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Top 50 cited articles on dental stem cell research

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No potential conflict of interest relevant to this article was reported.

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ABSTRACT

Objectives: Citation analysis provides a unique insight into how scientific interests and research trends have changed over time. The aim of this study was to report on the 50 top-cited papers in dental stem cell research using the Science Citation Index Expanded provided by the Web of Science database to determine the academic importance of each contribution.
Materials and Methods: After the screening, article title and type, total citations and citations per year, publication journal, publication year, first and senior authors, country of origin, institution, and university of reprint author were documented for the 50 top-cited articles in dental stem cell research. Keyword analysis was performed to determine which keywords were most/least popular.
Results: Top 50-cited articles were cited between 179 to 2,275 times. The majority of papers were published in 2008 and originated from the United States with the highest contribution from the National Institute of Dental & Craniofacial Research. *Journal of Dental Research* published the highest number of top-cited articles, followed by *Stem Cells* and *Journal of Endodontics*. The greatest number of articles was published by two individual authors, Shi and Gronthos. Among 197 unique keywords, dental pulp stem cells and mesenchymal stem cells were the most frequently used. Thirty-eight of the 50 most cited articles were original articles, and 37 of them were in the field of basic science.
Conclusions: Basic science studies in dental stem cell research published in high impact factor journals had the highest citation rates.

Keywords: Bibliometrics; Citation analysis; Dental stem cell

INTRODUCTION

Tissue engineering in endodontology represents a scientific field that applies the basic principles of engineering and life sciences to the regeneration of oral tissues affected by trauma or infectious diseases providing possibilities for treatment plans where present conventional treatments are inadequate. More specifically, stem cell-based therapies represent a promising tool to replace damaged dental structures and restore compromised dental pulp or even tooth loss [1].

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Fifteen years have passed since Gronthos *et al.* [2], first began experiments to isolate dental pulp stem cells, and ten years since the first published report concerning stem cells from exfoliated deciduous teeth. Dental stem cell literature has been rapidly evolving over the last few decades. Several populations of post-natal stem cells have been isolated from different parts of the tooth including cells from the pulp of deciduous or permanent teeth, the periodontal ligament, the apical papilla, the dental follicle, with these tissues being studied as potential sources of cell types for regenerative tissue engineering approaches and related clinical applications [2-8]. Tissue engineering applications represent treatment modalities that combine stem cells, molecular signals to induce cell differentiation and scaffolds as a three-dimensional environment for cell proliferation and differentiation [1].

The bibliometric analysis includes both quantitative descriptions of research outcomes and qualitative analysis using citation analysis. Citation analysis is a feasible method to assess scientific productivity and the impact of specific research. More specifically, it examines how often an article is cited in different sources to analyze scientific production. Scientific outputs of countries, institutions, or journals in medicine such as interventional cardiology [9], orthopedics [10], neurocritical care research [11], urology [12] and in dentistry [13], paediatric dentistry [14], regenerative endodontics [15] and endodontics [16] and implantology [17] have been evaluated using bibliometric methods.

Review articles covering this scientific field give the reader insights into the current status of stem cell literature and existing research protocols by reflecting on increasing or decreasing trends in tissue engineering research and providing future perspectives. Despite the rapid growth rate in scientific publications, there have been few attempts at gathering and evaluating data on dental stem cell research. By now, highly cited papers in dental stem cell research have not been evaluated. The present study objected to reporting on the 50 top-cited articles published in the dental stem cell field to assess the academic importance of the related publications.

