Research article

Bibliometric analysis of synovial in osteoarthritis in the last 10 years

Guangtao Han , Lijun Cai , Bohua Li , Qianhao Li , Yue luo , Qiuru Wang , Pengde Kang [*]

West China Hospital of Sichuan University, China

ARTICLE INFO

ABSTRACT

Background: Our aim was to examine trends in the bibliometric analysis of synovial for osteoarthritis over the last 10 years.

Methods: Publications relevant to synovial in osteoarthritis from 2013 to 2022 were retrieved from the Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), and Web of Science Core Collection (WoSCC) databases. The countries/regions, institutions, authors, journals, references, and keywords related to this topic were extracted using Citespace and Vosviewer. Citespace and Vosviewer were also used to identify and analyze this field's research hotspots and trends.

Results: Over the past 10 years, 5738 articles addressing the role of synovium in osteoarthritis have been published. Between 2013 and 2022, 2021 had the highest amount of published articles (a total of 756 published articles, or 13.18 % of the total articles) covering synovial in osteoarthritis. China was the country that published the most articles, while Duke University was the institution that published the most articles. Osteoarthritis and Cartilage was the journal with the most publications related to the study of Synovium in osteoarthritis. The National Nature Science Foundation of China provided the most funding. According to the analysis of keyword burst detection, human cartilage, control experiment, and exosomes were the most searched at different points in time.

Conclusion: In the last ten years, both the number of citations and the article discussing synovial in osteoarthritis have increased. The top 10 most searched keywords were "osteoarthritis","synovial fluid", "inflammation", "cartilage", "expression","rheumatoid arthritis","articular cartilage", "knee osteoarthritis", "synovial", "knee". According to the timeline view of co-citation clustering, synovial components and their expressions have emerged as hotspots of research associated with synovial osteoarthritis.

1. Introduction

Osteoarthritis, a chronic osteojoint disease, is typified by subchondral osteosclerosis, osteophyte generation, progression of articular cartilage deterioration, and joint inflammation [1]. Osteoarthritis is by far the most prevalent form of arthritis, and its causes are related to age, obesity, joint overstrain, joint deformity, and other factors [2]. The main clinical manifestations of osteoarthritis are

chronic pain and joint mobility disorders, which can impact the patient's quality of life [3]. Osteoarthritis is most common in middle-aged individuals and the elderly [4]. Previous studies have linked the deterioration of cartilage to osteoarthritis. As the study progressed, researchers found that the synovial membrane played a smaller role in osteoarthritis than in rheumatoid arthritis, but it was essential [5]. Histopathology in the 1980s indicated that although features of synovial inflammation (excessive cell proliferation, increased angiogenesis, and the presence of lymphocyte aggregation) were highly heterogeneous between patients, they were associated with pain and osteoarthritic progression from osteoarthritis [6]. Moreover, the thickness of synovial tissue hyperplasia in osteoarthritis patients was related to the degree of inflammatory cell infiltration. Moreover, studies have shown that synovial macrophages have more significant infiltration in joints in the late stage of osteoarthritis than in the early stage of osteoarthritis [7]. Cytokines and inflammatory factors secreted by synovial macrophages, such as IL-1, IL-6, TNF and vascular endothelial growth factor, can be diffused into cartilage through synovial fluid to promote the apoptosis of chondrocytes and the invasion of new blood vessels in cartilage tissue [8]. It leads to the destruction and degradation of chondrocytes, aggravates joint wear and tear, and eventually leads to osteoarthritis. Synovial fluid and serum of patients with osteoarthritis contain a large number of synovial cells and products of chondrocyte metabolism. The above evidence proves that osteoarthritis is closely related to synovial membrane [7].

Bibliometric is a discipline introduced by Pritchard in 1969 that uses mathematical and statistical methods to quantitatively evaluate scientific publications, books, and other forms of literature [9]. Information from extensive sources can be quickly retrieved and assessed using this method, thereby helping researchers to identify research hotspots and development trends. Authors, Journals, countries, and institutions contributing to a particular field can also be evaluated further providing a basis for research. Furthermore, bibliometrics can be utilized to quantitively and qualitatively assess the trends in research [10]. Based on public databases, this approach can efficiently and precisely show the most significant research findings in a certain topic, offering a theoretical foundation for more study [11]. Moreover, decision-makers can also use this information as a source of reference [12]. A bibliometric analysis of the literature on osteoarthritis and synovial arthritis published between 2013 and 2022 was done in this work. The current development status, future research trends, and hotspots in this field were summarized based on the analysis results, offering guidance and references for further study.

