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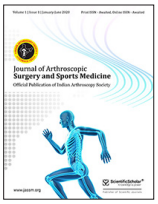

Original Article

Trends of the publications of platelet-rich plasma use in osteoarthritis knee – A PubMed and Scopus bibliometric analysis

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ABSTRACT

Objectives: Bibliometrics is being used to assess the quantity and quality of scientific research output. This study is aimed to evaluate the worldwide research productivity in the field of platelet-rich plasma (PRP) use in osteoarthritis (OA) knee.

Materials and Methods: Scopus and PubMed databases were searched to identify published articles on PRP and OA knee. The contributions of authors, countries, institutions, and collaborations across the world were analyzed. The top journals publishing in this field were analyzed for the citations and other parameters.

Results: Total publications on this topic were 1309 in Scopus and 921 in PubMed, and the yearly average of publication numbers has seen a steady increase over the past 10 years. Top journal in terms of number of articles and citations was *Arthroscopy* and *AJSM,* respectively. *Osteoarthritis* and *Cartilage* published the maximum preclinical studies. *Kon E* emerges to be the leading author in both the databases. Original clinical research articles (15.31% and 22.15%) are less compared to review articles (34.6% and 28.3%) in both PubMed and Scopus, respectively. The largest number of articles in this field was from the USA and six of the top 10 productive universities were also from the USA.

Conclusion: There has been a rapid increase in the scientific research productivity in the past 10 years and this topic has gained attention in the recent past. There is a need for more clinical trials in this field.

Keywords: Osteoporosis, Platelet-rich plasma, Trends, cartilage

INTRODUCTION

Platelet-rich plasma (PRP) is a hot topic among orthopedic surgeons and has emerged over the past decade as a potential treatment options for various orthopedic conditions.[1,2] The positive role of PRP in favoring cartilage anabolism, decreasing catabolism, and other anti-inflammatory effect on the synovium and cartilage has been demonstrated in various *in vivo* and *in vitro* studies;[3,4] and this pre-clinical research has translated to clinical research over the past decade and various randomized controlled trials (RCTs) and meta-analysis have positively supported the use in early osteoarthritis (OA) knee.[5,6] A large number of research studies related to PRP and OA have been published in the past two decades due to the huge clinical demand for such treatments. To date, there has not been any bibliometric analysis on PRP use in OA knee.

The aim of the present study was to perform bibliometric analysis of research articles published in this field and analyze the journals, authors, collaboration network, and countries of research involved in both pre-clinical studies and clinical studies. We used PubMed and Scopus to complement each other to fill gaps in the information. This will enable in choosing the right journal for the article type, identify the authors involved in this research, enable to analyze the number and type of each research, and hence better summarize the trends in publications pertaining to PRP use in OA knee.

MATERIALS AND METHODS

Data extraction

We have used PubMed and Scopus databases for the main investigation of our study for the timeframe 1975–2020. The methods and scientific processes for the distribution of

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information are very similar within these databases. We have looked for the terms related to PRP in the title, abstract, or keywords to extract the relevant publications. The following query was designed for data extraction [Table 1].

query = base_query AND <extension>

<extension> = NULL or subquery

Where, subquery is a set of filters or qualifiers which fetch results specific to the study type we intended to analyze. It should be noted that when the <extension> is set to NULL, all the relevant publications related to PRP are extracted irrespective of the study type

The subtype analysis of studies included clinical studies, RCT, animal studies (*in vivo*), *in vitro* studies, meta-analysis, and review for PubMed; while clinical studies, animal studies, *in vitro* study, meta-analysis, review, and RCT for Scopus**.**

Data analysis

The extracted data were in BibTeX format. It contains information such as documents, authors and their affiliations, journals, keywords, and citations.

We deployed the Bibliometrix-R package for analyzing the extracted data.[7]

Table 1: Data extraction query and selection criteria in PubMed and Scopus, explaining the articles tagged for the respective categories with the publication types.