MATERIALS AND METHODS

The Science Citation Index Expanded (SCIE) from the database Clarivate Analytics Web of Science (WoS) was utilized to perform the search and analyze the highly cited articles in dental stem cell research, using predefined search terms [18]. On 2 October 2019, we tried to identify the top-cited articles pertaining to dental stem cell research using the keywords ("stem cell*" or "mother cell*" or "progenitor cell*" or "colony forming unit*") AND ("dental pulp*" or "apical papilla*" or "dental follicle*" or "periodontal ligament*" or "exfoliated deciduous teeth") in the topic field. Terms used for the stem cell searches were chosen in accordance with Medical Subject Heading used to index PubMed© contents. Additionally, the search in the topic field includes terms or phrases in specific parts of the document such as title, abstract, author keywords, and Keywords Plus. The Keyword Plus in the SCIE database supplied additional search terms included in the titles of articles cited by authors in their bibliographies in the Institute for Scientific Information database and substantially augmented title-word and author-keyword indexing [19]. No limitation was applied, apart from the "front page" filter, meaning that the keywords should be present on the front page of the papers, *e.g.*, title, abstract, or keywords. The papers included in the analysis were ranked in descending order according to their citation number. Two different investigators analyzed the dental stem cell papers and established the top-cited list.

Specific parameters regarding article title, total citations, citations per year, publication year, journals, journal impact factor (JIF), authors, number of authors, contributing institution and country (which was the institution and the country of the corresponding author) and keywords of each manuscript were retrieved. The authors' department was not taken into account when all of them came from the same institution. Papers were also categorized into original research articles and review studies. Research articles were further categorized into clinical science papers, *in vivo* (animal research), and *in vitro* (laboratory) studies.

RESULTS

Citations

The top 50 cited articles dedicated to dental stem cell received 2,275 to 179 citations, with mean citation per article 28.55. The vast majority of articles (n = 35) were cited than 150 times, while 4 articles had > 1,000 citations, and 10 articles received > 400 citations (**Table 1**).

Table 1. The top 50 cited articles on dental stem cell research

Article	Citations	Average citations
Gronthos *et al*. Postnatal human dental pulp stem cells (DPSCs) *in vitro* and *in vivo*. Proc Natl Acad Sci U S A 2000;97:13625-13630.	2,275	113.75
Seo *et al*. Investigation of multipotent postnatal stem cells from human periodontal ligament. Lancet 2004;364:149-155.	1,659	103.69
Miura *et al*. SHED: stem cells from human exfoliated deciduous teeth. Proc Natl Acad Sci U S A 2003;100:5807-5812.	1,436	84.47
Gronthos *et al*. Stem cell properties of human dental pulp stem cells. J Dent Res 2002;81:531-535.	1,104	61.33
Shi and Gronthos. Perivascular niche of postnatal mesenchymal stem cells in human bone marrow and dental pulp. J Bone Miner Res 2003;18:696-704.	906	53.29
