (FSCs) are mostly isolated (from embryonic cadaver tissue organs or are from tissue-specific embryonic stem cells), up to the 12th week of pregnancy. **(Abdulrazzak *et al.*, 2010; Qiu *et al.*, 2020)**.

- The umbilical cord epithelium (UCE) is derivative from the epithelial amniotic membrane and is a source of pluripotent stem cells. **(Charitos *et al.*, 2021)**.
- Adult somatic stem cells are produced during ontogenesis **(Posa *et al.*, 2021)**. They are found in specialized areas in almost all mammalian organs and tissues such as bone marrow, heart, kidneys, brain, skin, eyes, gastrointestinal tract, liver, pancreas, lungs, breasts, prostate, testicles, and ovaries.

1.2 History of stem cells

Stem cells also known as "progenitor or precursor" cells are defined as clonogenic cells capable of both self-renewal and multi-lineage differentiation. In 1868, the term "stem cell" for the first time appeared in the works of German biologist Haeckel. Wilson invented the term stem cell. In 1908, Russian histologist, Alexander Maksimov, postulated existence of hematopoietic stem cells at congress of hematologic society in Berlin. There term "stem cell" was proposed for scientific use. Stem cells have manifold applications and have contributed to the establishment of regenerative medicine **(Bansal and Jain, 2015).**

1.3 Dental stem cells

Teeth represent a very challenging material for regenerative medicine. Currently, there is a chance for stem cells to become more widely used than synthetic materials. Teeth have a large advantage of being the most natural and non-invasive source of stem cells. Mesenchymal dental stem cells (MDSCs) are multipotent cells that proliferate extensively, possess immunosuppressive properties, and express mesenchymal markers. MSDSCs can be isolated using explant cultures or enzymatic digestion. MDSCs can differentiate in in-vitro into

cells of all of the germinal layers, including ectoderm (neural cells), mesoderm (myocytes, osteo blasts, chondrocytes, adipocytes, and cardiomyocytes), and endoderm (hepatic cells) **(Bansal and Jain, 2015).**

Human dental stem cells that have been isolated and characterized are (Figure 1-1):

1. Dental pulp stem cells (DPSCs).

2. Stem cells from human exfoliated deciduous teeth (SHED).

3. Stem cells from apical papilla (SCAP).

4. Periodontal ligament stem cells (PDLSCs).

5. Dental follicle stem cells (DFCs).

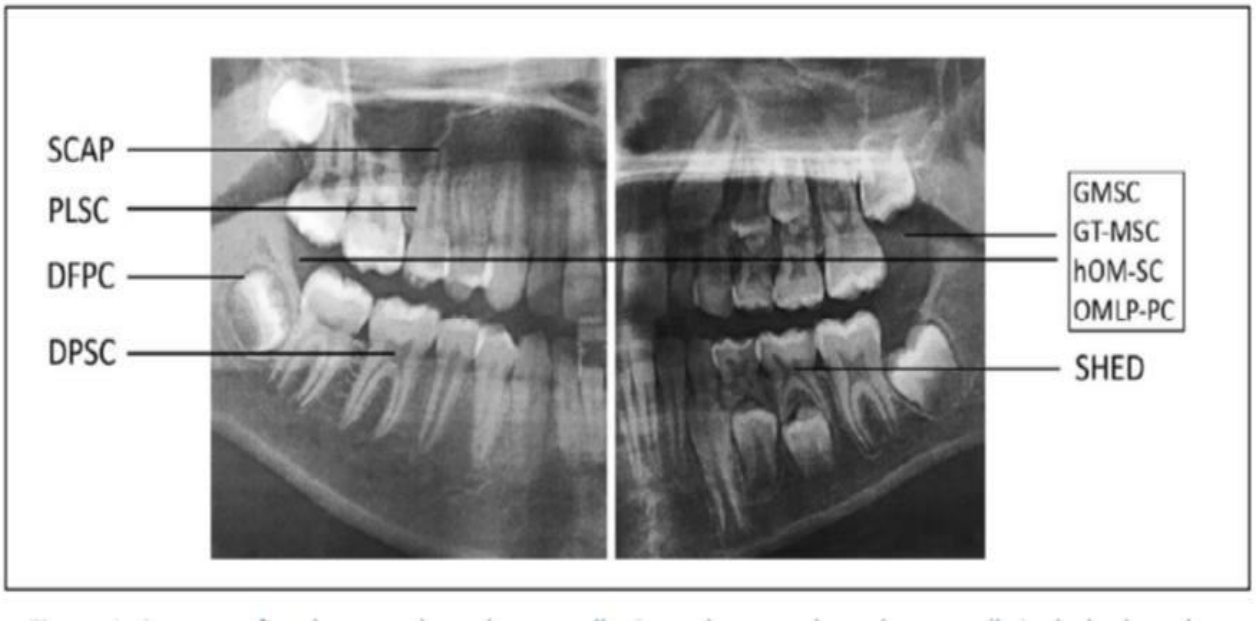

Figure 1-1: Sources of dental stem cells. (Luis and Moncayo, 2014)

1.3.1 Dental pulp stem cell (DPSC)

These were the first dental stem cells isolated from the human dental pulp, which were located inside dental pulp that have the ability to differentiate into odontoblasts/osteoblasts, adypocites and neural cells. DPSCs have osteogenic and chondrogenic potential *in vitro* and can differentiate into dentin, *in vivo* and also differentiate into dentin-pulp-like complex **(Gronthos *et al.,* 2000)**. Recently, immature dental pulp stem cells were identified which are a pluripotent sub-population of DPSC generated using dental pulp organ culture **(Kerkis *et al.,* 2007)**.

1.3.2 Stem cells from apical papilla

Stem Cells from Apical Papilla SCAP are the cells which are found at the tooth root apex. They have higher proliferation rates more over have a differentiation property in vitro similar to DPSCs. **(Hassouna *et al.,* 2018)**.