Query	Study type	PubMed	Scopus	No. of articles PubMed	No. of articles Scopus
Base_query	-	((platelet-rich plasma) OR (PRP)) OR (platelet growth factors)) AND ((((osteoarthritis) OR (osteoarthrosis)) OR (degenerative joint disease)) OR (degenerative chondropathy))	TITLE-ABS-KEY (platelet AND rich AND plasma) OR TITLE-ABS-KEY (prp) OR TITLE-ABS-KEY (platelet AND growth AND factors))) AND ((TITLE-ABS-KEY (osteoarthritis) OR TITLE-ABS-KEY (osteoarthrosis) OR TITLE-ABS-KEY (degenerative AND joint AND disease) OR TITLE-ABS-KEY (degenerative AND chondropathy)))	-	-
<extension>	All	NULL	NULL	921	1309
	Clinical trials	(Clinical Trial[pt] OR Clinical Study[pt] OR Adaptive Clinical Trial[pt] OR Clinical Trial Protocol[pt] OR Clinical Trial, Phase I[pt] OR Clinical Trial, Phase II [pt] OR Clinical Trial, Phase III [pt] OR Clinical Trial, Phase IV [pt] OR Controlled Clinical Trial[pt] OR Pragmatic Clinical Trial[pt])	(LIMIT-TO (EXACTKEYWORD, "Clinical Article") OR LIMIT-TO (EXACTKEYWORD, "Major Clinical Study") OR LIMIT-TO (EXACTKEYWORD, "Clinical Trial"))	100	278
	Randomized controlled trials	Randomized Controlled Trial [PT]	LIMIT-TO (EXACTKEYWORD, "Randomized Controlled Trial (topic)") OR LIMIT-TO (EXACTKEYWORD, "Randomized Controlled Trial")	67	222
	In vitro studies	"*In vitro* Techniques" [MeSH]	LIMIT-TO (EXACTKEYWORD, "*In vitro* Study")	50	89
	Animal studies	ANIMAL [filter]	LIMIT-TO (EXACTKEYWORD, "Animals") OR LIMIT-TO (EXACTKEYWORD, "Animal") OR LIMIT-TO (EXACTKEYWORD, "Animal Experiment") OR LIMIT-TO (EXACTKEYWORD, "Animal Model") OR LIMIT-TO (EXACTKEYWORD, "Animal Tissue") OR LIMIT-TO (EXACTKEYWORD, "Animal Cell")	159	259
	Meta-analysis	-	LIMIT-TO (EXACTKEYWORD, "Meta-analysis")	33	51
	Review	-	LIMIT-TO (DOCTYPE, "re")	226	356

Evaluation of research performance in the field of "PRP and Osteoarthritis" was done with the following tools as bibliometric data and indicators

a. Annual scientific production
b. Most relevant authors, coauthors, and their collaboration
c. The journals of greater prominence based on the number of documents published, citations, and h-index
d. The role of the different countries contributing in this field and their collaboration networks
e. Conceptual structure to identify subdomains of research.
f. Journals and authors in various subcategories such as clinical research, animal studies, and review articles.

(*Details of the methodology for above six parameters – supplementary materials Part 1*).

RESULTS

A total number of 921 documents were retrieved from the PubMed database, whereas for Scopus, it was 1309. The documents were published in 347 and 526 different sources for PubMed and Scopus, respectively. The various document types included the clinical studies, RCT, animal studies, *in vitro* studies, case reports, meta-analysis, and reviews [Table 2].

Table 2: General information.

Description	PubMed results	Scopus results
MAIN INFORMATION ABOUT DATA		
Timespan	1975:2020	1975:2020
Sources (journals, books, etc.)	347	526
Documents	921	1309
Average years from publication	5.76	5.96
Average citations per documents	NA	25.79
Average citations per year per doc	NA	3.138
References	1152	59272
Clinical studies. {*n*/(%)}	100/(15.31)	278/(22.15)
RCT {*n*/(%)}	67/(10.26)	222/(17.6)
Animal studies {*n*/(%)}	159/(24.34)	259/(20.6)
In vitro studies {*n*/(%)}	50/(7.6)	89/(7.09)
Case reports {*n*/(%)}	18/(2.7)	NA
Meta-analysis {*n*/(%)}	33/(5.05)	51/(4.06)
Review {*n*/(%)}	226/(34.6)	356/(28.3)

The highest number of documents was received in the year 2020 for Scopus ($n = 214$) as well as for PubMed ($n = 138$). The comparative time evolution of annual scientific production based on the number of documents for PubMed and Scopus is shown in [Figure 1]. It can be seen that the number of articles published before 2001 was <5. It also clearly depicts that the interest has grown among the research community over the past 10 years.