Chai *et al*. Fate of the mammalian cranial neural crest during tooth and mandibular morphogenesis. Development 2000;127:1671-1679.	868	43.40
Huang *et al*. Mesenchymal stem cells derived from dental tissues vs. those from other sources: their biology and role in regenerative medicine. J Dent Res 2009;88:792-806.	850	77.27
Sonoyama *et al*. Mesenchymal stem cell-mediated functional tooth regeneration in swine. PLoS One 2006;1:e79.	607	43.36
Sonoyama *et al*. Characterization of the apical papilla and its residing stem cells from human immature permanent teeth: a pilot study. J Endod 2008;34:166-171.	538	44.83
Morsczeck *et al*. Isolation of precursor cells (PCs) from human dental follicle of wisdom teeth. Matrix Biol 2005;24:155-165.	457	30.47
Ng *et al*. PDGF, TGF-beta, and FGF signaling is important for differentiation and growth of mesenchymal stem cells (MSCs): transcriptional profiling can identify markers and signaling pathways important in differentiation of MSCs into adipogenic, chondrogenic, and osteogenic lineages. Blood 2008;112:295-307.	340	28.33
Huang *et al*. The hidden treasure in apical papilla: the potential role in pulp/dentin regeneration and bioroot engineering. J Endod 2008;34:645-651.	334	27.83
Arthur *et al*. Adult human dental pulp stem cells differentiate toward functionally active neurons under appropriate environmental cues. Stem Cells 2008;26:1787-1795.	334	27.83
Zhang *et al*. Mesenchymal stem cells derived from human gingiva are capable of immunomodulatory functions and ameliorate inflammation-related tissue destruction in experimental colitis. J Immunol 2009;183:7787-7798.	327	29.73
Liu *et al*. Periodontal ligament stem cell-mediated treatment for periodontitis in miniature swine. Stem Cells 2008;26:1065-1073.	321	26.75
Cordeiro *et al*. Dental pulp tissue engineering with stem cells from exfoliated deciduous teeth. J Endod 2008;34:962-969.	306	25.50
De Miguel *et al*. Immunosuppressive properties of mesenchymal stem cells: advances and applications. Curr Mol Med 2012;12:574-591.	302	37.75
d'Aquino *et al*. Human postnatal dental pulp cells co-differentiate into osteoblasts and endotheliocytes: a pivotal synergy leading to adult bone tissue formation. Cell Death Differ 2007;14:1162-1171.	300	23.08
Pierdomenico *et al*. Multipotent mesenchymal stem cells with immunosuppressive activity can be easily isolated from dental pulp. Transplantation 2005;80:836-842.	295	19.67
Huang *et al*. Stem/progenitor cell-mediated de novo regeneration of dental pulp with newly deposited continuous layer of dentin in an *in vivo* model. Tissue Eng Part A 2010;16:605-615.	287	28.70
Young *et al*. Tissue engineering of complex tooth structures on biodegradable polymer scaffolds. J Dent Res 2002;81:695-700.	277	15.39
Laino *et al*. A new population of human adult dental pulp stem cells: a useful source of living autologous fibrous bone tissue (LAB). J Bone Miner Res 2005;20:1394-1402.	273	18.20
Kerkis *et al*. Isolation and characterization of a population of immature dental pulp stem cells expressing OCT-4 and other embryonic stem cell markers. Cells Tissues Organs 2006;184:105-116.	262	18.71
Nakashima and Reddi. The application of bone morphogenetic proteins to dental tissue engineering. Nat Biotechnol 2003;21:1025-1032.	261	15.35

