Review Article

A Bibliometric Analysis of the Top 100 Cited Articles in Regenerative Periodontics Surgery: Insights and Trends

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ABSTRACT

Aim: The aim of this study was to identify and appraise the bibliometric properties of top 100 most-cited articles on regenerative periodontics surgery (RPS). **Materials and Methods:** The bibliometric research technique was conducted using a dataset comprising the 100 highly cited articles obtained from Elsevier's Scopus database on RPS. Information regarding the growth of articles by year, number of citations, citations per year, study design, study field, modalities, journals, authors, and countries were extracted for each article. Microsoft Excel (v.16) was utilized for data evaluation and tabulation. These articles on RPS were published over a span of 45 years, from 1975 to 2019, with citation metrics ranging from 144 to 820. Out of the 422 participating authors, 82% contributed to a single article. **Results:** The 100 most cited articles on RPS were published in 45 years from 1975 to 2019 and number of citations ranged from 144 to 820. Out of the 422 participating authors, 82% contributed in a single article.. The study design with the highest number of cited articles was laboratory/animal studies. Others/not specified was the preferred modality, followed by infrabony modality. *The Journal of Periodontology* published about one-fourth of the articles, with W. V. Giannobile emerging as the most productive author. Among the 100 most-cited articles on RPS, authors from 25 different countries contributed, with the United States producing half of the articles (n = 51). Bibliometric investigation revealed that the most cited papers published before 2000 had higher citation counts due to their longer period of exposure. The ratio of authors per article increased after the year 2000. **Conclusions:** Infrabony emerges as a trending topic in RPS, with laboratory/animal studies, clinical trials, and literature reviews being the most frequently employed study designs.

Keywords: *Bibliometrics, citation analysis, dental surgery, regenerative periodontics surgery*

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Introduction

Periodontal surgery holds significant importance in the field of periodontics. It provides a range of treatment options to address patients' needs.[1] The periodontal regenerative procedure is among the commonly utilized periodontal procedures in daily periodontal practice. Initially, the utilization of the periodontal regenerative procedure was limited due to the restricted availability of evidence, techniques, and materials.[2] However, with advancements in knowledge, it has become a popular technique for treating intrabony

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defects. Several techniques and materials have been developed to facilitate the procedure.[3] Thus, the field of periodontics is rich in scientific literature, and a detailed analysis of the published articles is worthy to know the development of this subject over time.[4,5]

The assessment of research productivity is of utmost significance, and bibliometric analysis serves as a vital tool in evaluating research performance. Bibliometrics is a retrospective method used to review the scientific impact of research in a particular field.[6] Citation counts of publications support the identification of top research-producing countries, productive authors, publishing patterns, and collaboration networks, providing an overview of research activities.[7,8] Moreover, citation metrics offer a dataset that helps in understanding the current research trends within specific knowledge domains by highlighting the most frequently cited article.[9] Bibliometric analyses have been widely employed in various aspects of periodontics, a sub-category of dentistry, which includes periodontology, systemic manifestations of periodontal disease, regenerative periodontics surgery (RPS), and bone regeneration.[4,10-12]

Only a single bibliometric study has been found on RPS. This study covered a 30-year time span from 1980 to 2010 and analyzed the 1794 documents yielded from the Scopus database. The study exposed that more than half (54.7%) of the records were published in the last 10 years (2001–2010). Moreover, the analysis exposed that the highest number of authors (79.6%) had contributed just a single document.[11]

Another bibliometric study evaluated the most influential papers on periodontal regeneration based on Web of Science records, covering a period of 15 years from 2004 to 2018. Thirty-nine papers were appeared in the first 2 years of study (2004–2005), and it is reported that older papers have sufficient time to gain more citations compared to newly published papers. The examination of study design indicated that randomized controlled trials (RCTs) were the most common study type (n = 25), followed by reviews and *in vitro* studies with 20 and 16 articles, respectively. The majority of articles were produced by the United States, followed by Japan.[13]

Liu *et al*.[14] examined the 132 H-classic top-cited articles on periodontal regeneration, published from 1970 to 2012. The *Journal of Periodontology* and *Journal of Clinical Periodontology* were found to be the most preferred, with 53 and 26 articles, respectively. Only three articles (systematic reviews/meta-analysis) were found with the maximum level of evidence (LOE), followed by RCTs (n = 13). The study also discussed the defects and treatment modalities.[14]

In a review of relevant literature, only one comprehensive bibliometric study on RPS and two studies on the top-cited articles on periodontal regeneration were found.[11,13,14] To date, our understanding of the LOE presented in the top-cited papers remains limited. Additionally, there is a noticeable gap in the literature regarding the differentiation between clinical and non-clinical studies within these highly cited papers. Furthermore, the specific types of studies conducted and their respective fields of study among the highly cited papers remain unknown.

The main objective of current investigation was to ascertain and examine the bibliometric properties of top 100 highly cited articles on RPS.

Materials and Methods

The top 100 highly cited articles in RPS were selected by conducting a search on Elsevier's Scopus database. The data were retrieved on June 15, 2023. The search term "regenerative periodontics surgery" was entered into the search box without applying any filters, and the data were sorted based on the most-cited documents. The bibliographic details of the top 200 most-cited articles were downloaded, and two researchers reviewed the data extraction to select the top 100 most-cited articles. The following details were extracted from each article: distribution of articles and citations by years, citation impact, clinical and non-clinical studies, study design, field of study, modality, preferred journals, authors, and country.

The study design, including meta-analysis, systematic review, RCTs, clinical trial, cohort study, case-control study, cross-sectional study, case series, technical note, laboratory/animal study, and literature review, was classified based on the modified Oxford's LOE scale.[15]

The fields of study included infrabony, furcation, horizontal, buccal dehiscence/fenestration, recession, and other/nonspecified.

The articles were assessed on the following modalities: Guided tissue regeneration (GTR) (resorbable and non-resorbable), biologics [recombinant human osteogenic protein-1, bone grafts (allograft, xenograft, alloplast, and nano bioactive glass), recombinant human bone morphogenetic protein-2, bone morphogenetic protein, enamel matrix derivative, pidermal growth factor, fibroblast growth factor (FGF), platelet-derived growth factor (PDGF), insulin-like growth factor, platelet-rich plasma, poly lactic glycolic acid (PLGA), recombinant human basic FGF, recombinant human PDGF B, transforming growth factor-beta, stromal-derived factor-1], and others (stem cells, gene, 3D-printed bioresorbable scaffold, scaffold, interleukin-1, root resection, PLGA, Hertwig's epithelial root sheath, gum tragacanth, tetracycline, periodontal ligament stem cells, gingival stem cells, and hyaluronic acid).

