India’s contribution to regenerative endodontics: A bibliometric analysis

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Abstract
Regenerative endodontics (RE) is a dynamic field with widespread global impact. The aim of this bibliometric analysis is to highlight India’s contribution in the field. Electronic search was performed in PubMed and Web of Science database till December 2019 using the search terms “Dental pulp regeneration,” “Pulp revascularisation,” “Revitalisation,” “Regenerative endodontic,” and their permutation. Articles of Indian authors with affiliation to Indian institutes were included. The following data were extracted: first author, institute and state of affiliation, year and journal of publication, study design, level of evidence (LOE), and number of citations. A total of 76 articles (case reports [n = 29, 38.15%], review [n = 25, 32.8%]) were published between 2008 and 2019. Majority (42.6%) were categorized as LOE 4. 7.4% articles were in LOE1 category. Eight percent articles had citations above 100 (highest cited-354 citations). The average yearly growth rate between 2011 and 2019 was 33.28% and highest number of publications was in the year 2015. The south zone had the maximum publications. At an institutional level, Centre for Dental Education and Research, All India Institute of Medical Sciences, New Delhi, had the maximum publications. Journal of Conservative Dentistry published the highest number of articles. India contributed 7.6% of the global PubMed indexed publications and reported 22% of clinical trials. This analysis reveals increasing trend of research in RE in India. However, it highlights the need to generate articles with higher LOE by conducting quality multicenter trials and promote national and international collaborations.

Keywords: Bibliometric analysis; pulp regeneration; regenerative endodontics

INTRODUCTION
Over the last decade and a half, attempts for regeneration have been made for the replacement of diseased tissue or organs in the medical as well as the dental field. The biggest advantage of regeneration over replacement is establishment of the original tissue architecture.[1] Similar efforts have been made in the specialty of endodontics and have been termed as regenerative endodontic (RE) procedures. RE is defined as “biologically based procedures designed to replace damaged structures of the tooth, including dentin and root structures, as well as cells of the dentin-pulp complex.”[2] Various terminologies have been used to describe the procedure including revascularization,[3] induced/guided tissue regeneration,[4] maturogenesis,[5] revitalization (European Society of Endodontics – ESE),[6] but the term RE procedures/RE s is most commonly used. RE is specifically indicated in traumatized nonvital immature teeth with blunderbuss canals with or without periapical lesions. The concept was originally introduced by Dr. Nygaard Ostby, in 1961 who however did not observe true regeneration in the damaged tooth.[7] Following this, there was a Rip van Winkle phase in the field of RE for three to four decades.[3,8-10] The concept was reignited by a landmark publication by Dr. Banchs and Dr. Trope in 2004, where they demonstrated successful revascularization in a mandibular premolar tooth.[11] Since its re-introduction, RE has gained widespread global interest.
influencing not only the clinicians but also researchers, academicians and funding agencies all over the globe over the last 15 years. It is one of the fastest growing fields in dentistry and thus previous bibliometric analysis identifying the top-100 cited articles[12] and the global contributors[13] in the field has been done. A bibliometric analysis is used for the quantitative assessment of research output in a particular field. India has also significantly contributed to the field and thus the aim of the present article is to highlight India’s contribution in the field of RE by means of a bibliometric analysis. The objective of the present analysis was to study the status and trend of research and to elucidate the level of evidence (LOE) of the publications. Such an analysis will help to provide a view of the nation’s scientific research in the field for comparison and descriptions. This will help in recognizing research groups and under investigated aspects so to encourage collaborations, adequate fund utilization, and increased contribution to the global literature.

METHODOLOGY

Information sources and search strategy
An electronic search was performed in two databases, PubMed and Web of Science until December 2019 using the search terms:
1. Dental pulp regeneration
2. Pulp revascularization
3. Revitalization
4. Regenerative endodontic*
5. (1 OR 2 OR 3) AND (4).

Eligibility criteria
1. Articles with implications in RE were included
2. Articles belonging to authors of Indian ethnicity and affiliated to Indian institutes were included
3. Articles published in the English language were included.