(continued to the next page)

Table 1. (Continued) The top 50 cited articles on dental stem cell research

Article	Citations	Average citations
Beertsen *et al*. The periodontal ligament: a unique, multifunctional connective tissue. Periodontol 2000 1997;13:20-40.	256	11.13
Batouli *et al*. Comparison of stem-cell-mediated osteogenesis and dentinogenesis. J Dent Res 2003;82:976-981.	247	14.53
Matsuda *et al*. Tissue engineering based on cell sheet technology. Adv Mater 2007;19:3089-99.	245	18.85
Shi *et al*. Comparison of human dental pulp and bone marrow stromal stem cells by cDNA microarray analysis. Bone 2001;29:532-539.	235	12.37
Sakai *et al*. Human dental pulp-derived stem cells promote locomotor recovery after complete transection of the rat spinal cord by multiple neuro-regenerative mechanisms. J Clin Invest 2012;122:80-90.	233	29.13
Iohara *et al*. Dentin regeneration by dental pulp stem cell therapy with recombinant human bone morphogenetic protein 2. J Dent Res 2004;83:590-595.	224	14.00
Jo *et al*. Isolation and characterization of postnatal stem cells from human dental tissues. Tissue Eng 2007;13:767-773.	223	17.15
Zhang *et al*. Multilineage differentiation potential of stem cells derived from human dental pulp after cryopreservation. Tissue Eng 2006;12:2813-2823.	222	15.86
d'Aquino *et al*. Human mandible bone defect repair by the grafting of dental pulp stem/progenitor cells and collagen sponge biocomplexes. Eur Cell Mater 2009;18:75-83.	221	20.09
Feng *et al*. Dual origin of mesenchymal stem cells contributing to organ growth and repair. Proc Natl Acad Sci U S A 2011;108:6503-6508.	218	24.22
Wada *et al*. Immunomodulatory properties of human periodontal ligament stem cells. J Cell Physiol 2009;219:667-676.	218	19.82
Duailibi *et al*. Bioengineered teeth from cultured rat tooth bud cells. J Dent Res 2004;83:523-528.	216	13.50
Lekic and McCulloch. Periodontal ligament cell population: the central role of fibroblasts in creating a unique tissue. Anat Rec 1996;245:327-341	215	8.96
Gay *et al*. Isolation and characterization of multipotent human periodontal ligament stem cells. Orthod Craniofac Res 2007;10:149-160.	213	16.38
Bosshardt. Are cementoblasts a subpopulation of osteoblasts or a unique phenotype? J Dent Res 2005;84:390-406.	207	13.80
Mao *et al*. Craniofacial tissue engineering by stem cells. J Dent Res 2006;85:966-979.	205	14.64
Gandia *et al*. Human dental pulp stem cells improve left ventricular function, induce angiogenesis, and reduce infarct size in rats with acute myocardial infarction. Stem Cells 2008;26:638-645.	204	17.00
Iwata *et al*. Periodontal regeneration with multi-layered periodontal ligament-derived cell sheets in a canine model. Biomaterials 2009;30:2716-2723.	200	18.18
Ding *et al*. Allogeneic periodontal ligament stem cell therapy for periodontitis in swine. Stem Cells 2010;28:1829-1838.	199	19.90
Nagatomo *et al*. Stem cell properties of human periodontal ligament cells. J Periodontal Res 2006;41:303-310.	197	14.07
Nakashima and Akamine. The application of tissue engineering to regeneration of pulp and dentin in endodontics. J Endod 2005;31:711-8.	197	13.13
Kawaguchi *et al*. Enhancement of periodontal tissue regeneration by transplantation of bone marrow mesenchymal stem cells. J Periodontol 2004;75:1281-1287.	191	11.94
Iohara *et al*. Side population cells isolated from porcine dental pulp tissue with self-renewal and multipotency for dentinogenesis, chondrogenesis, adipogenesis, and neurogenesis. Stem Cells 2006;24:2493-2503.	188	13.43
Chen *et al*. Homing of endogenous stem/progenitor cells for in situ tissue regeneration: Promises, strategies, and translational perspectives. Biomaterials 2011;32:3189-3209.	184	20.44
Chen *et al*. A review on endogenous regenerative technology in periodontal regenerative medicine. Biomaterials 2010;31:7892-7927.	183	18.30
Yan *et al*. iPS cells reprogrammed from human mesenchymal-like stem/progenitor cells of dental tissue origin. Stem Cells Dev 2010;19:469-480.	179	17.90

Year of publication

The top-cited 50 articles were published between 1996 and 2012, with almost half of them (n = 27) published in the 5-year period between 2005 and 2009. 2008 was the most productive year, contributing to seven top-cited publications, followed by 2006 (n = 6) (**Figure 1**).

Journals

The most cited articles were published in 30 journals, with impact factors ranging from 0.946 to 59.102. Twenty-three of them contained only one article; 4 journals 2–3 articles; while 3 journals published more than five articles each, and accounted for 34% of the total articles. *Journal of Dental Research* published the highest number of top-cited articles (n = 8), followed by Stem Cells with 5, and Journal of Endodontics with 4, while their impact factors were estimated 5.125, 5.614 and 2.833, respectively (**Table 2**).