Results

The 100 most-cited articles on RPS were published over a span of 45 years, from 1975 to 2019. Within the initial 25-year period, from 1975 to 1999, 33 articles were published, while the remaining two-thirds (n = 67) were published from 2000 onwards. Notably, the highest number of articles, seven each, were published in four different years: 1997, 2003, 2012, and 2015. In total, these most-cited articles garnered 22,474 citations, averaging 224.74 citations/article. Articles published within the first 25 years received an average of 262.36 citations/article, whereas those published from 2000 onwards received an average of 206.20 citations/article [Figure 1].

The analysis of clinical and non-clinical study formats revealed that 28 articles were classified as clinical studies, while 72 articles were categorized as non-clinical studies. Articles in the clinical study format accumulated a total of 6864 citations, with an average of 245.14 citations/article. On the other hand, non-clinical articles amassed 15,610 citations, with an average of 210.81 citations/article.

The examination of document types among the 100 most-cited articles revealed that original research articles constituted the majority, with 76 documents, followed by review articles and conference papers with 21 and 3 documents, respectively. Despite review articles being fewer in number, they garnered more citations on average (233.19 citations/article) compared to original research articles (222.44 citations/article). Regarding accessibility mode, 21 articles were published as open-access, while 79 articles were subscription-based. Interestingly, subscription-based articles received a highest proportion of citations (235.43 citations/article) compared to open-access articles (184.52 citations/article).

Laboratory/animal studies were found to be the most frequently used study design, with 39 articles, followed by clinical trails and literature reviews, each comprising 18 articles. Among these, articles classified as RCTs garnered the highest citation impact, followed by clinical trails, while the systematic reviews received the lowest citation impact [Table 1]. In terms of LOE, more than half of the articles (n = 57) belonged to LOE-V, followed by LOE-I (n = 19) and LOE-II (n = 18). The lowest number of articles was found in LOE-IV.

The field of study in approximately half of the articles (n = 47) was categorized as not specific, while infrabony was the second most preferred field of study, with 30 articles, followed by furcation and infrabony/furcation, each with 6 articles. The study design of buccal dehiscence was found in five articles. Among the fields of study with only a single article, furcation/recession/infrabony received the highest citation average, with 352 citations/article [Table 2].

Out of the 100 most-cited articles, 65 articles were distributed into 6 specific modalities, while 35 articles were categorized under other modalities. The modality of biologics was found to be the most frequently occurring, with 27 articles, followed by the GTR/

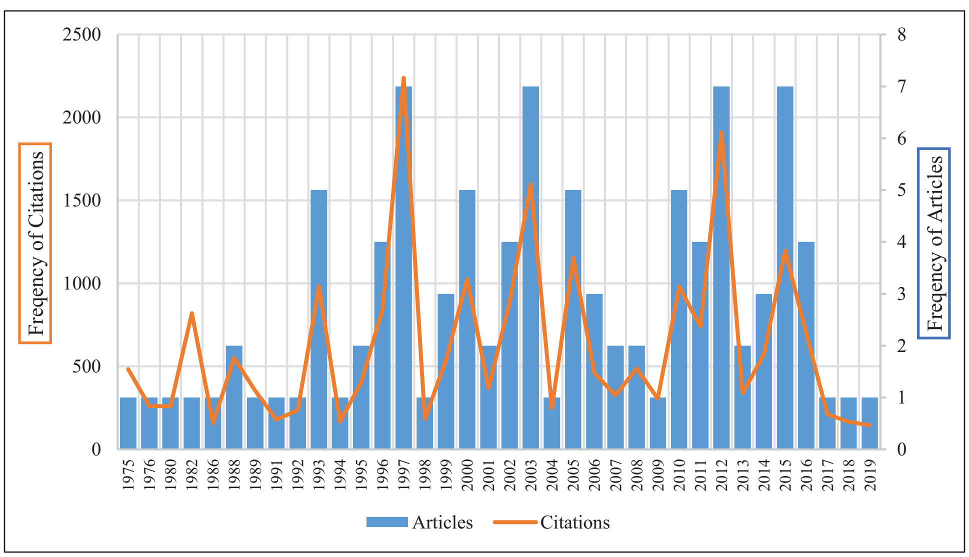

Figure 1: Distribution of articles and citations by years

Table 1: Distribution of articles and citation by study design

Serial no.	Study design (LOE)	Total articles	Total citations	Citation impact
1.	Laboratory/animal study (LOE-V)	39	8233	211.10
2.	Clinical trail (LOE-II)	18	4213	234.06
3.	Literature review (LOE-V)	18	4255	236.39
4.	Systematic review (LOE-I)	15	3130	208.67
5.	Case report (LOE-IV)	6	1365	227.50
6.	RCT (LOE-I)	3	1133	377.67
7.	Meta-analysis (LOE-I)[a]	1	145	145.00

[a]Meta-analysis has only one article which may not accurately reflect the citation impact

RCT = randomized controlled trial, LOE = level of evidence

Table 2: Distribution of articles by field of study

Serial no.	Field of study	Total articles	Total citations	Citation impact
1.	Others/not specified	47	9785	208.19
2.	Infrabony	30	6289	209.63
3.	Furcation	6	1409	234.83
4.	Infrabony/furcation	6	1369	228.16
5.	Buccal dehiscence	5	1356	271.20
7.	Horizontal	2	454	227.00
8.	Furcation/recession/infrabony	2	704	352.00
9.	Infrabony/furcation/horizontal/buccal dehiscence/fenestration	1	288	288.00
10.	Recession	1	820	820.00

Table 3: Breakdown of articles by modalities

Serial no.	Name of modalities	Total articles	Total citations	Citation impact
1.	Biologics	27	6470	239.62
2.	GTR/bone graft	21	5182	246.76
3.	Biologics/GTR/bone graft	7	1506	215.14
4.	Biologics and others	6	986	164.33
5.	GTR/bone graft/other	3	737	245.66
6.	Biologics/GTR/bone graft /other	1	202	202.00
7.	Others modalities	35	7391	211.17

GTR = guided tissue regeneration

bone graft modality, with 21 articles. Articles written on GTR/bone graft garnered the maximum citation impact, followed by GTR/bone graft/other, with an average of 246.76 and 245.66 citations/article [Table 3].

Fifty-three of the most-cited articles were published in top three journals [Table 4]. The maximum number of articles (n = 24) were published in *Journal of Periodontology*, followed by *Journal of Clinical Periodontology* and *Journal of Dental Research*, with 19 and 10 articles, respectively. Among these journals, two articles published in *Dental Materials* received the highest citation impact, with an average of 319 citations/article, followed by *Journal of Clinical Periodontology*, with an average of 300.26 citations/article. The lowest citation ratio was observed for *Acta Biomaterialia* and *International Journal of Periodontics and Restorative Dentistry*.

The cited articles had a total of 577 authors overall, including multiple counts, with an average of 5.77 writers per paper. The ratio of authors per article was recorded at 4.0 during the period from 1975 to 1999, whereas this ratio increased to 6.64 authors per article during the period from 2000 to 2019. The single-author tendency resulted in just eight papers; however, three-author pattern was found to be the most preferred, with 17 articles, followed by six-author and five-author patterns with 14 and 13 articles, respectively. Nine articles were contributed by four-author patterns, and these articles garnered the highest citation impact, with an average of 322.44 citations/article, compared to other authorship patterns.