2. Materials and procedures

2.1. Steps of material collection

The bibliometric analysis in this work was conducted using the Science Citation Index expanded and Social Science Citation Index of WoSCC database. The search phrase was set as follows:Topic=(synovial or synovium or synovialis and osteoarthritis). The publications extracted were only in English. A comprehensive database search of relevant publications published between 2013 and 2022 was conducted by Guangtao Han and Lijun Cai; only original articles and reviews were included in our analysis. Fig. 1 depicts a detailed flow chart of the selection procedure conducted in this research. On January 1, 2023, all publication searches and file downloads were carried out to prevent bias brought about by frequent database updates. In this study, two researchers evaluated the data input and collection independently. By conferring with field experts or holding discussions, the two researchers were able to come to a consensus regarding discrepancies in their findings.

2.2. Bibliometric analysis

All of the WoSCC data was textualized and then imported into analysis software for analysis. To identify co-cited articles, keywords, countries, institutions, journals, authors, and keyword breakout network characteristics, we employed VOSviewer 1.6.16, CiteSpace 6.1R6, 64-bit, and bibliometrics online analysis platforms. The results were then visualized. The Journal Citation Report 2022 was used as the source of all impact factors and category quartiles.

In order to analyze the hotspots of synovial in osteoarthritis, CiteSpace software was used to analyze the literature, including the analysis of publishing institutions, co-citation literature as well as keywords with the most relevance. The objects to be analyzed are presented as nodes in the constructed network visualization map; the larger the nodes, the more frequently the objects occur. In addition, CiteSpace software is a good software for analyzing centrality. Centrality is an index to define the importance of network nodes. Centrality is proportional to the prominence of nodes. Not to be ignored, the significance of node location in a network can also be measured using centrality. The more connections through this node in the network, the higher its centrality.

With VOSviewer, a science-based knowledge network that highlights the development of research fields, institutional
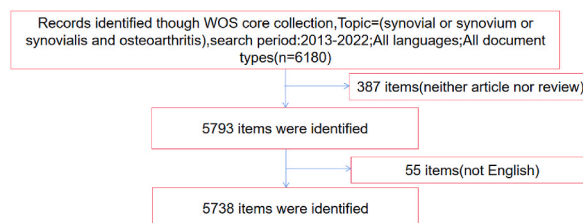

Fig. 1. Search strategy shown by a chart.

collaboration, and potential research hotspots can be establishedWe used the VOS viewer to construct a density map and conduct a visual analysis of keyword co-occurrence by analyzing the ksynovial hotspots associated with osteoarthritis. Co-occurrence analysis in the VOS viewer can divide keywords into different clusters that are color-coded. By using the keyword co-occurrence network to cluster the research hotspot, we can intuitively identify the development trend of the research hotspot.

## 3. Results

3.1. Overview of publications

A total of 5738 articles regarding the role of synovium in osteoarthritis have been published in the last 10 years (Fig. 1). Over 10 years, the number of articles on synovial in osteoarthritis increased, as did the number of citations (Fig. 2A). Between 2013 and 2022, the year with the largest number of published articles involving synovial in osteoarthritis was 2021, with 756 articles published in total, making up 13.18 % of all articles (Fig. 2B).

3.2. National distribution of synovial in osteoarthritis and distribution in research institutions

Fig. 3 shows the country collaborations of synovial studied in osteoarthritis research from 2013 to 2022, and Table 1 shows the top 20 country collaborations of synovial for articles studied in osteoarthritis research 2013–2022. We found that the country with the most studies of synovial in osteoarthritis 2013–2022 was China (1435), followed by the United States (1417), then the United Kingdom (419), Japan (407) and Germany (368). Of the total number of articles, 25.01 % were from China, making it the country with the highest research on synovial tissue in osteoarthritis. Nodes in the network are ranked according to their importance using the central
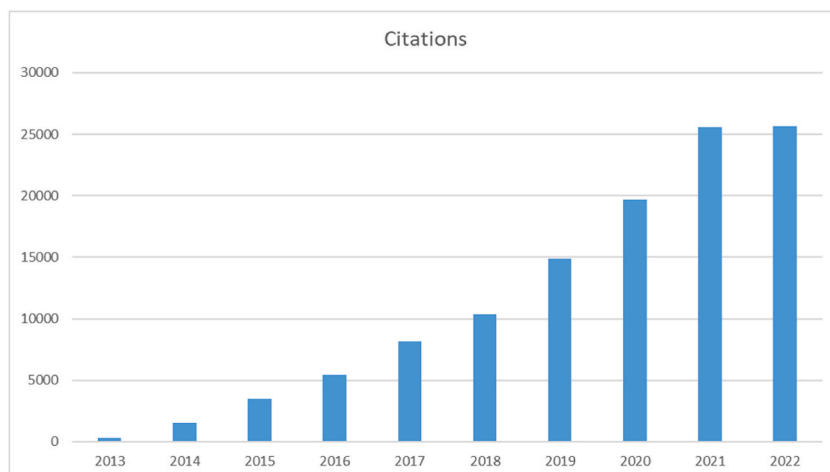
A
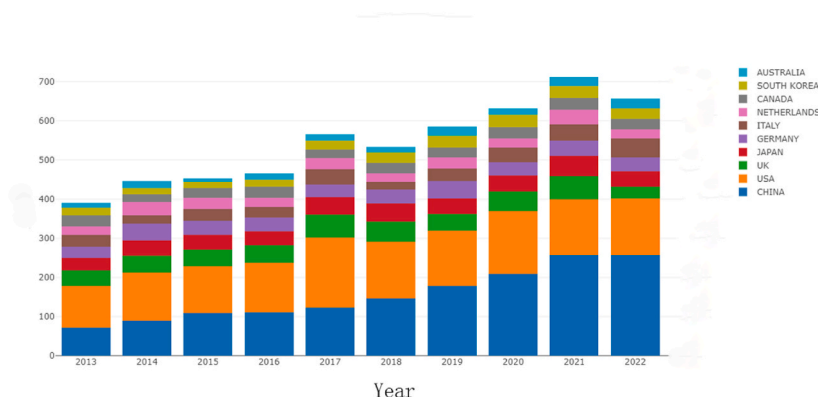
B