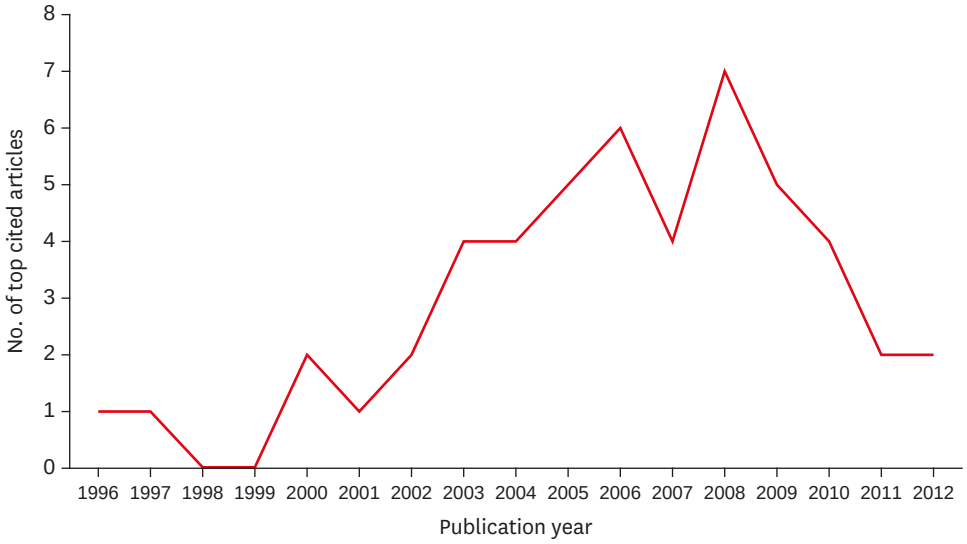

Figure 1. The number of publications in the top 50 by year of publication.

Table 2. Journals in which the top 50 cited articles were published

Journal name	2018 JIF	Top cited articles
Journal of Dental Research	5.125	8
Stem Cells	5.614	5
Journal of Endodontics	2.833	4
Biomaterials	10.273	3
Proceedings of the National Academy of Sciences of the USA	9.580	3
Tissue Engineering	3.508	2
Journal of Bone and Mineral Research	5.711	2
Advanced Materials	25.809	1
Anatomical Record	1.329	1
Blood	16.562	1
Bone	4.360	1
Cell Death and Differentiation	8.086	1
Cells Tissues Organs	1.333	1
Current Molecular Medicine	2.196	1
Development	5.763	1
European Cells & Materials	3.682	1
Journal of Cellular Physiology	4.522	1
Journal of Clinical Investigation	12.282	1
Journal of Immunology	4.718	1
Journal of Periodontal Research	2.613	1
Journal of Periodontology	2.768	1
Lancet	59.102	1
Matrix Biology	6.986	1
Nature Biotechnology	31.864	1
Orthodontics & Craniofacial Research	0.946	1
Periodontology 2000	7.861	1
PLos One	2.776	1
Stem Cells and Development	3.147	1
Tissue Engineering. Part A	3.616	1
Transplantation	4.593	1

JIF, journal impact factor.

Countries, institutions, and authors

There were 14 different countries of origin and 54 institutions accountable for the topmost cited papers. The United States of America was leading the top-cited list with 19 articles, distantly followed by Japan (8 articles) and China (5 articles), while Italy and Australia

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Table 3. Countries of origin of the top-cited articles

Country	No. of articles
USA	19
Japan	8
China	5
Italy	4
Australia	3
Netherlands	2
Spain	2
Brazil	1
Canada	1
Germany	1
Singapore	1
South Korea	1
Switzerland	1
United Kingdom	1

contributed 4 and 3 articles to the top-cited list, respectively (**Table 3**). The National Institute of Dental and Craniofacial Research (NIDCR) which is a branch of the National Institutes of Health (USA) was found to be the most productive institution ($n = 6$), followed by the Capital Medical University (China), the Second University of Naples (Italy), and the University of Maryland Baltimore Michigan (USA), each of them contributed with 3 articles. Twenty-three articles resulted from international collaborations, 15 from multi-university collaborations, and 12 from independent institutions. Author analysis identified 339 individual researchers who contributed to 50 top-cited articles (the total number was 243, including authors with more than one publication). Among them, 202 authors (83%) published one top-cited article; 22 (9.0%) authored two topmost publications; 11 (4.5%) had three topmost articles; 8 (3.5%) authors published four or more of the 50 most cited articles. Furthermore, the number of authors per paper ranged from 1 to 14, with a mean of 6.78. **Table 4** presents the most productive authors with 4 or more articles, showing that Shi, published the most articles (2 as first author and 17 as a co-author), followed by Gronthos, ($n = 12$), Liu and Robey each authored 6 articles. It should be noted here that Huang authored 5 publications, and in 3 of them, he was the first author.

