Knowledge and Attitude of Indian Dentists Regarding Dental Stem Cells: A Cross-sectional Descriptive Survey

Abstract

**Background:** Dental stem cells derived from tooth structures are adult stem cells that have received attention of researchers over the past decade. Dental stem cells can be used to regenerate dental tissues as well as non-dental organs. These dental stem cells are readily accessible as compared to other sources of stem cells and can be obtained and stored for future use through minimally invasive procedures. Research in this field is growing at a fast pace and it is essential that awareness regarding the same should be present amongst professionals. **Aim:** This study was carried out to assess the knowledge and attitude of Indian dentists regarding dental stem cells. **Material and Methods:** A cross sectional descriptive, questionnaire based survey based on Knowledge, Attitude and Practice (KAP) was conducted and a total of 823 dentists from Maharashtra, India participated in the survey. The Pearson’s Chi-Square Test and percentages of the total were used for statistical analysis. **Results and Conclusion:** A total of 823 dentists completed the questionnaire survey; out of which 396 were male and 427 were female. Maximum respondents (53%) were dental graduates, followed by post graduates (45%) and PhD (1.7%). Data from the study revealed that there is good awareness regarding stem cells in general; however, the awareness, knowledge regarding sources, applications, uses and clinical research guidelines regarding dental stem cells is lacking amongst most dentists. Despite this lack of knowledge, dentists are keen on updating their knowledge regarding dental stem cells. **Keywords:** Dental stem cells, regeneration, stem cell survey, stem cells from human exfoliated deciduous teeth, tooth bank

Introduction

Stem cells are defined as clonogenic unspecialized cells which are capable of both self-renewal for long periods and multilineage differentiation, contributing to regeneration of specific tissues.[1] Stem cells are broadly classified as embryonic or adult, depending on the developmental stage from which they are obtained.[2] Embryonic stem cells are derived from blastocysts which are left from in vitro fertilization in the laboratory or from aborted fetus. Adult stem cells are stem cells obtained from any postnatal organ. Depending on their origin, adult stem cells are further classified as Hematopoietic stem cells (HSCs) and nonhematopoietic-mesenchymal stem cells (MSCs). HSCs are obtained either from bone marrow, cord blood, or peripheral blood. MSCs are those that originate from the mesoderm layer of the fetus and in the adult tissues such as limbal stem cells, hepatic stem cells, dermal stem cells, and dental stem cells (DSCs).[3]

The DSCs, based on their origin, are further classified as dental pulp stem cells (DPSCs), stem cells from human exfoliated deciduous teeth (SHED), periodontal ligament stem cells, dental follicle stem cells, tooth germ progenitor cells obtained from third molars, and stem cells from the apical papilla.[4] Research has shown that DSCs have the potential to differentiate into adipocytes, neural cells, osteocytes, chondrocytes, and myocytes.[5] Apart from these, DSCs have also demonstrated dentin, periodontal, cemental, and pulp regeneration. The other craniofacial uses include salivary gland tissue regeneration, temporomandibular joint regeneration, and whole tooth regeneration.[6] Extensive research is being done to find out the potential uses of DSCs in cancer therapy and forensic dentistry. DSCs are easy to obtain as compared to other sources of stem cells and have the

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added advantage of having fewer ethical concerns. This has given rise to increasing popularity of tooth banking and harvesting of DSCs. It is imperative that dental practitioners are aware of the merits and demerits of DSCs to guide their patients regarding the same.

**Aim and objectives**

The aim of the study was to assess the knowledge and attitude of Indian dentists regarding DSCs. This objective was to determine and compare the knowledge, awareness, and attitude of dental graduates and postgraduates toward the harvesting and application of DSCs.

**Materials and Methods**

The present cross-sectional descriptive study was a questionnaire-based survey conducted from September to November 2015. The study protocol was reviewed and approved by the Institutional Review Board of Ethics of Terna Dental College, Navi Mumbai. The survey carried out was a knowledge, attitude, and practice study. The questions were formulated after going through similar studies and articles published in academic journals related to DSCs. The questionnaire was subjected to a pilot study on 20 dentists which included postgraduate students as well as teaching faculty of Terna Dental College comprising BDS and MDS qualification. The suggested points were incorporated depending on their merits in relation to the mentioned study. The final questionnaire consisted of twenty questions. Based on the findings of pilot study on twenty dentists, 5% alpha error, 95% confidence level, and 80% power, the sample size was determined to be 823.