Fig. 2. A.Number of citations of synovial in osteoarthritis research from 2013 to 2022. Fig. 2B.The number of articles published on synovial in osteoarthritis research between 2013 and 2022. Different colors represent different countries.
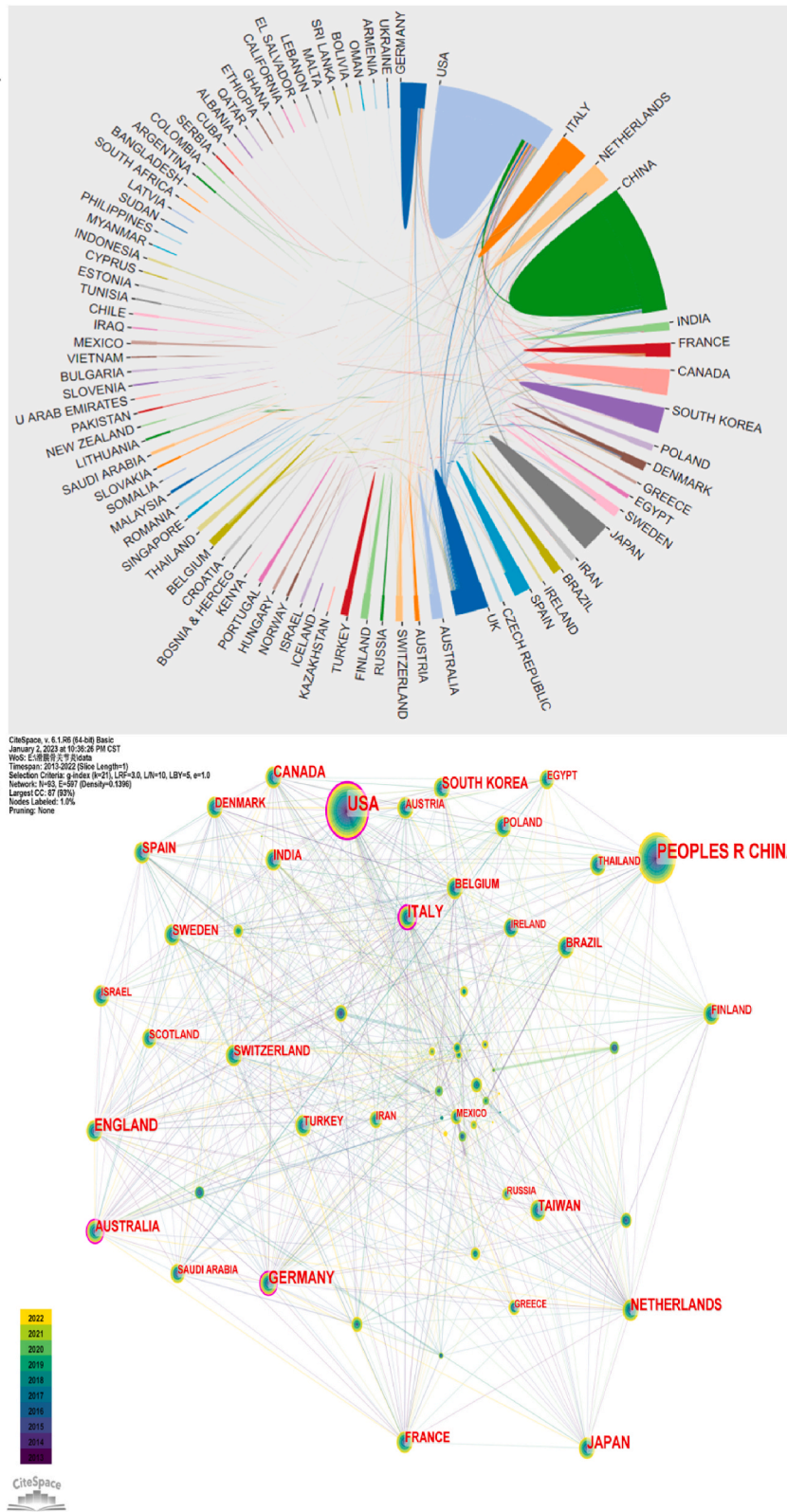
Fig. 3. Synovial in osteoarthritis research from 2013 to 2022 of national collaboration.