Keyword analysis

Keyword analysis revealed a total of 197 unique words. Dental pulp stem cells (DPSCs) ($n = 12$), mesenchymal stem cell(s) ($n = 8$), tissue engineering ($n = 7$) and odontoblasts ($n = 7$) were the most commonly used (**Table 5**).

Study design

Thirty-eight were original articles, whereas the other 12 were review articles. Regarding the type of original articles, 37 were in the field of basic science (26 animal studies and 11

Table 4. Authors of the top-cited articles

Author	First author	Co-author	Total
Shi ST	2	17	19
Gronthos S	2	10	12
Liu Y	1	5	6
Robey PG	0	6	6
Huang GT	3	2	5
Brahim J	0	4	4
Nakashima M	2	2	4
Wang S	0	4	4

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Table 5. Keywords in the top-cited articles

Keywords	Frequency
Dental pulp stem cells (DPSCs)	12
Mesenchymal stem cell	8
Tissue engineering	7
Odontoblasts	7
Periodontal ligament	4
Periodontal ligament stem cells (PDLSCs)	4
Dental pulp	4

laboratory studies) and there was 1 clinical study. Among the 26 top-cited animal studies, the overwhelming majority ($n = 18$) used rodents (13 used mice and 5 used rats), while 4 studies used dogs, 3 studies used miniature pigs, and 1 study used avian embryos from chickens.

DISCUSSION

The last few decades have seen rapid evolution and significant developments in dental stem cell research. Indeed, a large volume of articles is published almost daily. The purpose of the present study was to report and characterize the 50 top-cited articles in dental stem cell research. Even though the significance of citation analysis has been characterized as ambiguous, supporters advocate that such an analysis evaluates with objective and quantitative measures, the academic importance of an article on its respective field [12,20]. Indeed, this is one feasible method that demonstrates patterns of authorship, basic contributions, and conclusions that are guiding this scientific field. The establishment of a citation rank list allows researchers to specify the time frame on literature analysis, but also provides a comprehensive guide to education and training.

As stated by the WoS Core Collection, more than 8,850 of the world's leading scientific and technical journals across 150 scientific disciplines encompass the SCI Expanded [18]. Justifiably this database represents the most commonly used source database for a broad review of scientific accomplishment in citation analyses.

The citations ranged from 179 to 2,275 in the top-cited articles. The rapidly evolving nature of this scientific field might explain the wide range observed in the citations number. Even though a comprehensive assessment of each individual paper separately exceeds the objectives of the present study, it remains necessary to describe the distinguishing aspects of the first highly cited studies with more than 1,400 citations each. The outcomes reported in the 3 highly cited publications have had a formative historical impact on dental stem cell research and explains why they were so widely referenced. The most cited paper with 2,275 citations and the highest average citations per year values (113.75), published by Gronthos *et al.* [2] in *Proceedings of the National Academy of Sciences of the USA*, was describing for the first time the isolation of dental pulp stem cells from third molars. According to this study, postnatal DPSCs were characterized as clonogenic and highly proliferative cells, capable of generating densely calcified colonies and occasional nodules. Interestingly, the second most cited paper, published in 2004 by Seo *et al.* [8], has received 1,659 citations and described the presence of multipotent postnatal stem cells in the human periodontal ligament. When these cells were transplanted into rodents, they were able to generate a cementum/periodontal ligament-like structure and contributed to periodontal tissue repair. These cells could also be isolated from cryopreserved periodontal ligaments while still retaining their stem cell characteristics,

including single-colony strain generation, expression of mesenchymal stem cell (MSC) surface markers, multipotential differentiation and hence providing a ready source of MSCs. The third paper, published in 2003 by Miura *et al.* [3], has been cited 1,436 times. This research article identified that exfoliated human deciduous teeth contain highly proliferative, clonogenic stem cells, able to induce bone formation, generate dentin, and differentiate into neural cells and adipocytes *in vivo*.