Analysis of authors

The total authors were 3857 and 5059 in PubMed and Scopus data, respectively. The authors of single-authored documents were 33 and 74 and that of multi-authored were 3824 and 4985 for PubMed and Scopus, respectively. The authors per document were 4.18 and 3.86 from PubMed and Scopus, respectively.

Kon E emerges to be the leading author in both the databases with the maximum number of documents ($n = 30$ for PubMed and $n = 29$ for Scopus) published in this field. The list is followed by Filardo G, Cole BJ, Sánchez M, and Di Matteo B [Figure 2] for both the databases (*Supplementary material Part 2 for analysis of Top-Author's Production over time*).

Authors collaboration network

[Figure 3] shows the coauthorship network of the authors for PubMed and Scopus. The clusters of authors' collaboration were almost similar for both the databases. The red cluster represents the team of Kon *et al.* (Italian group of authors), the blue cluster has Sanchez *et al.* (Spanish authors), the green cluster represents Cole *et al.* (Chicago, USA), and so on.

Analysis of journals

The most prominent journals in terms of number of documents and influential in terms of H index and citations are tabulated in [Table 3 and in Figure 4].
(*Part 3 supplementary materials*)

Analysis of relevant countries

Among the top 10 countries publishing on this topic, the USA and China have published the highest number of documents whereas Canada and Germany top the list

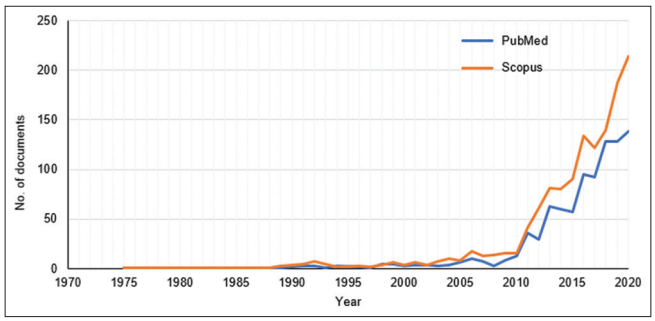

Figure 1: Annual scientific production from Scopus and PubMed.

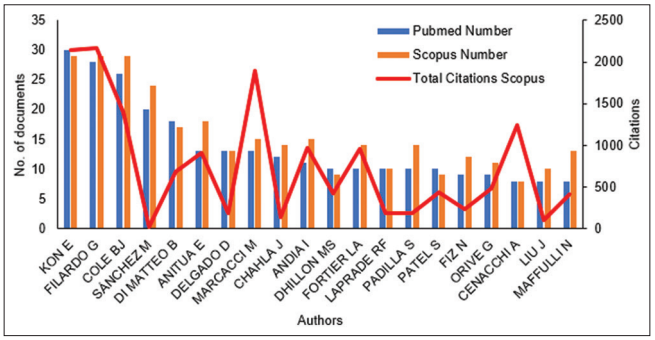

Figure 2: Top 20 relevant authors with publications in this field.

for collaborative studies as evident by better MCP ratio [Table 4].

Conceptual structure

The conceptual structure was created using multiple correspondence analyses (MCAs) method of the network of terms extracted from title, abstracts, and authors' keywords. It gives us an idea of the links between concepts through the co-occurrences of the terms. It helps in identifying the similar group of studies by dividing the keywords into clusters. Words present in the same clusters might represent the same concept/topic. Using the MCA methods for the conceptual structure map, two clusters were found [Figure 5]. The red-colored cluster seems to match clinical studies and the blue cluster corresponds to the animal studies and experimental studies.