SCAP are the source of odontoblasts and cause apexogenesis. These stem cells can be induced in vitro to form odontoblast-like cells, neuron-like cells, or adipocytes. SCAP have a higher capacity of proliferation than DPSCs, which makes them a better choice for tissue regeneration **(Bakopoulou *et al.,* 2011; Han *et al.,* 2010)**.

1.3.3 Periodontal ligament stem cells (PDLSCs)

The periodontal ligament is a soft connective tissue embedded between the cementum and the inner wall of the alveolar bone socket to help support teeth. These cells are used in periodontal ligament or cementum tissue regeneration. PDLSCs exist both on the root and alveolar bone surfaces; however, on the latter, these cells have better differentiation abilities than on the former.

PDLSCs have become the first treatment for periodontal regeneration therapy because of their safety and efficiency **(Chen *et al.*, 2016; Iwata *et al.*, 2010)**.

1.3.4 Dental follicle stem cells (DFCs)

These cells are loose connective tissues surrounding the developing tooth germ. DFCs contain cells that can differentiate into cementoblasts, osteoblasts, and periodontal ligament cells **(Luan *et al.*, 2006; Handa *et al.*, 2002)**. Additionally, these cells proliferate after even more than 30 passages **(Guo *et al.*, 2012).**

1.3.5 Stem cells from human exfoliated deciduous teeth (SHED) cells

SHED cells are highly proliferative stem cells isolated from exfoliated deciduous teeth capable of differentiating into a variety of cell types, including osteoblasts, neural cells, and odontoblasts, and inducing dentin and bone formation. These cells possess one major disadvantage: they form a non-complete dentin/pulp-like complex in vivo **(Yasui *et al.*, 2016)**.

1.4 Application of stem cells in dentistry

1.4.1 Dentofacial anomalies

Craniofacial deformities such as congenital and developmental malformation and those resulting from trauma, tumor resection and nonunion of fractures, are common clinical problems in craniofacial surgery, which are difficult to cure. Current surgical techniques in various combinations, autogenous, allogeneic, and prosthetic materials have been used to achieve bone and soft tissue reconstruction. **(Cowan *et al.*, 2004)**. These approaches have several complications such as insufficient autogenous resources, donor site morbidity, contour irregularities, postoperative pain, additional cost, long surgical time and postsurgical

reabsorption, disease transmission, graft versus-host disease, immunosuppression, unpredictable outcome for tissue formation and infection of foreign material **(Bayerlein *et al.*, 2006)**. In order to overcome these complications, stem cell-based tissue regeneration offers an approach to provide an advanced and reliable therapeutic strategy for craniofacial tissue reconstruction **(Shi Bartold *et al.*, 2005).**

MSCs have been shown to have the ability to form new bone when transplanted. Some case series studies in patients with cleft lip and palate reported that MSCs usage to regenerate alveolar cleft **(Khojasteh *et al.*, 2015)**. Composite scaffold of demineralized bone mineral and calcium phosphate loaded with MSCs showed 34.5% regenerated bone in the cleft area in one case and in the other there was 25.6% presentation of bone integrity **(Behnia *et al.*, 2009)**.

1.4.2 Distraction Osteogenesis (DO):

Stem cells can induce mobilization of osteoblastic and osteoclastic cells. Stem cells can also accelerate bone regeneration in the distraction gap and enhance bony tissue consolidation .Such application was carried on through many studies started by experimental studies and have been finalized by a clinical trial on the human being **(D'Aquino *et al.*, 2009)**.

1.4.3 Temporo-mandibular joint disorders and Defects

The primary methods used to reconstruct the TMJ includes autogenous bone grafting such as harvesting from the rib, or the use of alloplastic materials, with neither being ideally suited for the task and sometimes leading to unwanted adverse effects. The major and final option for those patients with advanced degenerative diseases is surgical replacement of the mandibular condyle. These approaches have complications such as immunorejection, infection, implant wear,

dislocation, suboptimal biocompatibility, donor site limitation and morbidity, and potential pathogen transmission **(Shanti *et al.*, 2007)**.

To overcome these disadvantages, strategies have been found to engineer osteochondral tissue, such as that found in the TMJ, will produce tissue that is both biologically and mechanically functional used. Recently, these cells have attracted much interest to joint reconstruction.

1.4.4 Rapid maxillary expansion

RME is similar to DO histologically. During RME, a gap in the midpalatal suture is created which is filled with blood and granulated tissue and followed by active bone formation. The expanded arch width relapses unless followed by an appropriate retention period. Therefore, providing a strategy to accelerate bone formation in the midpalatal suture might shorten treatment and retention period, achieve stability and prevent relapse. Because of the ability of SCs to differentiate into osteogenic cells, injection of SCs seems to have the ability to accelerate the process of bone formation. This was investigated in one animal study, in which local injection of MSCs into intermaxillary suture after force application resulted in increased new bone formation in the suture by increasing the number of osteoblasts and new vessel formation **(Ekizer, et al., 2015)**.

1.5 Applications in orthodontics

To evaluate the uses of SCs in orthodontics, current evidence regarding application of SCs in expanding the limitations of orthodontic tooth movement (OTM), tooth movement into periodontal defects, accelerating OTM and treatment

of external root resorption (ERR) have been reviewed (Figure 1-2).