Table 1
Synovial in osteoarthritis research from 2013 to 2022 in top 20 countries.

Rank	Counts	Centrality	Country
1	1435	0.09	PEOPLE R CHINA
2	1417	0.39	USA
3	419	0.1	ENGLAND
4	407	0.01	JAPAN
5	368	0.18	GERMANY
6	332	0.24	ITALY
7	276	0.08	NETHERLANDS
8	264	0.06	CANADA
9	241	0.06	SOUTH KOREA
10	174	0.12	AUSTRALIA
11	166	0.07	SPAIN
12	163	0.03	FRANCE
13	142	0.08	TAIWAN
14	134	0.08	SWEDEN
15	121	0.04	INDIA
16	119	0.05	SWITZERLAND
17	108	0.01	DENMARK
18	91	0.01	BRAZIL
19	86	0.03	BELGIUM
20	79	0.01	TURKEY

value. The number of links through the node increases as the center value increases. The highest central value among these countries is 0.39 in the United States. It was followed by 0.24 in Italy, 0.18 in Germany, 0.12 in Australia and 0.1 in Japan. Table 1 shows that there was a weak correlation between the studies on synovial in osteoarthritis, with the central values of the remaining countries all being less than 0.1.

In terms of research institutions, we found that the organization with the most studies on synovial in osteoarthritis from 2013 to 2022 was Duke Univ (98 papers), followed by China Med Univ (89 papers) and Univ Calgary (77 papers). Univ Med Ctr Utrecht ranked fourth with 68 articles and Southern Med Univ ranked fifth with 66 articles (Fig. 4). In terms of the central value, Hosp Special Surg ranked the first with 0.13, China Med Univ Hosp ranked the second with 0.11, and Duke Univ ranked the third with 0.1. The central values of other research institutions were all less than 0.1, indicating a weak correlation between research institutions on synovial in osteoarthritis (Table 2).

3.3. Author network analysis

We used vosviewer to analyze co-authors of synovial in osteoarthritis studies, and the results are shown in Table 3. The research
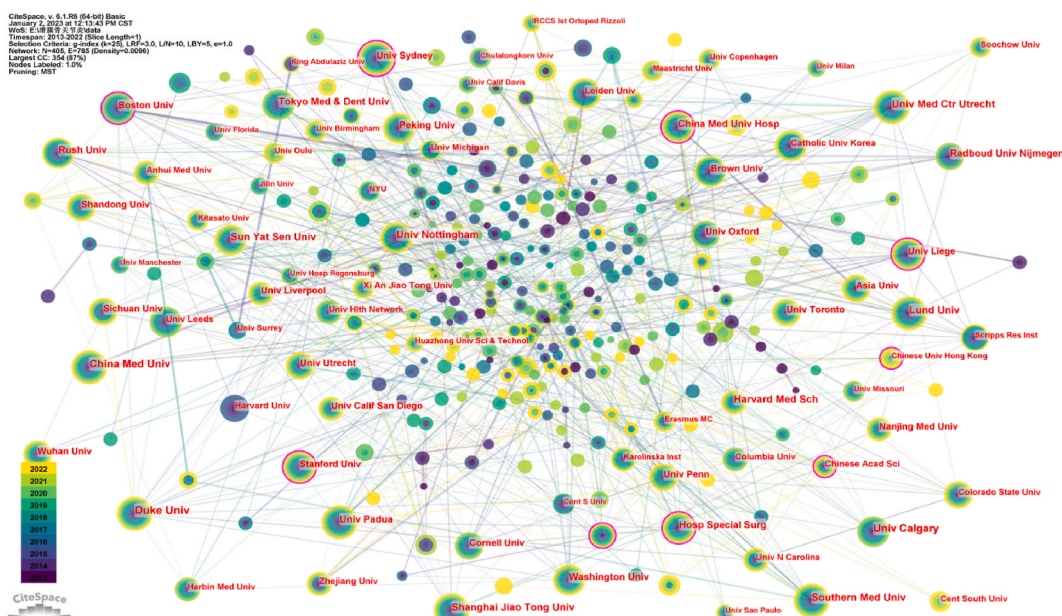
Fig. 4. Synovial of osteoarthritis research from 2013 to 2022 with institutional collaboration.