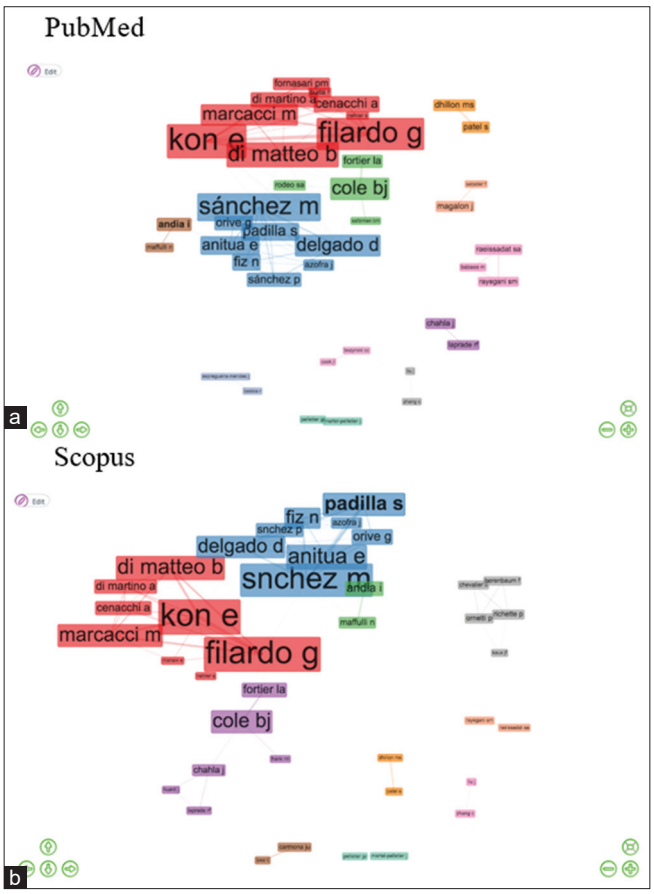

Figure 3: Authors collaboration network (a) PubMed and (b) Scopus. The colors represent the different clusters obtained using Louvain algorithm.

DISCUSSION

Bibliometric analysis is a good way at looking at global trends of the research within a topic, field, and across countries. It gives a wider outlook on the topic of interest. There are various publications on bibliometric analysis pertaining to spine topics,[8,9] arthroscopy topics,[10] and other orthopedic topics.[11] To the best of our knowledge, this is the first bibliometric analysis on this topic and it provides a broad picture of the worldwide research in this upcoming orthobiologic field. PRP has emerged as a valuable therapeutic option for various musculoskeletal disorders due to the pool of growth factors it contains and its role is tissue healing.[4] Initial studies in orthopedics were focused on PRP role in tendinopathies and started in 2006.[12] The clinical use of PRP for early OA of knee was first used by Sanchez *et al*. in 2008[13] and Kon *et al*.[14] came up with the first RCT of PRP use in OA knee. We analyzed the time frame from 1975 to 2020 and it can be clearly seen that the boom in publications has been in the past decade and is seeing a steady rise in the number of publications in both Scopus and PubMed.

A PubMed search resulted in a smaller number of documents in comparison to Scopus due to its narrow scope and coverage. PubMed mostly covers biomedical and life sciences literature, whereas Scopus covers wider range of scientific topics. However, PubMed database is a freely available database whereas Scopus is based on the subscription model.

Table 3: Top 10 journals publishing PRP and OA knee relevant studies.

Journal name	Total documents in PubMed	Total documents in Scopus	Total citations in Scopus	H-index
Arthroscopy – Journal of Arthroscopic and Related Surgery	54	50	1837	18
American Journal of Sports Medicine	46	48	2366	19
Osteoarthritis and Cartilage	25	31	2143	18
Knee Surgery, Sports Traumatology, Arthroscopy	24	25	1620	18
BioMed Research International	15	16	326	9
PM&R: The Journal of Injury, Function and Rehabilitation.	15	15	274	6
The Journal of Knee Surgery	14	4	98	3
International Orthopaedics	13	5	136	4
Arthritis and Rheumatology	12	12	146	3
Orthopaedic Journal of Sports Medicine	11	20	188	6

Green indicates the top journal and yellow indicates second in the respective parameter