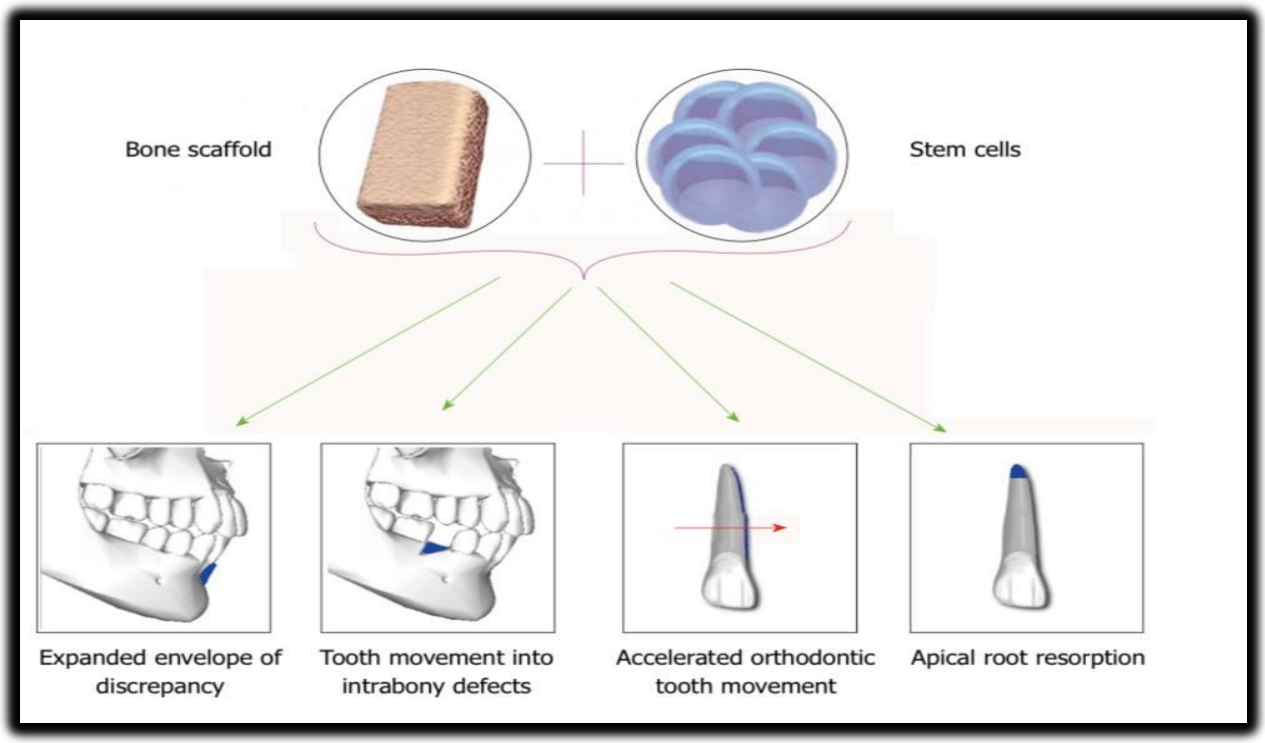

Figure 1-2: possible applications of stem cells in orthodontics.(Safari, *et al.*, 2018)

1.5.1 Expanded envelope of discrepancy

The extent of OTM is limited by several factors including the anatomy of the alveolar bone, pressures exerted by soft tissues, periodontal tissue attachment levels, neuromuscular forces and lip–tooth relationships. The anteroposterior, vertical, and transverse millimetric range of treatment possibilities in orthodontics can be expressed as an "envelope of discrepancy" Gingival recession occurs secondarily to an alveolar bone dehiscence, if overlying tissues are stressed during OTM beyond this envelope **(Teodora *et al.*, 2012)**.

SCs have the potential to generate different tissues, including bone, thereby stem cell therapy is a promising approach to alveolar bone regeneration. Some researchers have applied stem cell therapy in case of bone ridge augmentation in

humans and mainly used bone marrow cells. The outcome of alveolar bone regeneration showed a tendency to enhance bone formation **(Miguita *et al.*, 2017)**.

1.5.2 Periodontal regeneration

Periodontal regeneration has been defined as the formation of new cementum, alveolar bone, and a functional periodontal ligament on a previously diseased root surface. The current treatment approaches include the use of surgery, guided tissue regeneration (GTR), bone fillers and growth factors and application of bioactive molecules to induce regeneration **(Safari, *et al.*, 2018)**.

Based on the differential potential capability of SCs and their ability of renewal *via* mitosis, they have the quality to regenerate damaged tissues, hence they can be used for regeneration of periodontium. Periodontal defects could be a challenging situation both pre and post orthodontic treatment. It has been suggested that, by moving the teeth into infrabony defects, we can achieve the regeneration of the attachment apparatus. Several reports on application of SCs for regeneration of periodontal tissues have been published. In a study, induced pluripotent SCs have been implanted into a mouse periodontal fenestration defect model with a silk fibroin scaffold in combination with enamel matrix derivative gel. As a result, higher rate of cementumm and alveolar bone formation was observed. Also, it has been shown that the bone marrow derived mesenchymal stem cells treated wounds exhibited significantly accelerated wound closure, with increased re-epithelialization, cellularity, and angiogenesis. In another study conditioned medium obtained from PDLSCs were transplanted into a rat periodontal defect model and consequently enhanced periodontal regeneration by suppressing the inflammatory response *via* TNF-a production **(Nagata *et al.*, 2017)**.

1.5.3 Accelerated OTM

OTM is achieved by the remodeling of periodontal ligament (PDL) and alveolar bone in response to mechanical loading **(Meikle, 2006)**.

The initiating inflammatory event at compression sites is caused by constriction of the PDL microvasculature, resulting in a focal necrosis, followed by recruiting of osteoclasts from the adjacent marrow spaces, These osteoclasts are mostly derived from hematopoietic SCs. Hence, SCs could be used to accelerate OTM by providing progenitor cells. The development of new methods to accelerate OTM has been sought by clinicians as a way to shorten treatment times, reduce adverse effects such as pain, discomfort, dental caries, and periodontal diseases, and minimize iatrogenic damages such as root resorption and the subsequent development of non-vital teeth **(Zainal Ariffin *et al.*, 2011)**.

This ability of SCs could be used to accelerate OTM in response to orthodontic forces. When orthodontic force is applied, tooth movement is hindered until the necrosis is removed, leading to the clinical manifestation of a delay period. Hypothetically, transplantation of SCs in pressure sites may speed up the process, resulting in accelerated OTM **(Feng *et al.*, 2016)**.