Table 2

Synovial in osteoarthritis research from 2013 to 2022 in top 20 institutions.

Rank	Centrality	Article	Institutions
1	0.1	98	Duke Univ
2	0.06	89	China Med Univ
3	0.03	77	Univ Calgary
4	0.06	68	Univ Med Ctr Utrecht
5	0.06	66	Southern Med Univ
6	0.07	65	Univ Nottingham
7	0.05	64	Shanghai Jiao Tong Univ
8	0.03	64	Sun Yat Sen Univ
9	0.09	63	Lund Univ
10	0.07	62	Harvard Med Sch
11	0.05	58	Peking Univ
12	0.03	56	Tokyo Med & Dent Univ
13	0.06	55	Washington Univ
14	0.11	54	China Med Univ Hosp
15	0.13	54	Hosp Special Surg
16	0.03	52	Radboud Univ Nijmegen
17	0.07	51	Univ Padua
18	0.08	50	Rush Univ
19	0.05	49	Sichuan Univ
20	0.05	49	Brown Univ

results showed that Tang,Chih-Hsin published 53 articles at most, Sekiya and Ichiro published 47 articles ranked second, Koga, Hideyuki published 40 articles ranked third, Liu, Shan-Chi and Tsai, Chun-Hao published 35 articles tied for fourth. In terms of average citations, Mobasheri, Ali ranked first with 58.2, Kraus, Virginia B ranked second with 39.21, followed by Muneta, Takeshi ranked third with 28.72. The distribution of author collaboration is displayed in Fig. 5, demonstrating that the relationship among authors was rather fragmented. It follows that scholarly cooperation was generally insufficient and occurred infrequently.

3.4. Number of articles published in journals

In the recent 10 years, synovial studies in osteoarthritis was involved in many journals. OSTEOARTHRITIS AND CARTILAGE ranked first with 352 articles published in this journal, followed by 177 articles in ARTHRITIS RESEARCH THERAPY. JOURNAL OF ORTHOPAEDIC RESEARCH ranked third, INTERNATIONAL JOURNAL OF MOLECULAR SCIENCES ranked fourth and PLOS ONE ranked fifth. In terms of the number of references per literature, ANNALS OF THE RHEUMATIC DISEASES ranked first, ARTHRITIS RHEUMATOLOGY ranked second, and ARTHRITIS RESEARCH THERAPY ranked third. OSTEOARTHRITIS AND CARTILAGE ranked fourth and PLOS ONE ranked fifth. Most of the journals were located in the JCR Q1, demonstrating the high influence of synovial studies in osteoarthritis (Table 4). Fig. 6 shows the relationship between journals of synovial studies in osteoarthritis from 2013 to 2022. These journals are closely connected, indicating more collaboration among them.

3.5. Funding sponsorship

Synovial in osteoarthritis studies has been supported by many funds in recent 10 years, as shown in Table 5. At the top of the list of sponsored articles were the 715 articles sponsored by the National Nature Science Foundation of China; next in line were the 636 articles sponsored by the National Institutes of Health Nih USA and the United States Department of Health and Human Services; fourth place went to the Nih National Institute of Arthritis Musculoskeletal Skin Diseases (Niams) with 364 sponsored articles, and fifth place went to the European Commission with 264 sponsored articles. European countries and the USA made up the majority of the top 10 funders of synovial in osteoarthritis studies. However, the National Natural Science Foundation of China sponsored the most articles in

Table 3

Top 10 authors of synovial studies in osteoarthritis from 2013 to 2022.