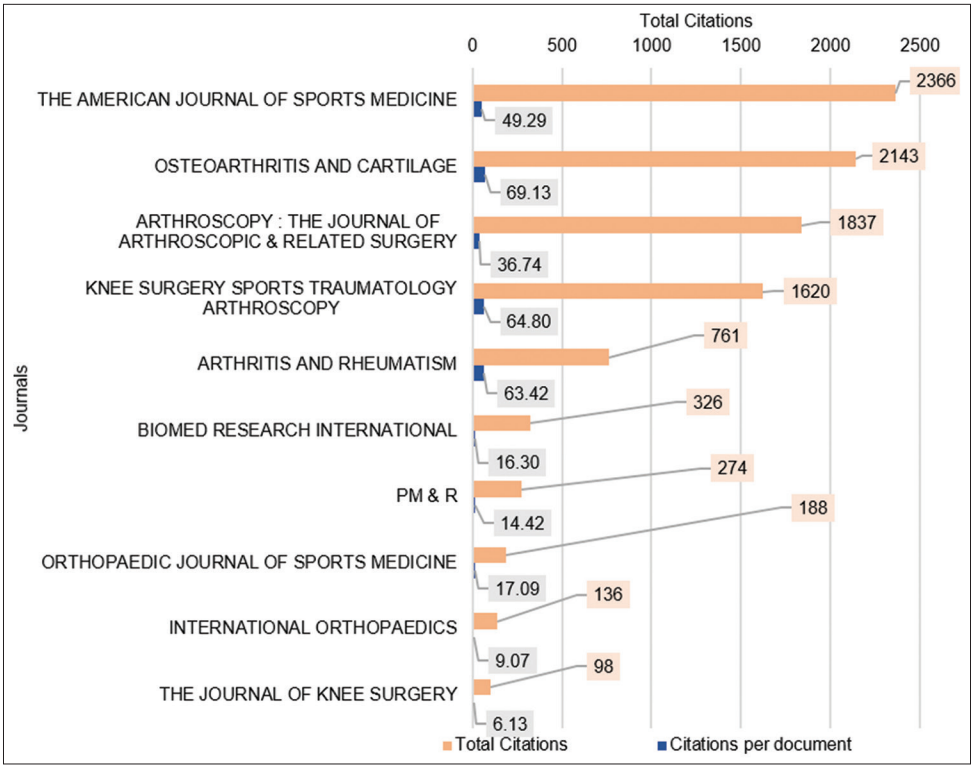

Figure 4: Top 10 journals based on total citations, citations per document, and documents from Scopus.

Table 4: Top 10 countries listed by total number of articles from Scopus.

Country	Articles	Freq.	SCP	MCP	MCP ratio
USA	335	0.307	286	49	0.146
China	109	0.100	97	12	0.110
Italy	86	0.079	66	20	0.232
Spain	61	0.056	47	14	0.229
Germany	48	0.044	35	13	0.270
Japan	38	0.034	35	3	0.078
Canada	34	0.031	24	10	0.294
Turkey	32	0.029	32	0	0
India	30	0.027	25	5	0.166
United Kingdom	30	0.027	23	7	0.233

Green indicates the top journal and yellow indicates second in the respective parameter. MCP: Multiple-country publication, SCP: Simple-country publication, MCP ratio: Multiple-country publication ratio

PubMed also has a sophisticated keyword optimization approach whereas Scopus provides search analysis tools that can produce representative figures. The alternate sources of bibliometric information such as Web of Science and Google Scholar are also available. However, Scopus data are considered to be more inclusive and accurate.[15] Citation-related parameters are also better available in Scopus and using both PubMed and Scopus the databases, optimal results can be acquired.

The top three journals in terms of number of documents published are *Arthroscopy – Journal of Arthroscopic and Related Surgery, American Journal of Sports Medicine, Osteoarthritis, and Cartilage*. The American Journal of Sports Medicine has the highest total citations of 2366 and highest H-index of 19 in this particular field. Top journals in the respective subcategories (animal studies, clinical studies, review articles, and RCTs) are tabulated in [Table 5]. It gives a list of journals to follow and consider for publishing respective research for upcoming research work.

The prolific authors in this field are Kon E, Filardo G, Cole BJ, and Sanchez.[16] [Table 5] also provides the top 10 authors in respective subcategories.

Original article by Patel *et al*. in 2013[6] which first established the superiority of PRP over placebo for early OA knee is the highest cited paper with 386 citations in this field. Top five cited papers are tabulated in [Table 6].

The geographic distribution of scientific research in a particular field is important to analyze as it can give a rough idea of the research capabilities and available technologies in the countries and respective institutions. Researchers wanting to start these procedures can look forward to collaboration and fellowships and help from these relevant countries or institutions. The USA and China followed by Italy and Spain are the leading countries in research in this field. Six of the top 10 universities are in the United States and Rush University Medical Center (United States) tops

Figure 5: Conceptual structure obtained from (a) PubMed and (b) Scopus.

the list of top universities involved in the research [Table 7]. Universities in the USA and Europe appear to be the leaders in this field.