As a distinct name, a total of 422 authors identified and 82% of the authors (n=345) contributed in a single article each while 43 (10.18%) authors contributed in two articles each. The top 19 authors who contributed

Table 4: Frequently used journal in most-cited articles in RPS

Serial no.	Name of journal	Coverage period	Total articles	Total citations	Citation impact
1.	*Journal of Periodontology*	1988–2015	24	4880	203.33
2.	*Journal of Clinical Periodontology*	1975–2016	19	5705	300.26
3.	*Journal of Dental Research*	1988–2016	10	2131	213.10
4.	*Biomaterials*	2009–2013	6	1391	231.83
5.	*Journal of Periodontal Research*	1986–2005	6	1149	191.50
6.	*Periodontology 2000*	1999–2015	6	1199	199.83
7.	*Acta Biomaterialia*	2011–2019	3	520	173.33
8.	*International Journal of Periodontics and Restorative Dentistry*	1996–2003	3	520	173.33
9.	*Dental Materials*	2012–2015	2	638	319.00
10.	21 Journals with one article each	—	21	4341	206.71

Table 5: Top authors contributed more than three articles each

Serial no.	Authors	Principal author	Second author	Third author	Fourth author	Other number	Total articles	Total citations	Citation impact
1.	W. V. Giannobile	3	—	—	1	6	10	2894	289.40
2.	P. Cortellini	6	—	2	—	1	9	1725	191.66
3.	M. S. Tonetti	2	2	4	—	—	8	1532	191.50
4.	S. E. Lynch	1	—	—	1	5	7	1592	227.42
5.	I. Ishikawa	—	—	—	—	6	6	1328	221.33
6.	P. M. Bartold	2	—	—	2	1	5	994	198.88
7.	D. L. Cochran	1	1	2	—	1	5	818	163.60
8.	T. Okano	—	—	—	1	4	5	1183	236.60
9.	M. Yamato	—	3	—	—	2	5	1183	236.60
10.	F.-M. Chen	3	—	—	—	1	4	847	218.50
11.	S. Gronthos	—	1	3	—	—	4	650	162.50
12.	S. Ivanovski	2	—	—	—	2	4	640	160.00
13.	T. Iwata	2	1	1	—	—	4	954	238.50
14.	M. Kitamura	1	—	1	1	1	4	671	167.75
15.	S. Nyman	1	3	—	—	—	4	1825	456.25
16.	G. Pini Prato	4	—	—	—	—	4	817	204.25
17.	J. M. Wozney	—	1	—	1	2	4	828	207.00
18.	U. M. E. Wikesjö	1	—	—	—	3	4	848	212.00
19.	M. Kitamura	1	—	1	1	1	4	671	167.75

more than three articles each are shown in Table 5. W. V. Gainnobile of Harvard School of Dental Medicine, United States, contributed 10 articles, with seven of them as a co-author. P. Cortellini of the University of Siena, Italy, ranked second with nine articles, six of which were contributed as a first author. G. Pini Prato of the University of Siena, Italy, contributed four articles, all as a first author. I. Ishikawa of Tokyo Medical and Dental University, Japan, contributed six articles as a co-author, with his name appearing after the fourth author in all his contributed articles. The four articles contributed by S. Nyman of the University of Gothenburg, Sweden, received the highest citation impact (456.25 citations/article), surpassing the top-ranked author, W. V. Giannobile (289.40 citations/article).

Authors from 25 different countries contributed to the 100 highly cited articles [Table 6]. Seven countries contributed to two or more articles, while eight countries contributed to one article each. The authors of the United States contributed to 51% of the articles, followed by Japan (n = 18), Switzerland (n = 15), Italy (n = 14), and Sweden (n = 12). The top five countries contributed more than 10 articles each. Articles contributed by authors from Sweden had the highest citation ratio, with a mean of 352.42 citations per article, followed by Canada, with an average of 278 citations per article.

Discussion

This study thoroughly examined the bibliometric features of the topmost 100 highly cited articles on RPS spanning 45 years from 1975 to 2019. Our findings revealed that articles focused on RCTs exhibited the most substantial citation impact, followed by clinical

Table 6: Distribution of articles by countries

Serial no.	Country	Total articles	Total citations	Citation impact
1.	United States	51	10,866	213.06
2.	Japan	18	3864	214.67
3.	Switzerland	15	3219	214.60
4.	Italy	14	2594	185.29
5.	Sweden	12	4229	352.42
6.	China	9	1695	188.33
7.	Australia	7	1325	189.29
8.	England	5	942	188.40
9.	Germany	5	919	183.80
10.	Netherland,	4	807	201.75
11.	India	3	821	273.67
12.	Israel	3	663	221.00
13.	Norway	3	612	204.00
14.	Canada	2	556	278.00
15.	Portugal	2	347	173.50
16.	Singapore	2	302	151.00
17.	South Korea	2	352	176.00
18.	Belguim, Brazil, Denmark, Poland, Iran, Saudi Arabia, Taiwan, and Yugoslavia	One article each	—	—

trials, whereas meta-analysis received the least citation impact. In addition, laboratory/animal studies held the highest article counts across all study designs. Moreover, the most preferred area of study was not specific studies, followed by infrabony. With regards to the modality of RPS, this study revealed that articles focusing GTR/bone graft received the highest level of citation impact, closely followed by GTR/bone graft/other, with a mean ratio of 246.76 and 245.66 citations per article, respectively.

In another study, the bibliometric characteristics of 132 top-cited h-classic articles on periodontal regeneration were elaborated, spanning a 43-years period from 1970 to 2012. Seventy percent of the articles were published in the first 30 years (1970–1999), while 30% of the articles were published from 2000 onward. Interestingly, the articles published from 2000 to 2009 had the highest citation impact.[14] In contrast, in our study, we found that articles published from the year 1975 to 1999 had gained slightly higher citation impact compared to the articles published from 2000 onward. This suggests that older articles on RPS tend to accumulate more citations.

Our study evaluated the LOE and reported that the majority of the articles (n = 57) belonged to LOE-V, followed by LOE-I and LOE-II with 19 and 18 articles, respectively. Interestingly, the LOE-I articles, particularly RCT, gained the highest citation impact. Other studies on most-cited articles in dentistry have also reported a low prevalence of LOE-I articles. For instance, Fardi *et al*.[16] conduced a study on implant dentistry and found only seven articles with LOE-I. Similarly, a study focusing on orthodontics revealed only three articles with LOE-I,[17] while an analysis on endodontics showed that most articles dealt with LOE-IV and V, and no articles found on LOE-I.[18] The *Saudi Dental Journal* also reported a low prevalence of LOE-I studies (5.56%).[19] Rajeh and Khayat[15] emphasized that LOE-I studies (meta-analysis, systematic reviews of RCTs, and randomized controlled clinical trials) require high-level expertise, optimal resources, substantial time investment, and professional commitment.