1.5.4 External root resorption (ERR)

ERR is a common and unfavorable side effect of orthodontic treatment, which any specialist may encounter **(Mohanty *et al.*, 2015)**. ERR may lead to loss of tooth structure such as cementum and in more advanced stages, dentin, however no specific treatment has been introduced so far. One possible treatment modality could be regeneration of resorbed roots by application SCs and tissue engineering. In severe cases ERR may cause poor prognosis of tooth, resulting in tooth loss. Regeneration of these lesions increases the longevity of tooth and may play an

important role in facilitating the treatment. In a study designed to induce de novo cementum formation by SC therapy, MSCs driven from periodontal ligament in *in vivo* transplantation were able to form cellular cementum-like hard tissue containing embedded osteocalcin- positive cells **(Shinagawa-Ohama *et al.*, 2017)**.

1.5.5 Alveolar bone defect repair

Orthodontic treatment includes extraction of premolars for correction of malocclusion. During surgical removal of teeth, accidentally buccal plates could be lost leading to alveolar bone defect. Such defects can be filled with stem cells to avoid the risk of dehiscence and periodontal damage after the spaces have been closed by retraction. Alveolar cleft osteoplasty can be successfully done with stem cells **(Mishra, 2016)**.

A study was accomplished autologous bone regeneration in humans. It was obtained through the use of a biocomplex of dental pulp stem/progenitor cells from extracted wisdoms seeded onto a collagen-based scaffold. The area treated with such complex was significantly better than the control side treated with scaffold only The study gave evidence that the procedure described using Autologous DPCs were a new tool for bone tissue engineering resulted in optimal bone repair **(D'Aquino *et al.*, 2009)**.

Chapter two: Materials and methods

2.1 Materials and Methods

This was cross-sectional study in the form of e-survey (Google form) questionnaire. The questions were designed and used to know the number of under graduated students in the 4th and 5th grade who are familiar with dental stem cells and their application in dentistry in general and in orthodontic in specific.

The survey took 3 months from January to April 2022. The participants were free to contact the researcher when they have doubts while answering the questionnaire.

The questionnaire contains 10 questions, which have been developed and modified on the basis of other similar studies related to stem cells **(Feng *et al.*, 2016; Chitroda *et al.*, 2017)**.

A copy of the questionnaire is included in the appendix.

This research was approved by the Department of Orthodontics-Collage of Dentistry/ University of Baghdad.

A Google form questionnaire was distributed through social media and personal contacts to dental students (4th and 5th grade) in the College of Dentistry-University of Baghdad. The preliminary survey was pilot tested on 10 students (5 grade four and 5 grade five students); consequently, the questions were reviewed and modified to the final form of the questionnaire.

Descriptive statistics were performed to define all categorical data in the form of counts, percentages and bar charts.

The questionnaire includes close-ended questions, which were divided into four parts as follow:

1. Gender and grade.

2. Types of stem cells

3. Sources of dental stem cells

4. Application of dental stem cells

Chapter three: Results

3.1 Response rate:

Out of 166 participants only 100 responded to the questionnaire making the response rate of 60%. Hundred participants have replied to the questionnaire.

The majority of participants were in the 5th grade about (84%), however only (16%) were in the 4th grade (Figure 3-1)

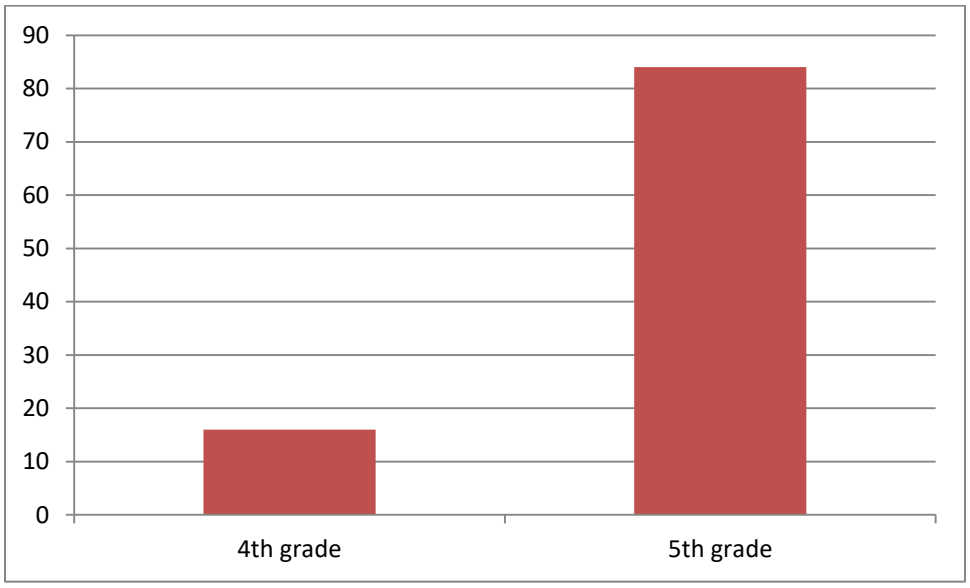

Figure 3-1: Distribution and response rate of participants, According to the grade

3.2 Responsive rate according to gender:

The rate of male participants who positively reacted to the survey was relatively low (28%). On the other hand, females represented a high percentage (72%) of the total number of the participants as shown in figure below (Figure 3-2)