During the beginning of the decade, there was a lot of hype around PRP use in orthopedics and there were a lot more review articles than original research and there was a need for more and more clinical trials.[17] Even after 10 years of research, original clinical research articles (15.31% and 22.15%) are less compared to review articles (34.6% and 28.3%) in both PubMed and Scopus, respectively. The absence of adequate well-designed studies in this field is well recognized and hence evidence is equivocal and PRP is yet to find its mention in various international guidelines.[18] Clinical research with well-designed studies is still the need of hour to establish the role of PRP in early OA knee.

Table 5: Top 10 journals and top 10 authors in various subcategories of studies.

Clinical studies		Animal studies		Review articles		Randomized control trials	
Top 10 journals	**Top 10 authors**	**Top 10 journals**	**Top 10 authors**	**Top 10 journals**	**Top 10 authors**	**Top 10 journals**	**Top 10 authors**
American Journal of Sports Medicine	Sanchez	Osteoarthritis and Cartilage	Cook	Arthroscopy: The Journal of Arthroscopic and Related Surgery	Cole	Arthroscopy: The Journal of Arthroscopic and Related Surgery	Kon
Arthroscopy - Journal of Arthroscopic and Related Surgery	Filardo	Plos One	Bozynski	Current Reviews In Musculoskeletal Medicine	Andia	American Journal of Sports Medicine	Filardo
Orthopaedic Journal of Sports Medicine	Kon	The American Journal of Sports Medicine	Kurok	Clinics In Sports Medicine	Sanchez	Orthopaedic Journal of Sports Medicine	Cole
Osteoarthritis and Cartilage	Fiz	Arthritis and Rheumatism	Zhang	International Journal Of Molecular Sciences	Maffuli	Knee Surgery Sports Traumatology Arthroscopy	Gobbi
Knee Surgery Sports Traumatology Arthroscopy : Official Journal Of The Esska	Bastos	BMC Veterinary Research	Carmona	Orthopaedic Journal of Sports Medicine	Rodeo	BMC Musculoskeletal Disorders	Dhillon
Arthritis and Rheumatism	Cenacchi	Journal of Orthopaedic Research - Official Publication of The Orthopaedic Research Society	Anitua	Physical Medicine And Rehabilitation Clinics of North America	Chahla	Clinical Rheumatology	Patel
Knee	Di Martino	American Journal of Veterinary Research	Bertone	The Journal of Knee Surgery	Laprade	International Journal of Surgery	Hunter
Clinical Orthopaedics and Related Research	Marcacci	Sports Medicine and Arthroscopy Review	Carrillo	Journal of Clinical Orthopaedics and Trauma	Anitua	PM and R	Liu
Clinical Rheumatology	Anitua	The Journal of Knee Surgery	Cole	Pm and R: The Journal of Injury Function And Rehabilitation	Filardo	Cartilage	CömertKiliç
European Journal of Orthopaedic Surgery and Traumatology	Delgado	Arthritis Research and Therapy	Fortier	The Physician and Sports Medicine	Kon	Journal of Orthopaedics	Di Matteo

Table 6: Top five cited papers in this field from Scopus.

Rank	Author (year)	Title	Journal	Citations
1	Patel *et al*. (2013)[6]	Treatment with platelet-rich plasma is more effective than placebo for knee osteoarthritis: A prospective, double-blind, randomized trial	Am J Sports Med	386
2	Kon *et al*. (2010)[14]	Platelet-rich plasma: Intra-articular knee injections produced favorable results on degenerative cartilage lesions	Knee Surg Sports Traumatol Arthroscopy	346
3	Fortier *et al*. (2011)[4]	The role of growth factors in cartilage repair	Clin OrthopRelat Res	334
4	Kon *et al*. (2011)[16]	Platelet-Rich Plasma Intra-Articular Injection Versus Hyaluronic Acid Viscosupplementation as Treatments for Cartilage Pathology: From Early Degeneration to Osteoarthritis	ARTHROSCOPY J ARTHROSCOPIC RELAT SURG	325
5	Barbero A (2004)[8]	Age-related changes in human articular chondrocyte yield, proliferation and post-expansion chondrogenic capacity	Osteoarthritis Cartilage	283

Table 7: Top 10 universities across the world involved in research.