Articles belonging to authors of Indian origin but affiliated to universities outside India were excluded.

Article selection
The title/abstract were manually screened by two independent reviewers (AK, AS) based on eligibility of the study. The ethnicity and affiliation of the authors was confirmed and correlated with the author information. Any disagreement was resolved by a third reviewer (AL).

Data extraction
The following information was collected: Name of first author, college/university and state of affiliation, year of publication, journal of publication, type of study design, LOE of study, and number of citations until December 2019. The publications were categorized based on the type of study design and the consequent LOE generated was recorded. The number of publications (NP) in a year and the annual growth rate ([NP per year] – [NP in the previous year])/[NP previous year] × 100) was calculated.[13] The journal and institution with the highest NP was recorded. All the data were manually searched and entered in an excel sheet. The distribution of the publications across the six zones of India was calculated. The state and institution with the highest publications were recorded.

RESULTS

Search results
The initial search identified 4887 and 3899 articles from PubMed and Web of Science, respectively. Eight thousand seven hundred and ten studies were excluded after screening the title and/or abstract, affiliation of author, and repeated titles. In total, 76 articles were included in the bibliometric analysis.

Global contribution
India contributed 7.6% of the global PubMed indexed publications and reported 22% of clinical trials.

Bibliometric analysis
The total numbers of first authors involved in the publications were 64. Among them, the highest NP were by Shah N (n = 4), Bansal R, Nagaveni NB, Jadhav GR (n = 3).

Regional distribution of publication
The distribution of the publications across the six zones of India[14] was as follows: highest publications were from south zone (46%; n = 35/76) followed by north (26%; n = 20/76), west (13%; n = 10/76), central (11%; n = 8/76), and east (4%; n = 4/76) zone as illustrated in [Figure 2].

Institutes in 20 states/union territory contributed to the publications. The state/union territory with highest publications was Karnataka (n = 13) followed by Delhi (n = 12) and Maharashtra, Kerala (n = 8 each) [Figure 3]. The institutes with highest NP were the Centre for Dental Education and Research, All India Institute of Medical Sciences (CDER, AIIMS), New Delhi (n = 8) followed by College of Dental Sciences, Davangere, Karnataka, Manipal College of Dental Sciences, Karnataka and Institute of 326 Journal of Conservative Dentistry | Volume 23 | Issue 4 | July-August 2020

Figure 1: Schematic illustrates the search process followed
Dental Sciences, Jammu and Kashmir (n = 3 each). The three randomized controlled trials have been reported from the Banaras Hindu University, Varanasi, Uttar Pradesh, in 2015; SRM Dental College, Chennai, Tamil Nadu in 2017 and Government Dental College, Thrissur, Kerala, in 2018.

**Publication metrics**

The first publication was in the year 2008, followed by two publications in 2009; however, in 2010 there were no publications. There after a growth was observed with the highest NP being in the year 2015 (n = 12) [Figure 4]. The average yearly growth rate between 2011 and 2019 was 33.28%. There were however fluctuations in the year-to-year growth rate analysis. The yearly growth rate was highest between 2011 and 2012 (increased from 3 to 8 publications for 166.7% growth) and the lowest between 2016 and 2017 (decreased from 9 to 3 publications for −66.7% growth).

**Analysis of study design and level of evidence**

The highest number of articles were case reports and case series (n = 29, 38.15%) followed by reviews (n = 25; 32.8%). There were no case control studies and meta-analysis reported. Other publications were *ex vivo/in vitro/animal* studies (n = 8, 10.5%); prospective clinical studies (n = 7, 9.2%); randomized controlled trials (n = 3, 3.9%); surveys (n = 2, 2.6%); and systematic review (n = 2, 2.6%) [Figure 5].

The articles were categorized on the pyramid of evidence through LOE 1-5 (excluding animal and laboratory studies) [Figure 6][15] as follows: LOE 1-7.35%; LOE 2-10.3%; LOE 3-2.9%; LOE 4-42.6%; LOE 5-36.8% [Figure 7].