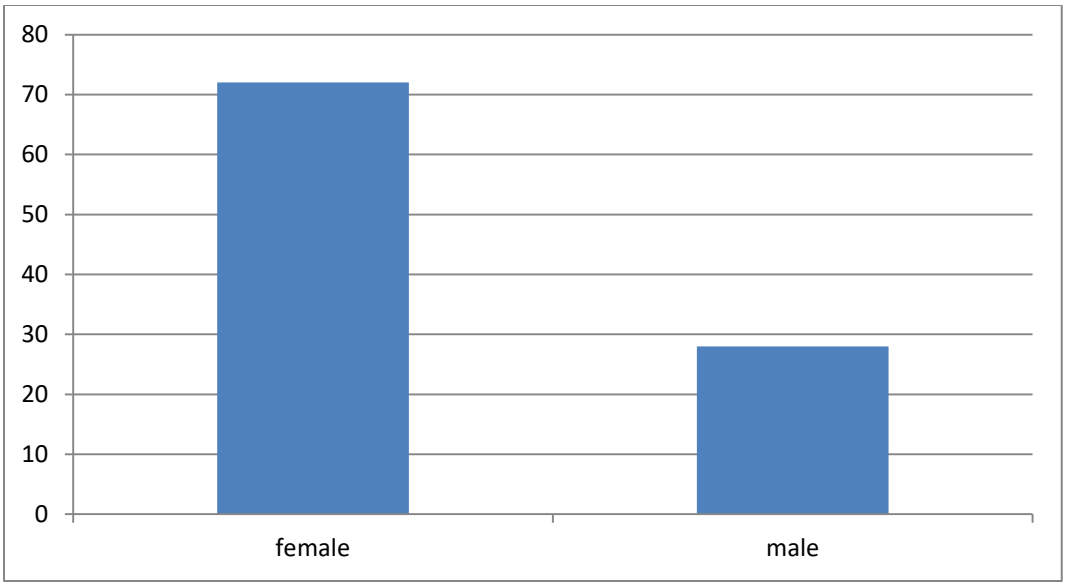

Figure 3-2: Distribution of male and female according to their response rate.

3.3 Familiarity about dental stem cell:

The majority of the participants (83.8%) responded positively to the question related to their familiarity with the term dental stem cells. However, only (16.2%) have never heard about the terminology dental stem cells (Figure 3-3)

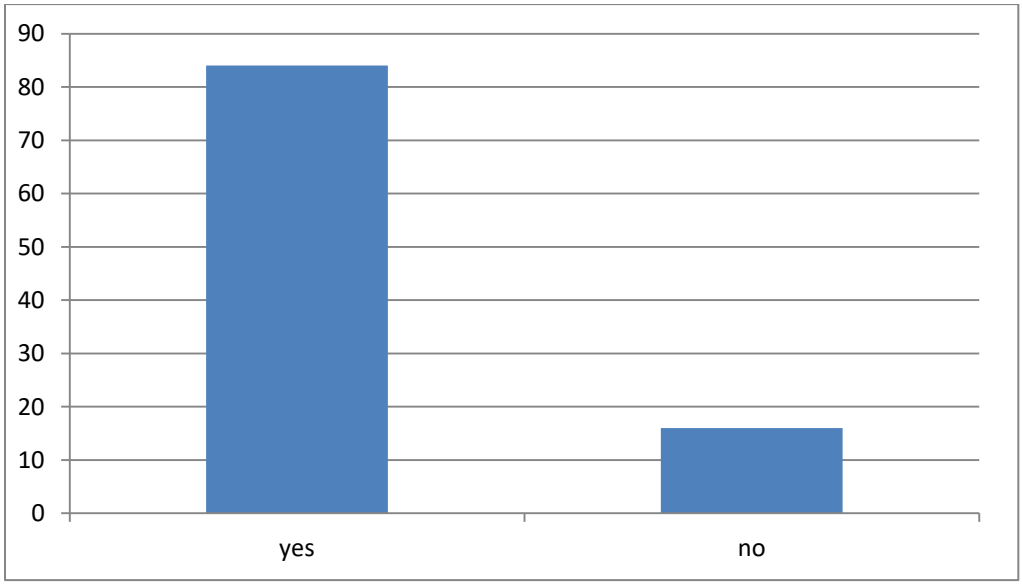

Figure 3-3: Distribution according to the familiarity with stem cells.

3.4 Sources of information:

More than halves of the participants confirmed that their source of information was the internet (64%) followed by books (36%), seminars (30%), undergraduate training (22%), journals (12%) in respectively, and only (6%) were from mass media and (3%) from conference (Figure 3-4).

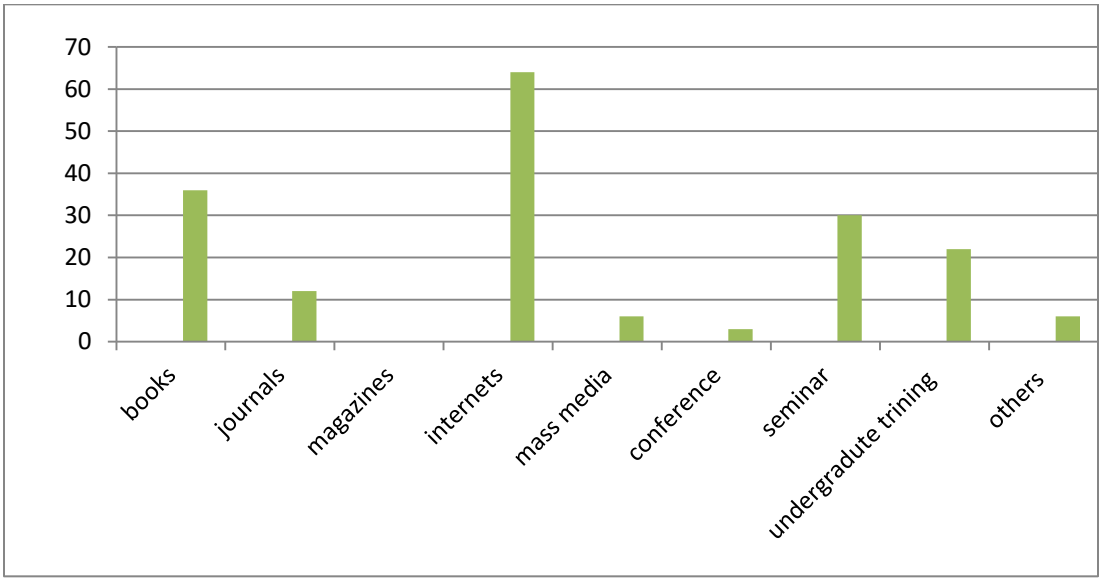

Figure 3-4: Distribution of the sources of information.