Rank	Institution (Country)	Articles
1	Rush University Medical Center, (United States)	42
2	Rizzoli Orthopaedic Institute, (Italy)	35
3	Taipei Medical University, (Taiwan)	34
4	Harvard Medical School, (United States)	29
5	Hospital for Special Surgery, (United States)	25
6	Tabriz University of Medical Sciences, (Iran)	18
7	Hospital Vithas San Jose, (Spain)	17
8	University of Missouri, (United States)	17
9	Cornell University, (United States)	15
10	University of California, (United States)	15

CONCLUSION

The present study is the first bibliometric evaluation on the worldwide research productivity in the field of PRP and OA knee. There has been a steady increase in publication in this field and there are many journals which are publishing articles related to this relatively new field in orthopedics. There is a need for more clinical trials in this field.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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SUPPLEMENTARY MATERIALS

Part 1-Details of the methodology

Generic attributes

It presents the general attributes of the information present in the bibliographic data. This information includes number of sources, documents, average citations per documents, average citations per year per document, average years from publications, and number of documents for seven different study types.

In this study, we have calculated the annual scientific production. It refers to how much output researchers produce within a specific time period. The number of documents published over the years was used as a criterion for mapping the annual scientific production.

Authors

Hirsch index or h-index has been used to evaluate the impact of authors in the field of PRP. H-index is calculated by the authors' number of publications (h) each of which has been cited at least h times in other papers.[1]

Authors' collaboration network

For the social structure, we have studied the collaboration pattern of authors. First, we constructed a network graph where the nodes represent the authors and the lines connecting them represent the coauthorship relationship between them. Further, the clusters of authors have been identified using modularity maximization based Louvain algorithm. The colors represent different clusters of authors. The authors belonging to the same cluster might have collaborated more number of times as compared to authors in the different clusters.[2]

Journals

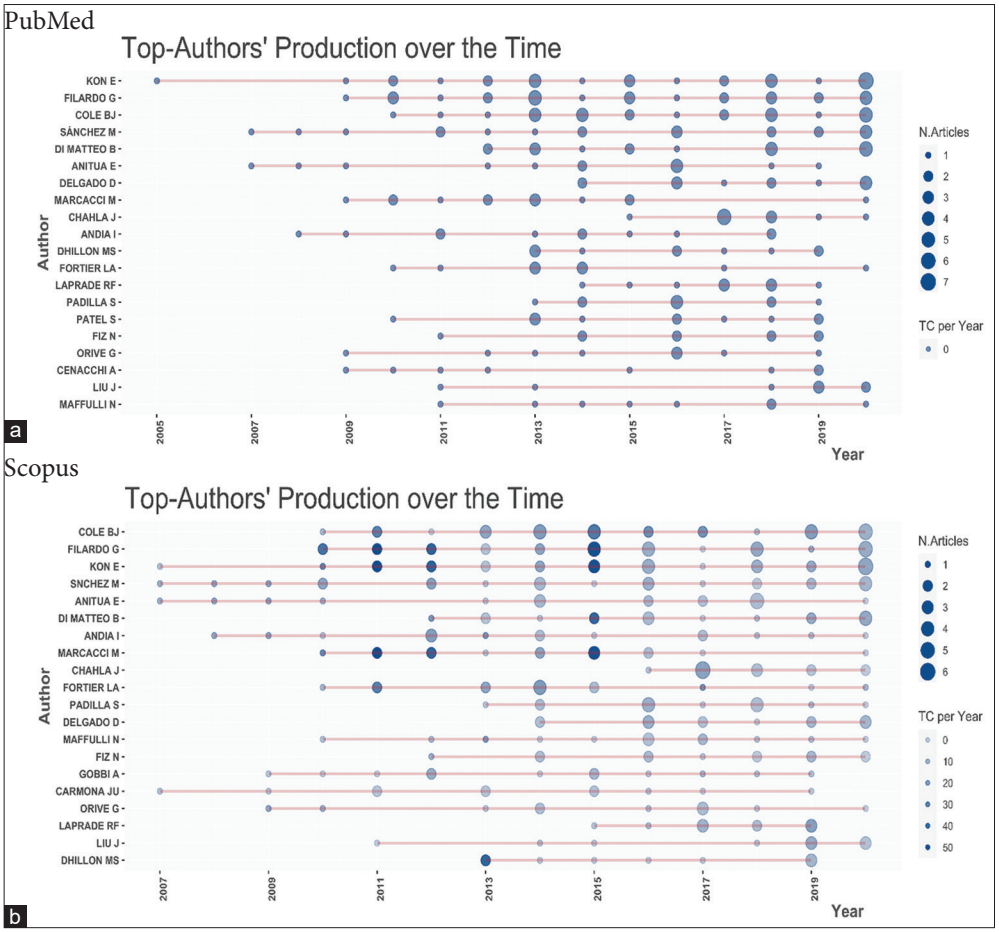
The key indicators used to evaluate the performance of journals were h-index, citations, and the total number of articles published in a journal.[3]