Additionally, our analysis demonstrated that in comparison to non-clinical papers (n = 72), which received a mean ratio of 210.81 citations per article, clinical articles (n = 28) had a greater citation impact (245.14 citations/article). Rajeh and Khayat[15] described that Saudi authors contributed to 7257 articles on dentistry from 2001 to 2020, and 21.46% (n = 1557) of these articles were of clinical nature. Among clinical articles, only 20% (n = 308) fell into LOE-I.

Liu *et al*.[14] divided highly cited studies on periodontal regeneration into four study types in their study. They found the highest number of papers on clinical trials, followed by animal studies.[14] In contrast, our study found that laboratory/animal studies were the most prevalent, followed by clinical trials. Liu *et al*.[14] reported that *in vitro* studies gained more citation impact, whereas our study stated that articles on RCTs gained the highest citation impact. On the other hand, Shaikh *et al*.[13] distributed the top-cited articles on periodontal regeneration into 13 study types. They found that RCTs were the most prevalent type of articles, with reviews following closely behind in terms of quantity. However, this study did not discuss the citation impact of study designs.

Liu *et al*.[14] described the defects and treatment modalities in periodontal regeneration, noting that infrabony and furcation defects were the two most common, occurring in 42 and 24 articles. In our study, approximately half of the articles (n = 47) were related to nonspecific modalities, while 30 articles focused on infrabony defects, followed by six articles each on furcation and infrabony/furcation. Only one article was found on recession, which received the highest citation impact, followed by two articles on furcation/recession/infrabony. Liu *et al*.[14] also analyzed treatment modalities and found that GTR was the most prevalent, with 45 articles, followed by biologics and bone grafts with 43 and 20 articles, respectively. Biologics received a higher citation impact compared to bone grafts.[14] In our study, the highest number of articles was recorded on other modalities (n = 35), followed by biologics (n = 27) and GTR/bone graft (n = 21). However, the articles focused on GTR/bone graft received the maximum citation impact. In human histology investigations, the proportion of defects indicating periodontal regeneration ranged from 34% to 80% across diverse biomaterial studies. Autografts had the highest percentage (80%), followed by allografts and xenografts (70% each), alloplastic materials (34%), barriers (75%), biologics (45%), and combinations (75%).[20]

The *Journal of Periodontology*, followed by the *Journal of Clinical Periodontology* and the "*Journal of Dental Research*, has published more than half of the most-cited articles in the study. Gutiérrez-Vela *et al*.[11] conducted a bibliometric analysis on RPS covering a 30-year period, revealing that more than one-third (n = 626; 35%) of the documents were published in two leading journals, *Journal of Periodontology* and *Journal of Clinical Periodontology*. Other studies also corroborated that the *Journal of Periodontology* and the *Journal of Clinical Periodontology* had been the most preferred sources.[13,14]

In our study, a total of 422 writers were identified, and 82% of the authors had contributed to a single article. An additional study on highly cited articles on periodontal regeneration testified that 349 writers in total had contributed to these articles, with 71% of authors having written just one article.[14] Gutiérrez-Vela *et al*.[11] stated that 4823 authors contributed to 1794 documents on RPS, and 79.6% of the authors had contributed to just a single document. These findings demonstrate that a small group of researchers contributed the highest number of research.[11] W. V. Giannobile emerged as the most productive author with 10 articles in our study, followed by P. Cortellini with nine articles, while Liu *et al*.[14] study revealed that P. Cortellini appeared to be the most prolific author with 14 articles. He is serving in the "Department of Oral Health Sciences, KU Leuven" and "Dentistry (Periodontology), University Hospitals Leuven, Belgium." W. V. Giannobile is a dean at the "Harvard School of Dental Medicine, Boston, Massachusetts, United States."

Our research revealed that 422 writers from 25 different countries participated in the study. The writers from the United States had contributed to 51% of the articles, followed by Japan. However, articles produced by Sweden received the highest citation impact, with Canada following closely behind. Shaikh *et al*.[13] study also endorsed similar findings, with the United States being the most productive country followed by Japan in a top-cited article on periodontal regeneration. Another study described that the research produced by Australia and Sweden received a higher ratio of citations.[14]

This study has several significant implications. It sheds light on previous work in RPS that has received the highest citation impact. In addition, our research revealed trends in research toward multidisciplinary collaboration as the number of writers per study improved. Moreover, this study aids researchers in prioritizing high-impact areas by identifying trends in study designs, fields of study, and treatment modalities. We noticed an emphasis on laboratory/animal studies and RCTs, which could help advance RPS. Therefore, this study serves as a valuable reference, helping researchers and clinicians understand the history, current trends, and future prospects in the field of RPS.

This study has several limitations. First, we incorporated all accessible Scopus records dating back to 1975; conversely, the addition of extra documents from other databases may have an impact. We extracted our dataset from the Scopus database, Elsevier introduced this database in 2004. It quickly gained popularity due to its comprehensive coverage of peer-reviewed literature comprising of abstracts and citation metrics of more than 25,000 active journals from 500 international publishers.[21] Therefore, conducting further studies that integrate diverse datasets would be beneficial. Second, our findings are specific to RPS and may not be generalizable to the broader field of periodontics. Exploring other aspects of periodontics in future studies would provide a more comprehensive understanding of the most-cited papers in this field. Finally, the study did not evaluate any biases or how they might affect the output and research and patterns of collaboration in the research area of RPS. It is advisable to conduct additional investigations into these aspects to gain a more nuanced understanding. The main drawback of this bibliometric analysis is the exclusion of freshly published articles due to time constraints on gathering citation data. Over time, the authors' affiliation might have changed, which might have had an impact on the specific analysis of the institution or country.

Conclusion

This study has highlighted the key literature on RPS and analyzed the 100 most influential articles. On average, these articles received approximately 224.74 citations per article over a span of 45 years. While the number of clinical studies (n = 27) was relatively low compared to non-clinical studies, clinical studies had a greater impact in terms of citations. Laboratory/animal studies were found to be the most frequent study design, but RCTs study design gained a higher citation impact. Others/not specified and biologics were found to be the most frequently occurring field of study and treatment modalities, respectively. The writers of the United States surpassed from other countries in terms of number of cited articles in RPS. The findings of this study support understanding the influential literature on RPS.

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Conflicts of interest

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Authors contributions

All authors contributed to conception, and design. IUH contributed to analysis and interpretation. All authors critically revised the manuscript, gave final approval, and agreed to be accountable for all aspects of the work.

Ethical policy and institutional review board

The King Abdullah International Medical Research Center Institutional Review Board exempted this study since it does not involve human subjects or relevant data(# SP23R/249/11).

Patient declaration of consent

Not applicable.