3.5 Are you aware of different types of dental stem cells?

Out of 100 participants only 47% answered yes, however the majority answered No (Figure 3-5).

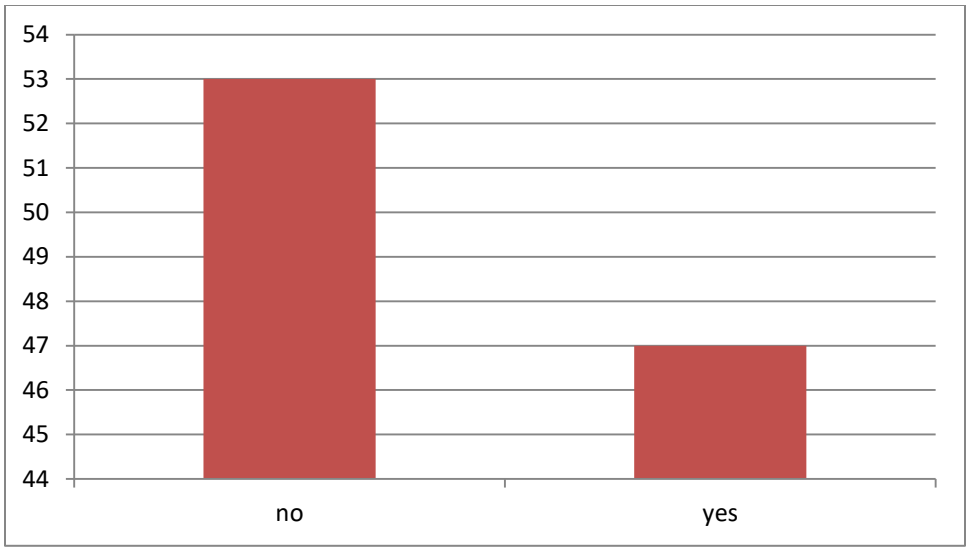

Figure 3-5: Distribution according to the awareness about dental stem cells

3.6 Dental stem cells can be extracted from which of the following sources?

The majority of the participants have no idea about the sources of dental stem cell, however (29%) answered dental pulp stem cells followed by (25%) which their answered were all of (dental pulp stem cells, stem cells from human exfoliated deciduous teeth, dental follicle stem cells, stem cells from PDL), in addition (20%) , (16%), (12%) answered dental follicle stem cells, stem cells from human exfoliated deciduous teeth, stem cells from PDL in respectively (Figure 3-6)

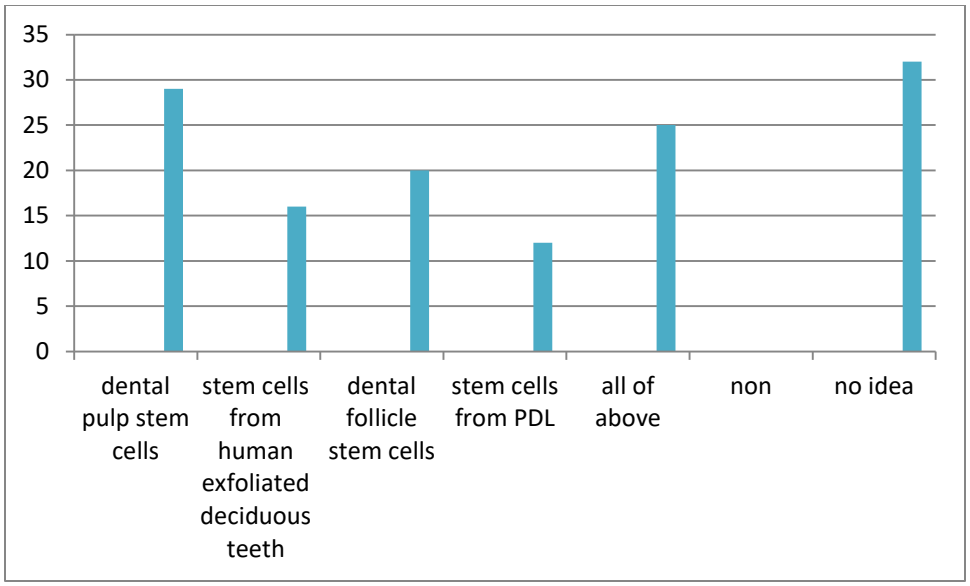

Figure 3-6: distribution of the participant about sources of dental stem cells

3.7 Application of dental stem cells:

From 100 responses only (29%) have responded positively, while (31%) have responded negatively. Surprisingly, the majority (40%) have no idea about the application of dental stem cells (Figure 3-7).

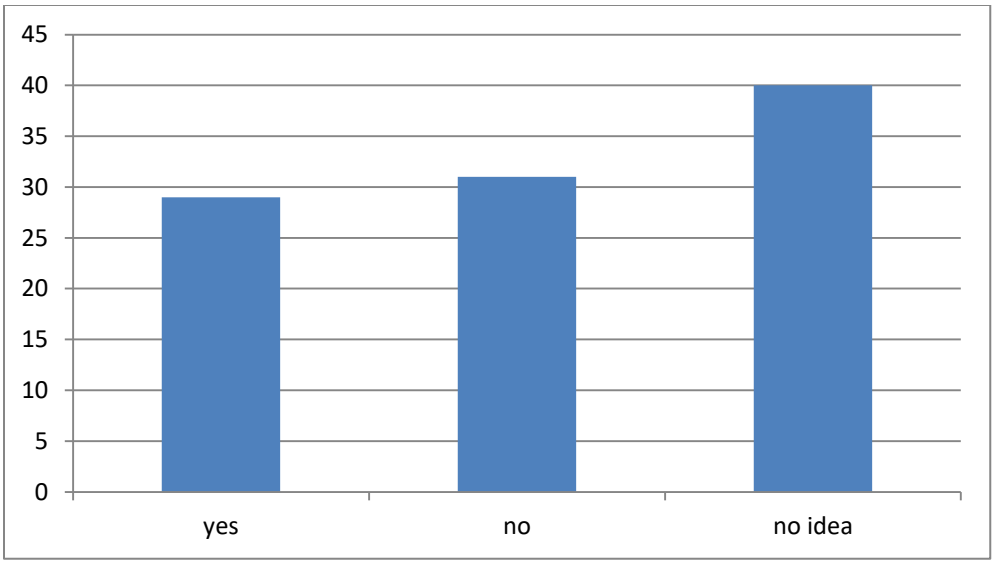

Figure 3-7: Usage of dental stem cells.