**Journal metrics**

The journals with the maximum NP were identified [Figure 8]. The Journal of Conservative Dentistry (16%) had the maximum number of articles followed by Contemporary Clinical Dentistry, and Journal of Clinical and Diagnostic Research (8% each) and the Journal of Endodontics (7%). The publications with the maximum number of citations were in the Journal of Endodontics followed by the Journal of Conservative Dentistry and International Endodontic Journal.

**Citation metrics**

There were six publications with citation above 100 (7.8%).

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**Figure 2:** Distribution of publications on Regenerative Endodontics across the six zones of India

**Figure 3:** Distribution of publications across various states and union territories of India in descending order

**Figure 4:** Trend of Indian publications on Regenerative Endodontics from 2008 till December 2019

**Figure 5:** The distribution of publications based on the study design
They were from the CDER, New Delhi (First case series and prospective clinical study); Jaslok Hospital and Research Centre, Mumbai, Maharashtra (Review); King George Medical University, Lucknow, Uttar Pradesh (Case report); Government dental college, Kozhikode, Kerala (case report) and Dayananada Sagar College of Dental Sciences, Bengaluru, Karnataka (Review). The publications with citations above 50 included mostly reviews and case reports (10.5%). About 81.5% of the publications had citations below 50 [Figure 9].

DISCUSSION

Regeneration and regenerative medicine have attained much attention and popularity in the current era.[16-18] Similarly, RE has gained immense global interest and impetus since 2004.[11,13] The American Association of Endodontists has in fact prioritized funding to encourage and support research in the field of RE.[19] The present article is the first of its kind highlighting India’s contribution and research output in the field of RE. It is among the first few articles to focus on an analysis in the field of endodontics.

Bibliometric analyses have been previously performed in the field of medicine to identify the institutes/researchers working actively or having an inclination in a particular field.[20,21] Nation-based bibliometric analysis in areas of research in dentistry/endodontics can provide us with the present available literature/resources/findings in the field on a national level. Such articles provide a platform to know the current status of national research and compare it with the global research output. According to the present review, India contributed 7.6% of the total PubMed indexed global publications on RE and the clinical trials reported from the nation constituted a substantial 22% of the total global output.

The highest NP came from the southern zone of India, with Institutes/research groups from Karnataka contributing the most. At an institutional level, the maximum NP with the highest citations came from the CDER, AIIMS, New Delhi.

Such an analysis can act as a guideline for institutes and investigators working in the field to prevent utilization of resources for any repetitive research and/or publication of old concepts and material.

Although the scope of RE is presently limited to the management of immature nonvital permanent teeth,[3] Research is underway to attain pulp regeneration in mature teeth,[22] which, if achieved, would revolutionize the field of Endodontics and be beneficial to patients and the public health sector. “Seal Bio” a nonobturation technique was among the initial efforts to practice regeneration in mature permanent teeth.[23,24]

Bibliometric analyses also address shortcomings in research output. The present analysis clearly indicates that the numbers of LOE1 publications were the least and maximum...
numbers of articles were case reports which provide the least LOE followed by review articles which often consist of repetitive information. The institutes/researchers can thereafter plan and undertake quality collaborative multicentric clinical work. Focused research and utilization of available resources/funds is the need of the hour and the way forward in the field of RE.

Being the second-most populous country in the world, improved research strategies will not only further our interest at a national level where careful utilization of public health resources is critical, but will also help us generate ample clinical evidence and contribute further to global literature. The identification of capable research groups with concurring interests, would pave the way for possible international collaborations as well, in order to advance further into the moderately explored domain of RE.

CONCLUSION

1. The present bibliometric analysis highlights India’s contribution to the field of RE
2. It aims to identify and recognize the efforts made in the field till date and gives an insight into the under investigated areas which can be exploited to further the nations research output
3. Identification of capable research groups with concurring interests, would pave the way for possible international collaborations.

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Conflicts of interest
There are no conflicts of interest.

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Figure 9: Categorization of articles based on number of citations (Source: Google scholar)