The survey population comprised dentists residing or practicing in Maharashtra, India. A total of 823 consenting dentists participated in the survey which included dental private practitioners as well as academicians from dental colleges within Maharashtra. The questionnaire was close-ended, self-administered, and hand delivered [Questionnaire].

The initial five questions pertained to sociodemographic variables. The sociodemographic variables included age, gender, area of work, qualification, and years of experience. The next set of questions assessed the awareness regarding stem cells and DSCs, source of knowledge, tooth banking procedure, applications, ethical concerns, barriers toward use of stem cells, and methods of increasing awareness regarding the same.

The questionnaire data were entered into Microsoft Excel 2010 by the investigator. The analysis was done using SPSS version 17 software (SPSS Inc., Chicago, IL, USA). The Pearson’s Chi-square test and percentages of the total were used for analysis to gain insight into the knowledge and attitude regarding DSCs among Indian dentists.

**Results**

A total of 823 dentists completed the questionnaire survey, of which 396 were male and 427 were female. Table 1 shows the demographic characteristics of participants. 572 (69.5%) participants were <35 years of age, 212 (25.8%) were between 35 and 50 years of age, and 39 (4.7%) were above 50 years of age. Maximum respondents (53%) were dental graduates, followed by postgraduates (45%) and PhD (1.7%).

Awareness of stem cells in general was 86% and awareness of DSCs was 74% [Figure 1]. 79.4% of graduates, 95.1% of postgraduates, and 78.6% of PhD participants were aware of stem cells. DSC awareness was highest among postgraduates (91.4%), followed by graduates (60.1%) and PhD participants (57.1%). Two hundred and eleven participants (25.6%) were not aware of DSCs, and hence, they did not continue with the survey.

The source of information regarding DSCs was found to be through journals (32.6%), internet (32.3%), magazines (18.8%), professional societies (18.3%), television (12.5%), and commercial companies (7.7%) [Figure 2].

**Table 1: Demographic characteristics of participants**

| Characteristics | Frequency | Percent |
|-----------------|-----------|---------|
| Age (in years)  |           |         |
| <35             | 572       | 69.5    |
| 35-50           | 212       | 25.8    |
| >50             | 39        | 4.7     |
| Gender          |           |         |
| Male            | 396       | 48.1    |
| Female          | 427       | 51.9    |
| Qualification   |           |         |
| BDS             | 436       | 53      |
| MDS             | 370       | 45      |
| PhD             | 14        | 1.7     |
| Others          | 3         | 0.4     |
| Experience (in years) |   |         |
| <5              | 502       | 61.0    |
| 5-10            | 185       | 22.5    |
| >10             | 136       | 16.5    |

**Figure 1: Awareness of stem cells in general and dental stem cells in 823 participants**
The participants were enquired about the teeth that can be used for stem cell banking. Most of the graduates (29.8%) and PhD participants (35.7%) selected exfoliated teeth as candidates for DSC banking. 41.6% postgraduates said that teeth with no pathology can be used for banking [Figure 3].

The procedural details of DSC banking were known to only 20.9% of graduates, 37.8% of postgraduates, and 28.6% of PhD participants. The percentage is seen to be higher among postgraduates and PhD participants.

53.8% of postgraduates, 42.9% of PhD participants, and only 28.9% of graduates were aware of the presence of DSC banks in India.

18.3% of graduates, 37.6% of postgraduates, and 35.7% of PhD participants had knowledge about the ethical concerns related to DSC banking. The awareness about existence of regulatory bodies within India governing stem cell banking was known only to 17.7% graduates, 30% postgraduates, and 28.6% PhD respondents.

The application of DSCs in the development of nondental organs was known to 31.9% of graduates, 52.4% of postgraduates, and 21.4% of PhD participants.