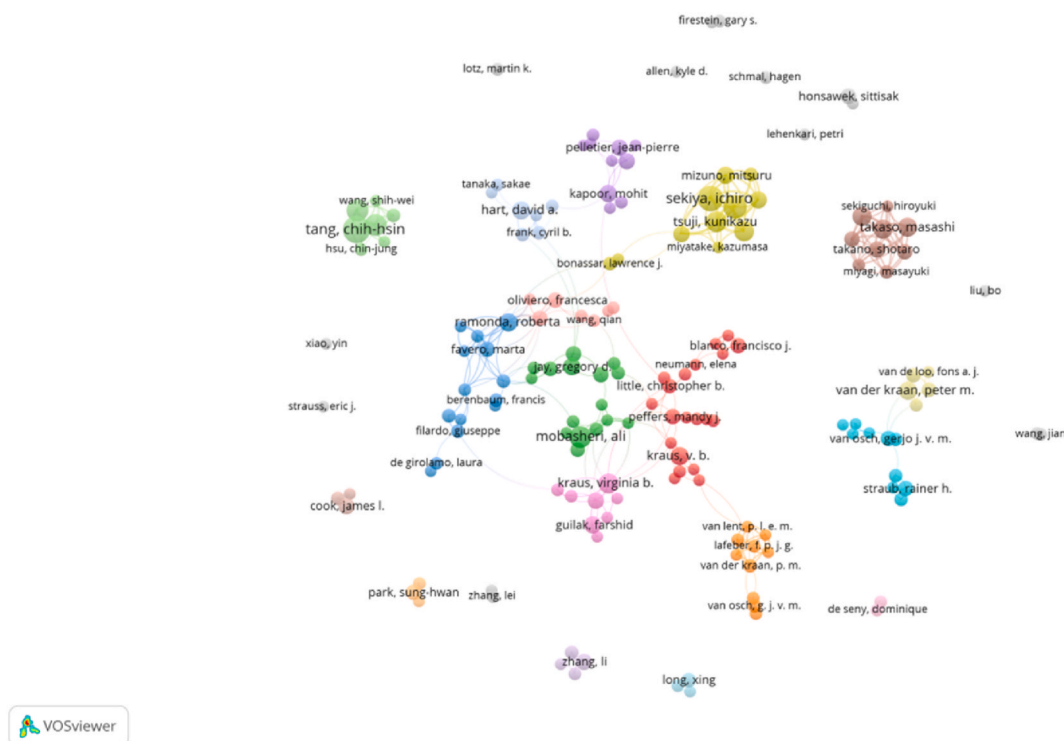| Rank	Author	Publication	Citations	Citations/Publications
1	Tang, Chih-Hsin	53	1149	21.67924528
2	Sekiya, Ichiro	47	1122	23.87234043
3	Koga, Hideyuki	40	876	21.9
4	Liu, Shan-Chi	35	724	20.68571429
5	Tsai, Chun-Hao	35	827	23.62857143
6	Mobasheri, Ali	35	2037	58.2
7	Tsuji, Kunikazu	33	695	21.06060606
8	Muneta, Takeshi	29	833	28.72413793
9	Kraus, Virginia B.	29	1137	39.20689655
10	Takaso, Masashi	27	231	8.555555556

Fig. 5. Author diagram of synovial studies in osteoarthritis from 2013 to 2022.

Table 4
Top 10 journals of synovial studies in osteoarthritis from 2013 to 2022.

Rank	Publications	Article counts	Citations	Citations/ Article	IF	Self- citation	IF(except Self- citation rate)	JCR
1	OSTEOARTHRITIS AND CARTILAGE	352	11857	33.68465909	7.507	8 %	6.90644	Q1
2	ARTHRITIS RESEARCH THERAPY	177	6032	34.07909605	5.606	2.20 %	5.482668	Q1
3	JOURNAL OF ORTHOPAEDIC RESEARCH	155	3118	20.11612903	3.103	5.60 %	2.929232	Q2
4	INTERNATIONAL JOURNAL OF MOLECULAR SCIENCES	135	2266	16.78518519	6.208	9.70 %	5.605824	Q1
5	PLOS ONE	128	2681	20.9453125	3.752	3.80 %	3.609424	Q2
6	SCIENTIFIC REPORTS	105	2129	20.27619048	4.997	4.20 %	4.787126	Q2
7	ARTHRITIS RHEUMATOLOGY	97	4040	41.64948454	15.483	3.30 %	14.972061	Q1
8	BMC MUSCULOSKELETAL DISORDERS	87	1310	15.05747126	2.562	6.10 %	2.405718	Q3
9	CARTILAGE	68	512	7.529411765	3.117	8.70 %	2.845821	Q2
10	ANNALS OF THE RHEUMATIC DISEASES	67	3899	58.19402985	28.003	8.50 %	25.622745	Q1

this area during the last 10 years.