Data availability statement

Not applicable.

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10. Ahmad P, Slots J. A bibliometric analysis of periodontology. Periodontol 2000 2021;85:237-40.
11. Gutiérrez-Vela MM, Díaz-Haro A, Berbel-Salvador S, Lucero-Sánchez A, Robinson-García N, Cutando-Soriano A. Bibliometric analysis of research on regenerative periodontal surgery during the last 30 years. J Clin Exp Dent 2012;4:e112-8.
12. Huang X, Liu X, Shang Y, Qiao F, Chen G. Current trends in research on bone regeneration: A bibliometric analysis. Biomed Res Int 2020;2020:8787394.
13. Shaikh MS, Ullah R, Lone MA, Matabdin H, Khan F, Zafar MS. Periodontal regeneration: A bibliometric analysis of the most influential studies. Regen Med 2019;14:1121-36.
14. Liu HN, Yeung AWK, Leung WK. A bibliometric study of the top cited papers related to periodontal regeneration. J Oral Sci 2021;63:201-8.
15. Rajeh M, Khayat W. Level of evidence of dental research in Saudi Arabia (2000-2020). Int J Dent 2021;2021:3463434.
16. Fardi A, Kodonas K, Lillis T, Veis A. Top-cited articles in implant dentistry. Int J Oral Maxillofac Implants 2017;32:555-64.
17. Hui J, Han Z, Geng G, Yan W, Shao P. The 100 top-cited articles in orthodontics from 1975 to 2011. Angle Orthod 2013;83:491-9.
18. Fardi A, Kodonas K, Gogos C, Economides N. Top-cited articles in endodontic journals. J Endod 2011;37:1183-90.
19. Jamjoom FZ, Al-Barrak N, Al-Shehri H, Chitumalla RK, Ul-Haq I. Level of evidence analysis of the Saudi Dental Journal: A bibliometric analysis of publications from 2012 to 2021. Saudi Dent J 2023;35:812-8.
20. Sculean A, Nikolidakis D, Nikou G, Ivanovic A, Chapple IL, Stavropoulos A. Biomaterials for promoting periodontal regeneration in human intrabony defects: A systematic review. Periodontol 2000. 2015;68:182-216.
21. Zhu J, Liu W. A tale of two databases: The use of web of science and scopus in academic papers. Scientometrics 2020;123:321-35.

Appendices

List of 100 most-cited articles with total citations and citation density by year.

Serial no.	Description of article	Total citations	Citation density by year
1.	Nyman S, Lindhe J, Karring T, Rylander H. New attachment following surgical treatment of human periodontal disease. J Clin Periodontol. 1982;9(4):290–96.	820	20.00
2.	Bottino MC, Thomas V, Schmidt G, Vohra YK, Chu T-MG, Kowolik MJ, *et al*. Recent advances in the development of GTR/GBR membranes for periodontal regeneration—A materials perspective. Dent Mater. 2012;28(7):703–21.	492	44.73
3.	Hamp SE, Nyman S, Lindhe J. Periodontal treatment of multirooted teeth. Results after 5 years. J Clin Periodontol. 1975;2(3):126–35.	484	10.08
4.	Heijl L, Heden G, Svärdström G, Ostgren A. Enamel matrix derivative (EMDOGAIN) in the treatment of intrabony periodontal defects. J Clin Periodontol. 1997;24(9 Pt 2):705–14.	476	18.31
5.	Hammarström L, Heijl L, Gestrelius S. Periodontal regeneration in a buccal dehiscence model in monkeys after application of enamel matrix proteins. J Clin Periodontol. 1997;24(9 Pt 2):669–77.	471	18.12
6.	Garg T, Singh O, Arora S, Murthy R. Scaffold: A novel carrier for cell and drug delivery. Crit Rev Ther Drug Carrier Syst. 2012;29(1):1–63.	434	39.45
7.	Somerman MJ, Archer SY, Imm GR, Foster RA. A comparative study of human periodontal ligament cells and gingival fibroblasts *in vitro*. J Dent Res. 1988;67(1):66–70.	392	11.20
8.	Gestrelius S, Andersson C, Lidström D, Hammarström L, Somerman M. *In vitro* studies on periodontal ligament cells and enamel matrix derivative. J Clin Periodontol. 1997;24(9 Pt 2):685–92.	356	13.69
9.	Nakashima M, Reddi AH. The application of bone morphogenetic proteins to dental tissue engineering. Nat Biotechnol. 2003;21(9):1025–32.	354	17.70
10.	Lynch SE, Williams RC, Polson AM, Howell TH, Reddy MS, Zappa UE, *et al*. A combination of platelet-derived and insulin-like growth factors enhances periodontal regeneration. J Clin Periodontol. 1989;16(8):545–8.	353	10.38
11.	Bartold PM, McCulloch CA, Narayanan AS, Pitaru S. Tissue engineering: A new paradigm for periodontal regeneration based on molecular and cell biology. Periodontol 2000. 2000;24:253–69.	344	14.96
12.	Heijl L. Periodontal regeneration with enamel matrix derivative in one human experimental defect. A case report. J Clin Periodontol. 1997;24(9 Pt 2):693–6.	310	11.92
13.	Iwata T, Yamato M, Tsuchioka H, Takagi R, Mukobata S, Washio K, *et al*. Periodontal regeneration with multi-layered periodontal ligament-derived cell sheets in a canine model. Biomaterials. 2009;30(14):2716–23.	307	21.93
14.	Howell TH, Fiorellini JP, Paquette DW, Offenbacher S, Giannobile WV, Lynch SE. A phase I/II clinical trial to evaluate a combination of recombinant human platelet-derived growth factor-BB and recombinant human insulin-like growth factor-I in patients with periodontal disease. J Periodontol. 1997;68(12):1186–93.	302	11.62
15.	Chen FM, Zhang J, Zhang M, An Y, Chen F, Wu ZF. A review on endogenous regenerative technology in periodontal regenerative medicine. Biomaterials. 2010;31(31):7892–927.	300	23.08
16.	Okuda K, Kawase T, Momose M, Murata M, Saito Y, Suzuki H, *et al*. Platelet-rich plasma contains high levels of platelet-derived growth factor and transforming growth factor-beta and modulates the proliferation of periodontally related cells *in vitro*. J Periodontol. 2003;74(6):849–57.	295	14.75
17.	Bosshardt DD. Are cementoblasts a subpopulation of osteoblasts or a unique phenotype? J Dent Res. 2005;84(5):390–06.	290	16.11
18.	Sculean A, Nikolidakis D, Schwarz F. Regeneration of periodontal tissues: Combinations of barrier membranes and grafting materials—Biological foundation and preclinical evidence: A systematic review. J Clin Periodontol. 2008;35(8 Suppl):106–16.	288	19.20
19.	Nevins M, Camelo M, Nevins ML, Schenk RK, Lynch SE. Periodontal regeneration in humans using recombinant human platelet-derived growth factor-BB (rhPDGF-BB) and allogenic bone. J Periodontol. 2003;74(9):1282–92.	285	14.25
20.	Garrett S. Periodontal regeneration around natural teeth. Ann Periodontol. 1996;1(1):621–66.	273	10.11