The barriers to the use of DSCs were cited as high cost by 55.8% and lack of patient awareness by 55% of the participants. Eighty-six percent also stated that apart from these factors, lack of operator skill and lack of knowledge about procedure are factors hindering the use and application of DSCs.

The participants were enquired whether they would recommend DSC banking to their patients. 46.6% of graduates, 69.5% of postgraduates, and 42.9% of PhD participants were willing to recommend DSC banking to their patients. 56.9% of graduates, 87.6% postgraduates, and 50% PhD participants were keen on updating their knowledge regarding DSCs. Methods recommended to increase dental stem cells awareness were seminars, journals, conferences, advertisements and other sources [Figure 4].

Table 2 shows the association between age, qualification, and experience with awareness and attitude toward DSCs [Figure 5].

Table 3 shows the association between age, qualification, and experience with knowledge regarding procedural aspects, ethical concerns, regulatory bodies, and application of DSCs [Figure 6].

Qualification and experience were significantly associated with awareness and knowledge regarding DSCs ($p \leq 0.05$).

Discussion

Research in the field of stem cells and DSCs has been advancing at a fast pace. The use of stem cells for medical applications is on the rise. Increasing research is widening the scope and application of DSCs. As this is a recent advancement, there is a possibility that this topic may not have been a part of dental education curriculum. The general population is becoming increasingly aware about DSCs through media such as advertisements and news. Dental professionals are approached by patients for further information regarding the same. The dental professionals are also approached by DSC companies for promotion of DSC collection and storage. It is therefore essential that dentists have knowledge regarding the sources, storage, and applications of DSCs. Hence, this survey was conducted to assess the awareness of basic knowledge regarding stem cells and DSCs among Indian dentists.

The awareness of stem cells in general was 79.4% in graduates, 95.1% in postgraduates, and 78.6% in PhD participants. However, the awareness of DSC was lesser among the same population – graduates (60.1%), postgraduates (91.4%), and PhD participants (57.1%).
Table 2: Association of age, qualification, experience with awareness and attitude regarding Dental stem cells (DSCs)

| Age       | ≤35 | 35-50 | >50 | p      |
|-----------|-----|-------|-----|--------|
|           | Yes | No    | Yes | No    | Yes | No    |        |
| Awareness of SCs in general | 59.5 | 10.0 | 22.6 | 3.2 | 4.4 | 0.4 | 0.417 |
| Awareness of DSCs | 51.4 | 18.1 | 19.1 | 6.7 | 3.8 | 1.0 | 0.904 |
| Awareness about tooth banking procedure following extraction | 18.1 | 33.3 | 8.5 | 10.7 | 1.9 | 1.8 | 0.128 |
| Interest in updating knowledge about DSC | 49 | 2.4 | 18.0 | 1.2 | 3.6 | 0.1 | 0.836 |
| Inclusion of DSC topic in curriculum | 48.7 | 2.7 | 18.7 | 0.5 | 3.8 | 0.0 | 0.386 |

Table 3: Association of age, qualification, experience with awareness and knowledge regarding dental stem cells (DSCs)

| Age       | ≤35 | 35-50 | >50 | p      |
|-----------|-----|-------|-----|--------|
|           | Yes | No    | Yes | No    | Yes | No    |        |
| DSC banks in India | 25.6 | 5.3 | 20.4 | 12.3 | 2.3 | 4.6 | 2.6 | 0.1 | 1.1 | 0.012 |
| Ethical concerns | 18.3 | 8.1 | 24.9 | 7.5 | 2.2 | 9.5 | 1.3 | 3.2 | 0.7 | 0.0196 |
| Regulatory bodies in India governing DSC research | 15.8 | 4.3 | 31.3 | 6.3 | 1.8 | 11.1 | 1.2 | 0.0 | 2.6 | 0.0029 |
| Use of DSCs in developing non dental organs | 27.0 | 7.5 | 16.9 | 11.7 | 1.5 | 6.1 | 2.2 | 0.6 | 1.0 | 0.293 |