3.6. Keyword co-occurrence analysis

We performed co-occurrence analysis of synovial in osteoarthritis from 2013 to 2022 using vosviewer, and the results are shown in Fig. 7. The term "keyword co-occurrence analysis" describes how frequently two keywords occur together in a single article. The thickness of the line and the size of the circle represent the frequency of co-occurrences and keyword occurrences. We selected these keywords from 5738 articles in total. About 20436 keywords were selected for their frequency of co-occurrence, as they met the criteria (Fig. 7A). The top ten keywords of synovial in osteoarthritis were "osteoarthritis (n = 3352)", "synovial fluid (n = 1588)", "inflammation (n = 1159)", "cartilage (n = 1117)", "expression (n = 1114)", rheumatoid arthritis (n = 879) ", articular cartilage (n = 874) ", knee osteoarthritis (n = 868) ", synovial (n = 667) ", "knee (n = 596) "(Fig. 7A). Five clusters were divided into keyword co-occurrence:the expression of genes and pathway in synovial in osteoarthritis, synovial fluid's function in osteoarthritis diagnosis, the role of targeting synovial in the treatment of osteoarthritis, The clinical impact of synovial on osteoarthritis and their function in the pathogenesis of osteoarthritis. Fig. 7B shows that studies before 2017 focused on the expression of genes and pathway in synovial in osteoarthritis, research on the clinical effect of synovial in osteoarthritis was conducted between 2017 and 2019, and studies after
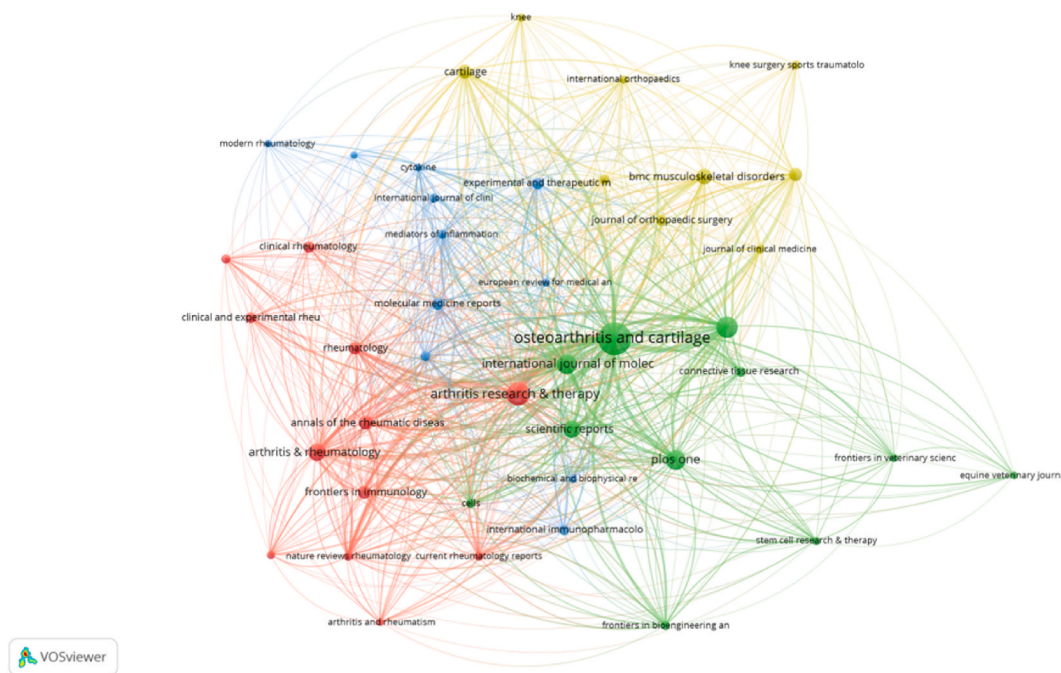
Fig. 6. Journal relationship of synovial in osteoarthritis studies from 2013 to 2022.

Table 5
Top 10 journals of synovial studies in osteoarthritis from 2013 to 2022.

Rank	Funding Agency	Counts
1	National Nature Science Foundation of China	715
2	National Institutes of health Nih USA	636
3	United States Department of health Human Servies	636
4	Nih National Institute of Arthritis Musculoskeletal skin disease niams	364
5	European Commission	264
6	Ministry of education culture sports science and technology japan mext	188
7	Versus Arthritis	145
8	Japan society for the promotion of science	144
9	Uk research innovation Ukri	138
10	Medical research Council UK Mrc	103

2019 focused on the influence of synovial in the treatment of osteoarthritis. The VOSviewer can use the frequencies of keywords to determine their density, as shown in Fig. 7C. We discovered that the density increases with color warmth (moving toward red). The area with a large gray level is typically where the research hotspot in this field were found. Using citespace for keyword outbreak analysis, we found that "human articular cartilage (n = 6.91)" had the largest keyword outbreak from 2013 to 2015, and "clinical trials" (n = 6.66) had the largest keyword outbreak from 2015 to 2019. The largest keyword outbreak in 2020–2022 was "exosome" (n = 6.66) (Fig. 7D).