Appendices: Continued

Serial no.	Description of article	Total citations	Citation density by year
21.	Rosling B, Nyman S, Lindhe J. The effect of systematic plaque control on bone regeneration in infrabony pockets. J Clin Periodontol. 1976;3(1):38–53.	262	5.57
22.	Caton J, Nyman S, Zander H. Histometric evaluation of periodontal surgery. II. Connective tissue attachment levels after four regenerative procedures. J Clin Periodontol. 1980;7(3):224–31.	259	6.02
23.	Carreira AC, Lojudice FH, Halcsik E, Navarro RD, Sogayar MC, Granjeiro JM. Bone morphogenetic proteins: Facts, challenges, and future perspectives. J Dent Res. 2014;93(4):335–45.	256	28.44
24.	Tonetti MS, Pini-Prato G, Cortellini P. Periodontal regeneration of human intrabony defects. IV. Determinants of healing response. J Periodontol. 1993;64(10):934–40.	254	8.47
25.	Sigurdsson TJ, Lee MB, Kubota K, Turek TJ, Wozney JM, Wikesjö UM. Periodontal repair in dogs: Recombinant human bone morphogenetic protein-2 significantly enhances periodontal regeneration. J Periodontol. 1995;66(2):131–8.	252	9.00
26.	Kawaguchi H, Hirachi A, Hasegawa N, Iwata T, Hamaguchi HS, Takata T, *et al*. Enhancement of periodontal tissue regeneration by transplantation of bone marrow mesenchymal stem cells. J Periodontol. 2004;75(9):1281–7.	249	13.11
27.	Tonetti MS, Lang NP, Cortellini P, Suvan JE, Adriaens P, Dubravec D, *et al*. Enamel matrix proteins in the regenerative therapy of deep intrabony defects. J Clin Periodontol. 2002;29(4):317–25.	245	11.67
28.	Tsumanuma Y, Iwata T, Washio K, Yoshida T, Yamada A, Takagi R, *et al*. Comparison of different tissue-derived stem cell sheets for periodontal regeneration in a canine 1-wall defect model. Biomaterials. 2011;32(25):5819–25.	240	20.00
29.	Hasegawa M, Yamato M, Kikuchi A, Okano T, Ishikawa I. Human periodontal ligament cell sheets can regenerate periodontal ligament tissue in an athymic rat model. Tissue Eng. 2005;11(3–4):469–78.	240	13.33
30.	Akizuki T, Oda S, Komaki M, Tsuchioka N, Kawakatsu N, Kikuchi A, *et al*. Application of periodontal ligament cell sheet for periodontal regeneration: A pilot study in beagle dogs. J Periodontal Res. 2005;40(3):245–51.	238	13.22
31.	Wikesjö UM, Nilvéus RE, Selvig KA. Significance of early healing events on periodontal repair: A review. J Periodontol. 1992;63(3):158–65.	237	7.65
32.	Cortellini P, Pini Prato G, Tonetti MS. Periodontal regeneration of human infrabony defects. I. Clinical measures. J Periodontol. 1993;64(4):254–60.	232	7.73
33.	Camargo PM, Lekovic V, Weinlaender M, Vasilic N, Madzarevic M, Kenney EB. Platelet-rich plasma and bovine porous bone mineral combined with guided tissue regeneration in the treatment of intrabony defects in humans. J Periodontal Res. 2002;37(4):300–6.	229	10.90
34.	Grzesik WJ, Narayanan AS. Cementum and periodontal wound healing and regeneration. Crit Rev Oral Biol Med. 2002;13(6):474–84.	227	10.81
35.	Chen FM, Sun HH, Lu H, Yu Q. Stem cell-delivery therapeutics for periodontal tissue regeneration. Biomaterials. 2012;33(27):6320–44.	224	20.36
36.	Lyngstadaas SP, Lundberg E, Ekdahl H, Andersson C, Gestrelius S. Autocrine growth factors in human periodontal ligament cells cultured on enamel matrix derivative. J Clin Periodontol. 2001;28(2):181–8.	220	10.00
37.	Srinivasan S, Jayasree R, Chennazhi KP, Nair SV, Jayakumar R. Biocompatible alginate/nano bioactive glass ceramic composite scaffolds for periodontal tissue regeneration. Carbohydr Polym. 2012;87(1):274–83.	216	19.64
38.	Yukna RA, Mellonig JT. Histologic evaluation of periodontal healing in humans following regenerative therapy with enamel matrix derivative. A 10-case series. J Periodontol. 2000;71(5):752–9.	213	9.26
39.	Wang H-L, Greenwell H, Fiorellini J, Giannobile W, Offenbacher S, Salkin L, *et al*. Periodontal regeneration. J Periodontol. 2005;76(9):1601–22.	212	11.78
40.	Sheikh Z, Hamdan N, Ikeda Y, Grynpas M, Ganss B, Glogauer M. Natural graft tissues and synthetic biomaterials for periodontal and alveolar bone reconstructive applications: A review. Biomater Res. 2017;21:9.	212	35.33