Table 2: Association of age, qualification, experience with awareness and attitude regarding Dental stem cells (DSCs)

| Qualification       | BDS | MDS | PhD | Others | p      |
|---------------------|-----|-----|-----|--------|--------|
| Awareness of SCs in general | Yes | No | D/k | Yes | No | D/k | Yes | No | D/k |        |
| Awareness of DSCs | 42.0 | 10.9 | 42.8 | 2.2 | 1.3 | 0.4 | 0.4 | 0.0 | 0.000* |
| Awareness about tooth banking procedure following extraction | 31.9 | 21 | 41.1 | 3.9 | 1.0 | 0.7 | 0.2 | 0.1 | 0.000* |
| Interest in updating knowledge about DSCs | 11.1 | 21.1 | 17.0 | 23.9 | 0.5 | 0.5 | 0.0 | 0.2 | 0.000* |
| Inclusion of DSC topic in curriculum | 30.1 | 2.1 | 39.4 | 1.6 | 0.9 | 0.1 | 0.2 | 0.0 | 0.000* |

Internet and journals were the main sources cited for obtaining information regarding dental cells, followed by magazines, professional societies, commercial companies, and television. One of the reasons for this may be due to high advertising and marketing of stem cells on television and other media sources.

Stem cells have been isolated from pulp tissue of permanent teeth, from periodontal ligament cells, from apical papilla of young permanent teeth, from developing dental follicle, and from primary teeth. Stem cells are also obtained from the pulp of exfoliating deciduous teeth and have been termed as SHED by Miura et al. in 2003. Miura et al. provided evidence that SHED is capable of extensive proliferation and multipotential differentiation. Primary incisors and canines with no pathology and at least one-third of root length remaining are ideal candidates.
for stem cell isolation and harvesting.\textsuperscript{[10,11]} The awareness among participants regarding the teeth used for banking was moderate, with higher awareness among postgraduates. This may be due to the possibility that the postgraduate curriculum includes topics related to DSCs.

The first commercial tooth bank was established as a venture company at National Hiroshima University of Japan in 2004.\textsuperscript{[12]} Tooth banks have emerged in all parts of the world including India and marketing strategies are employed to promote tooth banking. More than 50% of the participants were not aware of the presence of DSC banks in India. It is imperative that dentists should not only have thorough scientific knowledge through literature but also have awareness regarding the commercial aspects of DSC banking.

There are two widely used methods for the isolation of DPSCs: the explant method and the enzymatic digestion method of the pulp tissue.\textsuperscript{[12]} There are two widely used methods for the isolation of DPSCs: the explant method and the enzymatic digestion method of the pulp tissue.\textsuperscript{[12,13]} Following isolation, the stem cells are stored either by cryopreservation method or by magnetic freezing.\textsuperscript{[14,15]} The awareness regarding these procedural details was comparatively higher among the postgraduate participants. However, less than a quarter of other faculties had insight into the procedural aspects of stem cell harvesting.

Both high cost and lack of patient awareness were considered as barriers in stem cell banking by the participants. The additional factors cited such as lack of operator skills and lack of knowledge about procedure indicate that even though theoretical knowledge on the subject is being developed in recent years, there is lack of practical knowledge and skill among practitioners.

Guidelines regarding stem cell harvesting were laid down by the Indian Council of Medical Research which has been updated in 2012. These guidelines have been laid down to ensure that research with human stem cells is conducted in a responsible and ethically sensitive manner and complies with all regulatory requirements pertaining to biomedical research in general and stem cell research in particular. These guidelines are applicable to individual researchers, organizations, sponsors, oversight committees and others, associated with research on human stem cells and for their derivatives, both basic and clinical. Hence, dentists aspiring to conduct research related to DSCs should keep themselves updated with these guidelines.\textsuperscript{[16]}

DSCs have shown potential in regenerating odontoblasts, pulp dentin-like complex, and dentin.\textsuperscript{[10]} Furthermore, DSCs can differentiate into adipocytes, osteocytes, and neurons, and hence, these have potent nondental applications too.\textsuperscript{[10]}

The main reason for the growing advancement in stem cell research is the vast range of applications and treatment of diseases.\textsuperscript{[2]} Certain patient population suffering from systemic diseases can especially benefit from this tissue regenerative capacity of stem cells. Dentists must be aware of these applications and guide the patients accordingly in order for them to receive the right benefits from DSC storage.
Despite the lack of in-depth knowledge regarding DSC banking, isolation, and storage, a majority of dentists were keen on updating their knowledge and recommending DSC storage to their patients. This may be attributed to the fact that dental professionals are realizing that this is an upcoming and fast growing field with benefits such as ease of obtaining the dental cells as well as potential to differentiate into multiple cell lineages.