3.8 If yes, what are the clinical applications of stem cell in dentistry?

Figure (3-8) shows that the majority have no idea about the applications of stem cells in oral health, however (22%) think that all of the option were true, (11%) were regeneration of pulp and dentin, (8%) were whole tooth regeneration, (7%) for both root formation and PDL, cementum, alveolar bone regeneration, (3%) were non2 and only (1%) were OTM.

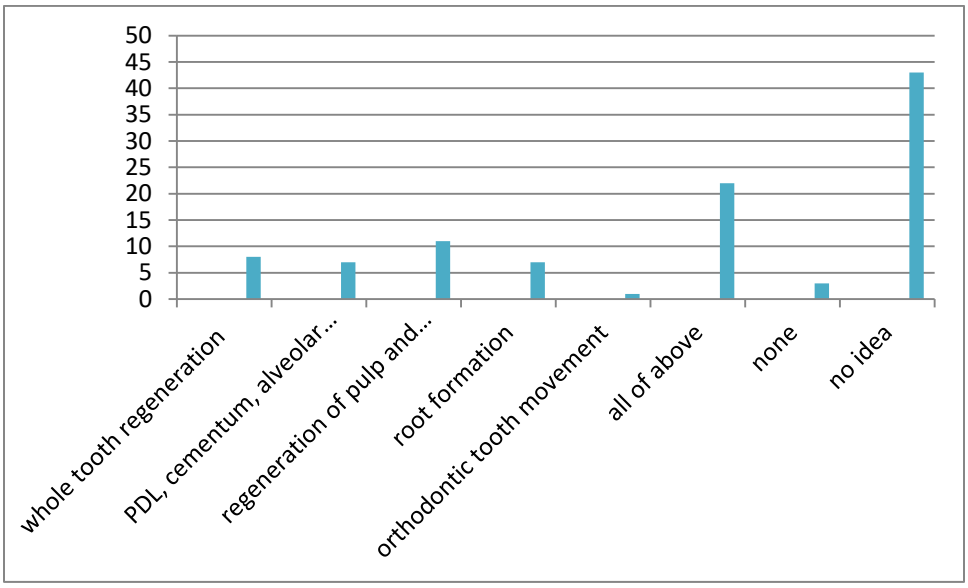

Figure 3-8: distribution of the participants regarding clinical application of stem cells in dentistry

3.9 The main obstacle to seek treatment with aid of dental stem cells:

The high cost was the top of the answerers followed by insufficient knowledge about stem cells among bot the people and dental practitioners, only (6%) see it have an ethical issue, but the majority see that all of above are the main

obstacle and 4 see that there is no obstacle from using stem cell therapy, (Figure 3-9).

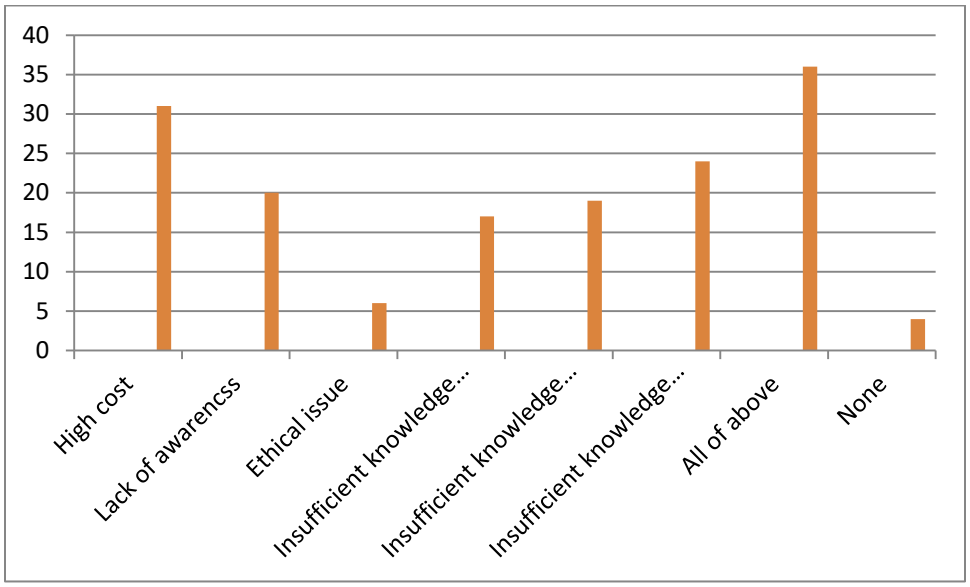

Figure 3-9: Opinion of the participants about the obstacle from using dental stem cells in the treatment.

3.10 Do you think dental stem cells will be used for acceleration of orthodontic tooth movement?

Figure (3-10), show that more than have of respondents been not sure about the usage of stem cell in acceleration orthodontic tooth movement, however 41% think that it will be useful and only 3% said no.