Appendices: Continued

Serial no.	Description of article	Total citations	Citation density by year
41.	Chen F-M, Gao L-N, Tian B-M, Zhang X-Y, Zhang Y-J, Dong G-Y, *et al*. Treatment of periodontal intrabony defects using autologous periodontal ligament stem cells: A randomized clinical trial [published correction appears in Stem Cell Res Ther. 2018 Oct 7;9(1):260]. Stem Cell Res Ther. 2016;7:33.	206	29.43
42.	Sigurdsson TJ, Nygaard L, Tatakis DN, Fu E, Turek TJ, Jin L, *et al*. Periodontal repair in dogs: Evaluation of rhBMP-2 carriers. Int J Periodontics Restorative Dent. 1996;16(6):524–37.	202	7.48
43.	Bosshardt DD. Biological mediators and periodontal regeneration: A review of enamel matrix proteins at the cellular and molecular levels. J Clin Periodontol. 2008;35(8 Suppl):87–105.	199	13.27
44.	Bashutski JD, Eber RM, Kinney JS, Benavides E, Maitra S, Braun TM, *et al*. Teriparatide and osseous regeneration in the oral cavity. N Engl J Med. 2010;363(25):2396–405.	198	15.23
45.	Cochran DL, Wozney JM. Biological mediators for periodontal regeneration. Periodontol 2000. 1999;19:40–58.	195	8.13
46.	Albanese A, Licata ME, Polizzi B, Campisi G. Platelet-rich plasma (PRP) in dental and oral surgery: From the wound healing to bone regeneration. Immun Aging. 2013;10(1):23.	194	19.40
47.	Cortellini P, Pini Prato G, Tonetti MS. Periodontal regeneration of human intrabony defects with bioresorbable membranes. A controlled clinical trial. J Periodontol. 1996;67(3):217–23.	193	7.15
48.	Zhu W, Liang M. Periodontal ligament stem cells: Current status, concerns, and future prospects. Stem Cells Int. 2015;2015:972313.	192	24.00
49.	Mota J, Yu N, Caridade SG, Luz GM, Gomes ME, Reis RL, *et al*. Chitosan/bioactive glass nanoparticle composite membranes for periodontal regeneration. Acta Biomater. 2012;8(11):4173–80.	192	17.45
50.	Rasperini G, Pilipchuk SP, Flanagan CL, Park CH, Pagni G, Hollister SJ, *et al*. 3D-printed bioresorbable scaffold for periodontal repair. J Dent Res. 2015;94(9 Suppl):153S–7S.	185	23.13
51.	Kao RT, Nares S, Reynolds MA. Periodontal regeneration - intrabony defects: A systematic review from the AAP Regeneration Workshop. J Periodontol. 2015;86(2 Suppl):S77–104.	184	23.00
52.	Trombelli L, Heitz-Mayfield LJ, Needleman I, Moles D, Scabbia A. A systematic review of graft materials and biological agents for periodontal intraosseous defects. J Clin Periodontol. 2002;29(Suppl 3):117–62.	184	8.76
53.	Bottino MC, Thomas V, Janowski GM. A novel spatially designed and functionally graded electrospun membrane for periodontal regeneration. Acta Biomater. 2011;7(1):216–24.	183	15.25
54.	Giannobile WV, Ryan S, Shih MS, Su DL, Kaplan PL, Chan TC. Recombinant human osteogenic protein-1 (OP-1) stimulates periodontal wound healing in class III furcation defects. J Periodontol. 1998;69(2):129–37.	183	7.32
55.	Murakami S, Takayama S, Kitamura M, Shimabukuro Y, Yanagi K, Ikezawa K, *et al*. Recombinant human basic fibroblast growth factor (bFGF) stimulates periodontal regeneration in class II furcation defects created in beagle dogs. J Periodontal Res. 2003;38(1):97–103.	180	9.00
56.	Arceo N, Sauk JJ, Moehring J, Foster RA, Somerman MJ. Human periodontal cells initiate mineral-like nodules *in vitro*. J Periodontol. 1991;62(8):499–503.	179	5.59
57.	Cortellini P, Pini Prato G, Tonetti MS. Periodontal regeneration of human infrabony defects. II. Re-entry procedures and bone measures. J Periodontol. 1993;64(4):261–8.	179	5.97
58.	King GN, King N, Cruchley AT, Wozney JM, Hughes FJ. Recombinant human bone morphogenetic protein-2 promotes wound healing in rat periodontal fenestration defects. J Dent Res. 1997;76(8):1460–70.	179	6.88
59.	Larsson L, Decker AM, Nibali L, Pilipchuk SP, Berglundh T, Giannobile WV. Regenerative medicine for periodontal and peri-implant diseases. J Dent Res. 2016;95(3):255–66.	179	25.57
60.	Hynes K, Menicanin D, Gronthos S, Bartold PM. Clinical utility of stem cells for periodontal regeneration. Periodontol 2000. 2012;59(1):203–27.	177	16.09
61.	Vaquette C, Fan W, Xiao Y, Hamlet S, Hutmacher DW, Ivanovski S. A biphasic scaffold design combined with cell sheet technology for simultaneous regeneration of alveolar bone/periodontal ligament complex. Biomaterials. 2012;33(22):5560–73.	176	16.00

Appendices: Continued

Serial no.	Description of article	Total citations	Citation density by year
62.	Giannobile WV, Hernandez RA, Finkelman RD, Ryan S, Kiritsy CP, D'Andrea M, *et al*. Comparative effects of platelet-derived growth factor-BB and insulin-like growth factor-I, individually and in combination, on periodontal regeneration in Macaca fascicularis. J Periodontal Res. 1996;31(5):301–12.	176	6.52
63.	Shimono M, Ishikawa T, Ishikawa H, Matsuzaki H, Hashimoto S, Muramatsu T, *et al*. Regulatory mechanisms of periodontal regeneration. Microsc Res Tech. 2003;60(5):491–502.	175	8.75
64.	Pirnazar P, Wolinsky L, Nachnani S, Haake S, Pilloni A, Bernard GW. Bacteriostatic effects of hyaluronic acid. J Periodontol. 1999;70(4):370–4.	174	7.25
65.	Kitamura M, Akamatsu M, Machigashira M, Hara Y, Sakagami R, Hirofuji T, *et al*. FGF-2 stimulates periodontal regeneration: Results of a multi-center randomized clinical trial. J Dent Res. 2011;90(1):35–40.	173	14.42
66.	Okuda K, Tai H, Tanabe K, Suzuki H, Sato T, Kawase T, *et al*. Platelet-rich plasma combined with a porous hydroxyapatite graft for the treatment of intrabony periodontal defects in humans: A comparative controlled clinical study. J Periodontol. 2005;76(6): 890–8.	173	9.61
67.	Panda S, Jayakumar ND, Sankari M, Varghese SS, Kumar DS. Platelet rich fibrin and xenograft in treatment of intrabony defect. Contemp Clin Dent. 2014;5(4):550–4.	171	21.38
68.	Sculean A, Nikolidakis D, Nikou G, Ivanovic A, Chapple IL, Stavropoulos A. Biomaterials for promoting periodontal regeneration in human intrabony defects: A systematic review. Periodontol 2000. 2015;68(1):182–216.	169	21.13
69.	Murakami S, Takayama S, Ikezawa K, Shimabukuro Y, Kitamura M, Nozaki T, *et al*. Regeneration of periodontal tissues by basic fibroblast growth factor. J Periodontal Res. 1999;34(7):425–30.	169	7.04
70.	Reddi AH, Cunningham NS. Initiation and promotion of bone differentiation by bone morphogenetic proteins. J Bone Miner Res. 1993;8(Suppl 2):S499–502.	169	5.63
71.	Kim K, Lee CH, Kim BK, Mao JJ. Anatomically shaped tooth and periodontal regeneration by cell homing. J Dent Res. 2010;89(8):842–7.	168	12.92
72.	Giannobile WV, Finkelman RD, Lynch SE. Comparison of canine and non-human primate animal models for periodontal regenerative therapy: Results following a single administration of PDGF/IGF-I. J Periodontol. 1994;65(12):1158–68.	167	5.76
73.	Nasajpour A, Ansari S, Rinoldi C, Rad AS, Aghaloo T, Shin SR, *et al*. A multifunctional polymeric periodontal membrane with osteogenic and antibacterial characteristics. Adv Funct Mater. 2018;28(3):1703437.	167	33.40
74.	Cortellini P, Tonetti MS. A minimally invasive surgical technique with an enamel matrix derivative in the regenerative treatment of intra-bony defects: A novel approach to limit morbidity. J Clin Periodontol. 2007;34(1):87–93.	165	10.31
75.	Bartold PM, Shi S, Gronthos S. Stem cells and periodontal regeneration. Periodontol 2000. 2006;40:164–72.	164	9.65
76.	Camelo M, Nevins ML, Schenk RK, Lynch SE, Nevins M. Periodontal regeneration in human Class II furcations using purified recombinant human platelet-derived growth factor-BB (rhPDGF-BB) with bone allograft. Int J Periodontics Restorative Dent. 2003;23(3):213–25.	164	8.20
77.	Schwartz Z, Carnes DL Jr, Pulliam R, Lohmann CH, Sylvia VL, Liu Y, *et al*. Porcine fetal enamel matrix derivative stimulates proliferation but not differentiation of pre-osteoblastic 2T9 cells, inhibits proliferation and stimulates differentiation of osteoblast-like MG63 cells, and increases proliferation and differentiation of normal human osteoblast NHOst cells. J Periodontol. 2000;71(8):1287–96.	164	7.13
78.	Donzelli E, Salvadè A, Mimo P, Viganò M, Morrone M, Papagna R, *et al*. Mesenchymal stem cells cultured on a collagen scaffold: In vitro osteogenic differentiation. Arch Oral Biol. 2007;52(1):64–73.	161	10.06
79.	Ivanovski S, Vaquette C, Gronthos S, Hutmacher DW, Bartold PM. Multiphasic scaffolds for periodontal tissue engineering. J Dent Res. 2014;93(12):1212–21.	160	17.78
80.	Iwata T, Yamato M, Zhang Z, Mukobata S, Washio K, Ando T, *et al*. Validation of human periodontal ligament-derived cells as a reliable source for cytotherapeutic use. J Clin Periodontol. 2010;37(12):1088–1099.	158	12.15