More than 80% of the participants showed a positive attitude toward updating their knowledge regarding DSCs. Conferences, seminars, academics, journals, and internet were considered as the source of obtaining information and increasing knowledge regarding DSCs.

**Conclusion**

Data from this study reveal that there is good awareness regarding stem cells. However, the awareness, knowledge regarding sources, applications, uses, and clinical research guidelines regarding DSCs are lacking among the dentists participating in the survey. Relatively, higher awareness was seen among the postgraduates probably due to updated and research-oriented curriculum. A positive attitude toward updating the knowledge regarding DSCs has been displayed by the respondents. This can be achieved by incorporating this subject to a greater depth in the academic curriculum. This can be aided by discussion on the subject in conferences, seminars, and academic journals. It is important that dental professionals update themselves with knowledge regarding stem cells and DSCs in particular as this field holds a vast potential.

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**Conflicts of interest**

There are no conflicts of interest.

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Questionnaire

Questionnaire 1

TPCTti TERNA DENTAL COLLEGE
Plot No. 12, Sector-22, Phase-II, Nerul, Navi Mumbai - 400 706, Maharashtra, India.
Department of Paedodontics and Preventive Dentistry

Knowledge and attitude of Indian Dentists regarding Dental Stem Cells

We request you to kindly take a few minutes and answer the following questionnaire. Thank you for your cooperation.

Tick the appropriate choice wherever applicable:

1. Age:
   • Less than 35 years
   • 35–50 years
   • Above 50 years.

2. Gender:
   • Male
   • Female.

3. Area of work?
   • General practice
   • Specialty practice
   • Academics
   • Others – Specify.

4. What is your qualification?
   • BDS
   • MDS – Specialty ________________________
   • PhD
   • Others – Specify: ________________________.

5. How many years of experience do you have?
   • Less than 5
   • 5–10
   • More than 10.

6. Are you aware about “stem cells”?
   • Yes
   • No.

7. Are you aware about “dental stem cells”?
   • Yes
   • No.

If answer to Q. 7 is YES, then proceed with the survey

8. What is your source of information about dental stem cells?
   • Television programs
   • Commercial companies
   • Magazines
   • Professional societies
   • Journals
   • Internet
   • Others (specify).

9. Dental stem cells can be derived from
   • Primary teeth
   • Permanent teeth
   • Both.
10. Which teeth can be used for stem cell banking?
   • Carious tooth
   • Exfoliated tooth
   • Tooth extracted due to pathologic condition
   • Tooth extracted due to nonpathologic condition.

11. Do you know the procedure for dental stem cell banking after extraction?
   • Yes
   • No.

12. Are there any dental stem cell banks in India?
   • Yes
   • No
   • Do not know.

13. What is the main barrier in banking dental stem cells? (multiple options can be marked)
   • High cost
   • Lack of patient awareness
   • Others (Specify) ____________.

14. Are there any ethical concerns regarding use of stem cells in dentistry?
   • Yes
   • No
   • Do not know.

15. Are there any bodies in India which regulate dental stem cell banking?
   • Yes
   • No
   • Do not know.

16. Can dental stem cells be used to develop nondental tissues?
   • Yes
   • No
   • Do not know.

17. Will you recommend a patient to store dental stem cells?
   • Yes
   • No
   • Cannot say.

18. Would you like to gain or update your knowledge on dental stem cells?
   • Yes
   • No.

19. What are the ways you would recommend to increase dental stem cell awareness? (multiple options can be marked)
   • Seminars
   • Journals
   • Conferences and CDE programs
   • Advertisements
   • Others (specify).

20. Should topics related to stem cells be included in the dental curriculum?
   • Yes
   • No.

Name: ________________________________ (Name will remain anonymous)

Thank you for your time and cooperation.