Countries

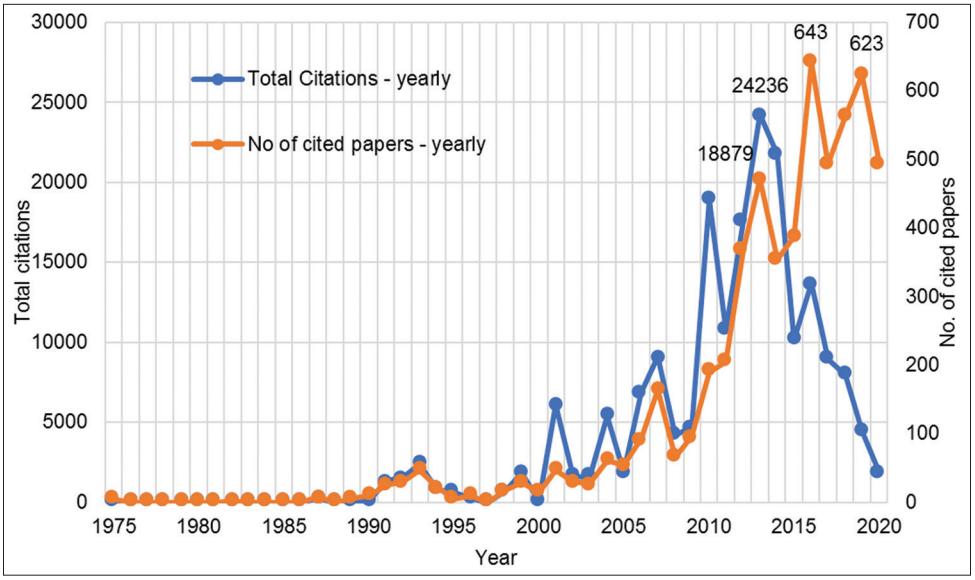
The key measures which were used to identify the top countries working in this field are single-country publications, multiple-country publications (MCPs), and MCP ratio. The MCP ratio is the measure of multicountry publications to the total number of articles.[4] The information about countries was available only with Scopus, so it has been used to find out the top 10 countries working in this field.

Documents

Citation analysis is used as a measure to evaluate the impact of an article. The number of global citations received per year



Supplementary Figure 1: Top authors' production over time (a) PubMed and (b) Scopus.



Supplementary Figure 2: Total yearly citations and number of cited papers from Scopus.

has been employed as a metric to evaluate the impact of an article.[4]

Conceptual Structure

This tool was used to construct and visualize the co-occurrence data of authors' keywords. The analysis of keywords plays a significant role as it helps in investigating the core topics in the field.[5] Multiple correspondence analyses have been used to identify conceptual structure. It unfolds the patterns geometrically by mapping each word of analysis as a point in a low dimensional space.[6,7]

Part 2-Analysis of Top Author's Production Over Time

The top author's production over time is shown in [Supplementary Figure 1]. The X-axis represents an author's timeline. It can be clearly observed that Kone E emerges as the first one to start publishing in this field starting from the year 2005 in the PubMed. In 2015, Cole BJ published four articles with the highest citations per year of 34.57.

Part 3: Yearly Citations and Number of Cited Papers

[Supplementary Figure 2] shows the total citations per year and number of cited papers per year from Scopus.

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