Appendices: Continued

Serial no.	Description of article	Total citations	Citation density by year
81.	Magnusson I, Batich C, Collins BR. New attachment formation following controlled tissue regeneration using biodegradable membranes. J Periodontol. 1988;59(1):1–6.	158	4.51
82.	Terranova VP, Franzetti LC, Hic S, DiFlorio RM, Lyall RM, Wikesjö UM, *et al*. A biochemical approach to periodontal regeneration: Tetracycline treatment of dentin promotes fibroblast adhesion and growth. J Periodontal Res. 1986;21(4):330–7.	157	4.24
83.	Ranjbar-Mohammadi M, Zamani M, Prabhakaran MP, Bahrami SH, Ramakrishna S. Electrospinning of PLGA/gum tragacanth nanofibers containing tetracycline hydrochloride for periodontal regeneration. Mater Sci Eng C Mater Biol Appl. 2016;58:521–31.	157	22.43
84.	Villar CC, Cochran DL. Regeneration of periodontal tissues: Guided tissue regeneration. Dent Clin North Am. 2010;54(1):73–92.	156	12.00
85.	Costa PF, Vaquette C, Zhang Q, Reis RL, Ivanovski S, Hutmacher DW. Advanced tissue engineering scaffold design for regeneration of the complex hierarchical periodontal structure. J Clin Periodontol. 2014;41(3):283–94.	155	17.22
86.	Miron RJ, Sculean A, Cochran DL, Froum S, Zucchelli G, Nemcovsky C, *et al*. Twenty years of enamel matrix derivative: The past, the present and the future. J Clin Periodontol. 2016;43(8):668–83.	155	22.14
87.	Mellonig JT. Human histologic evaluation of a bovine-derived bone xenograft in the treatment of periodontal osseous defects. Int J Periodontics Restorative Dent. 2000;20(1):19–29.	154	6.70
88.	Cortellini P, Pini Prato G, Tonetti MS. Periodontal regeneration of human intrabony defects with titanium reinforced membranes. A controlled clinical trial. J Periodontol. 1995;66(9):797–803.	152	5.43
89.	D'Errico JA, Berry JE, Ouyang H, Strayhorn CL, Windle JJ, Somerman MJ. Employing a transgenic animal model to obtain cementoblasts *in vitro*. J Periodontol. 2000;71(1):63–72.	150	6.52
90.	Cortellini P, Tonetti MS. Clinical concepts for regenerative therapy in intrabony defects. Periodontol 2000. 2015;68(1):282–307.	150	18.75
91.	Ivanovski S, Gronthos S, Shi S, Bartold PM. Stem cells in the periodontal ligament. Oral Dis. 2006;12(4):358–63.	149	8.76
92.	Takayama S, Murakami S, Shimabukuro Y, Kitamura M, Okada H. Periodontal regeneration by FGF-2 (bFGF) in primate models. J Dent Res. 2001;80(12):2075–79.	149	6.77
93.	Oates TW, Rouse CA, Cochran DL. Mitogenic effects of growth factors on human periodontal ligament cells *in vitro*. J Periodontol. 1993;64(2):142–8.	148	4.93
94.	Pilipchuk SP, Plonka AB, Monje A, Taut AD, Lanis A, Kang B, *et al*. Tissue engineering for bone regeneration and osseointegration in the oral cavity. Dent Mater. 2015;31(4):317–38.	146	18.25
95.	Chew JRJ, Chuah SJ, Teo KYW, Zhang S, Lai RC, Fu LP, *et al*. Mesenchymal stem cell exosomes enhance periodontal ligament cell functions and promote periodontal regeneration. Acta Biomater. 2019;89:252–64.	145	36.25
96.	Luan X, Ito Y, Diekwisch TG. Evolution and development of Hertwig's epithelial root sheath. Dev Dyn. 2006;235(5):1167–80.	145	8.53
97.	Wachtel H, Schenk G, Böhm S, Weng D, Zuhr O, Hürzeler MB. Microsurgical access flap and enamel matrix derivative for the treatment of periodontal intrabony defects: A controlled clinical study. J Clin Periodontol. 2003;30(6):496–504.	145	7.25
98.	Kinoshita A, Oda S, Takahashi K, Yokota S, Ishikawa I. Periodontal regeneration by application of recombinant human bone morphogenetic protein-2 to horizontal circumferential defects created by experimental periodontitis in beagle dogs. J Periodontol. 1997;68(2):103–9.	145	5.58
99.	Kaigler D, Avila G, Wisner-Lynch L, Nevins M, Rasperini G, Lynch SE, *et al*. Platelet-derived growth factor applications in periodontal and peri-implant bone regeneration. Expert Opin Biol Ther. 2011;11(3):375–85.	145	12.08
100.	Yang H, Gao L-N, An Y, Hu C-H, Jin F, Zhou J, *et al*. Comparison of mesenchymal stem cells derived from gingival tissue and periodontal ligament in different incubation conditions. Biomaterials. 2013;34(29):7033–47.	144	14.40