The vast majority of the top-cited articles (96%) were published after 2000, which may reflect the successful isolation of stem cells from dental pulp in 2000, stimulating the study of the dental stem cells to reach new levels. More than half of the top-cited articles (27 out of 50) were published in a 4-year peak period, between 2005 and 2009. Thirty journals published the 50 top-cited articles, with the predominance of *Journal of Dental Research*, *Stem Cells*, and *Journal of Endodontics*. Two hundred forty-three authors from 32 institutions in 14 countries authored the 50 articles. Shi dominated with 19 publications, was leading the top-cited list and followed by Gronthos, who was the first author or co-author in 12 top-cited papers. The articles written by authors Liu and Robey were also prominent in citations.

As it was expected, most of the top-cited papers (38%) originated from the United States, a result which follows patterns from other scientific fields such as neurocritical care research, dentistry, regenerative endodontology, endodontology, implant dentistry, and dental education journals [11,13,15-17,21]. The size of the scientific community, in conjunction with the availability of funding opportunities for US-led scientific and clinical research, promotes high impact and publication output. Even though the United States was the leading country in the topmost cited publications, Asian or European residents contributed 15 and 11 articles, respectively. It should also be taken into account that 11 of the articles originating from the United States were the product of international collaborations, 6 papers resulted from multi-university collaborations, and 2 articles from independent institutions.

Scientific co-operation has been documented as an essential component in enhancing the scientific influence of research [22]. It has been estimated that highly cited papers were produced by multinational research, while the least cited articles were the single institution papers within a single country [22]. More than half (n = 38) of the top-cited articles were the product of collaboration, namely 23 internationally collaborative and 15 multi-university papers. NIDCR in the USA was the home institution of the corresponding author in six out of 50 highly cited papers during the period 2000–2004.

This study also identified keywords that trended across the topmost cited publications. Among 197 unique keywords, DPSCs (n = 12) and mesenchymal stem cell(s) (n = 8) were the most frequently used. A keyword analysis is one of the most important indicators of bibliometrics. It can potentially detect trending research topics and provides a clear aspect of the analysis of the research hotspots. A detailed classification and analysis of a research area may be more accurate as the use of keywords retrieves more relevant results than using sentences or phrases. Representing what authors consider the essential keywords in their publication, they act as "codes" to source the relevant scientific literature. Keyword analysis can potentially detect trending research topics both currently and in the past [23]. Regarding study limitations, lack of keyword was recorded in 13 top-cited articles in the present study.

The majority of highly cited articles were in the field of basic science (74%). It is widely accepted that basic sciences play a fundamental role in dental stem cell research. The design

of new treatment strategies firstly involves laboratory studies to collect safety data, followed by further animal studies, to confirm the initial evidence about the effects of the new treatment, and finally, the application of the new knowledge to clinical studies.

There are some limitations innate to citation analyses. Besides the fact that citation analysis is an objective technique for the investigators' or scientific research recognition, it does not take into consideration self-citation or negative citation [24] and language bias. In addition, the following methodological limitations must be kept in mind when reviewing the results of the present citation analysis: articles included in this study were identified through SCI Expanded of WoS, omitting some papers from other sources which might be considered essential to the field. The 'obliteration by incorporation' effect described by Garfield *et al.* [25] represents an additional bias since older publications tend to be referenced more than newer, as their results become integrated part of the evolving body of knowledge over time. Additionally, it has been documented that citation analysis omits or undervalues recently published influential papers that fail to accumulate enough citations to warrant inclusion [26]. Notwithstanding, the shortcoming of time was not so obvious in the present analysis, as the majority of the topmost cited articles were published within the last 15 years because dental stem cell research dates back relatively few years.

CONCLUSIONS

Citation analysis in dental stem cell research may provide an evaluation of the significant contributions of authors and institutions, but also deciphers the development of scientific interests and priorities and assist with future research. This is the first citation analysis that examines the trends associated with dental stem cell research. As there is an ever-increasing amount of research in this respective field, this technique allows investigators to optimize the time spent on a literature study and assist with future investigative efforts.

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