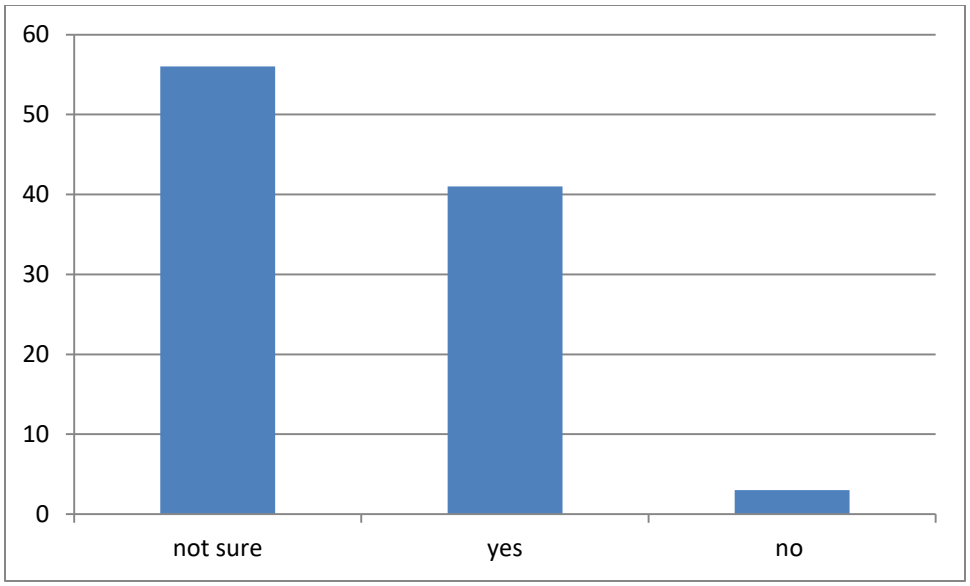

Figure 3-10: opinion of the participants about use stem cells in acceleration OTM

Chapter four: 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)**. The discovery of stem cells in the pulps of permanent and deciduous teeth and the possibility of using dental pulp stem cells for tissue engineering has prompted much research in this field. Stem cell research is a fast growing field in medicine with about 20,000 publications for tissue engineering or regenerative medicine in 2019 and 1,300 publications in dentistry in 2019 (Pubmed search). There is therefore, enthusiasm for the incorporation of regenerative procedures into dental practices, and a growing demand for more lectures, together with incorporation into undergraduate teaching programmes.

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 are essential among future dentistry.

The application of dental stem cells is the future of dentistry and has a wide range of usage in dentistry and medicine. Therefore, the present study was set to assess the awareness regarding stem cells among pre-graduated dental student in Baghdad, Iraq.

The response rate in the present study was 60%. Various studies showed different response rates. Previous studies reported comparable response rate such as a UK study (66%) in which 935 questionnaires were sent **(Banks *et al.*, 2010)**. Whilst, other studies showed very low response rate for example an American study in which 10,523 questionnaires were sent (7.7%) **(Keim *et al.*, 2008).**

Furthermore, the present study reported higher response rate in females rather than males, which was also reported by other studies **(Basson *et al.*, 2016)**.

Almost 83% of dental student are aware of the dental stem cells. And this study revealed 29% awareness of the application of dental stem cells. According to our study, the major source of information was internet followed by books which may be due ease of access to the source. The finding comes in agreement to previous study carried out in India done by **(Chitroda *et al.*, 2017)**, conversely to a study who was conducted by **(Sedgley *et al.*, 2012)** who reported that the undergraduate training and conference/symposium/seminar were the primary source of information. This could be due to increased spurt of conversation regarding the topic within the public through a variety of forums like increased publication of scientific articles.

About 32% of dental student believed that the main obstacles to seek treatment with the aid of dental stem cells are high cost, and insufficient knowledge about stem cells among dental practitioners as well as people. The present finding comes in accordance to a survey performed by **(Chitroda *et al.*, 2017)** and by **(Goyal, 2015)** where 49.6% and 63.50% in respectively agreed that the high cost, lack of awareness, and lack of sufficient knowledge were hindering people to obtain treatment using dental stem cells. On the contrary, other studies found that cost is not an obstacle when it comes to the application of stem cells **(Basson *et al.*, 2016).**

The participants of this questionnaire were optimistic about the possibility of stem cell utilization in dentistry with the budding awareness of stem cells in the country.

Chapter five: Conclusion and suggestion

5.1 Conclusion:

Among dental students in Baghdad, Iraq, there was moderate to positive awareness toward stem cells and their therapeutic applications in dentistry and orthodontics; 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.

5.2 Suggestion:

Further studies are needed with larger sample size and the inclusion of other dental schools in Baghdad and other regions of Iraq. We further recommend that the stem cell in general and dental stem cells should be included in the curriculum of the dental schools, and there should be more seminars and conferences about dental stem cells and their applications in dentistry.

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Appendix:

1. Grade?
2. Gender?
    - female
    - male
3. Have you heard of terminology stem cells?
    - Yes
    - No
4. Specify your source of information?
    - Books
    - Journals
    - Magazines
    - Internet
    - Mass media (TV and radio)
    - Conference/convention/symposium
    - Seminar
    - Undergraduate training
    - If other (specify)
5. Are you aware of different types of stem cell?
    - Yes
    - No
6. If yes, what are different types of stem cell?
    - Embryonic stem cell
    - Adult stem cell
    - All of above
    - No idea
7. Are you aware of various application of dental stem cell?
    - Yes
    - No
    - No ide
8. If yes, what are the different clinical applications of dental stem cells in relation to oral health care?
    - Whole tooth regeneration
    - Periodontal ligament, cementum, alveolar bone regeneration
    - Regeneration of pulp, dentin
    - Root formation
    - Orthodontic tooth movement

- All of above
- None
- No idea

9. What do you think is the main obstacle to seek the treatment with the aid of dental stem cell?
    - High cost
    - Lack of awareness
    - Ethical issue
    - Insufficient knowledge about stem cell among dental practitioners
    - Insufficient knowledge about stem cell among people
    - Insufficient knowledge about stem cell among dental practitioners as well as people
    - All of above
    - None
10. Do you think dental stem cells will be used for acceleration of tooth movement?
    - Yes
    - Not sure
    - No