3.7. Analysis of cited articles

The top 10 citation articles on synovial in osteoarthritis studies from 2013 to 2022 are shown in the table below. The number of citations for the top 10 articles ranged from 915 to 400. Berenbaum, F. had the most articles cited (n = 915); Khandpur Ritika had 756 articles cited, ranking the second; Jeon Ok Hee had 600 articles cited ranking the third. Most of the citations were located in JCR Q1, demonstrating the high influence on synovial in osteoarthritis studies (Table 6).

3.8. Analysis of co-cited literature

The co-cited literature on the influence of synovial in osteoarthritis is shown in Fig. 8. A visual network of all references is displayed in Fig. 8A, including 971 nodes and 1813 links. Cited articles are represented as nodes, and the linkages among them show how frequently the same literature is cited. The node's diameter and reference frequency are proportional. Links between nodes indicate the
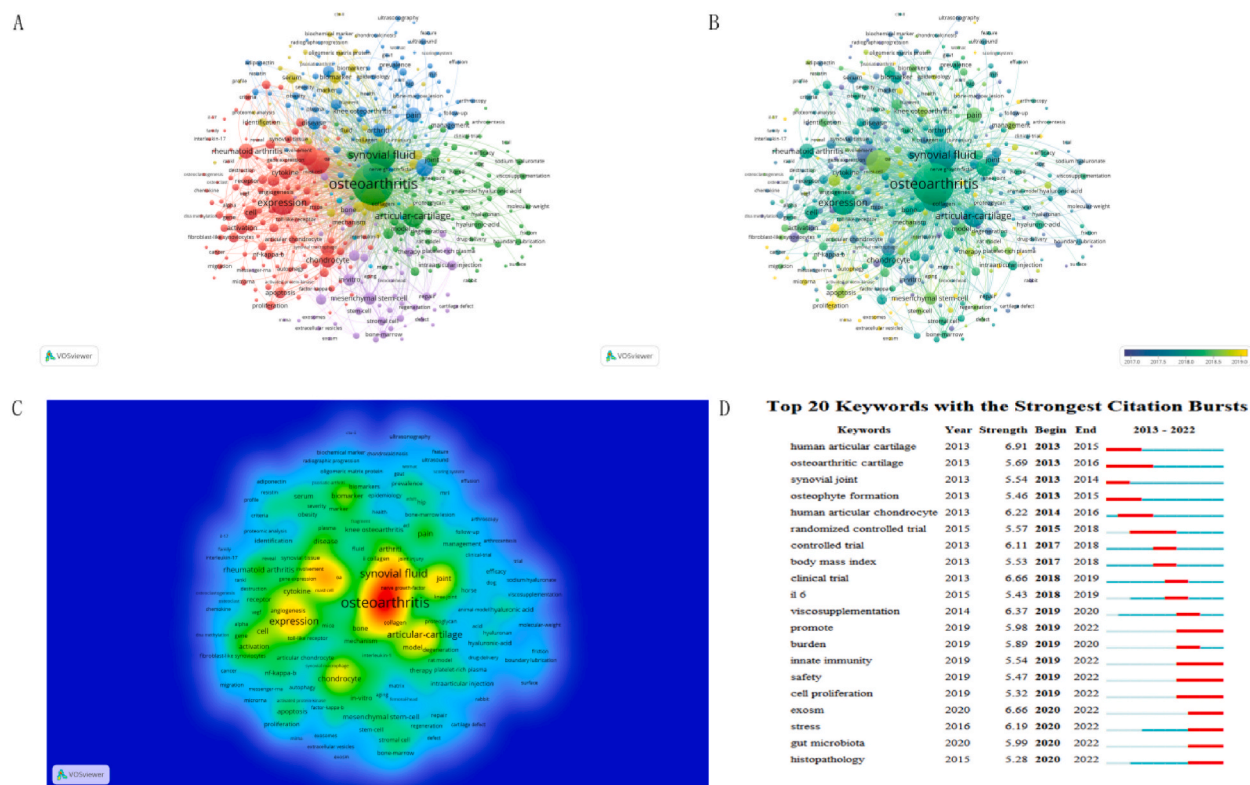
Fig. 7. Co-occurrence analysis of synovial in osteoarthritis studies from 2013 to 2022 based on WoSCC database. Fig. 7A. Mapping of key words of synovial in osteoarthritis studies. Fig. 7B. Mapping time distribution of synovial in osteoarthritis studies. Fig. 7C. According to the keyword distribution of average occurrence frequency, the red keyword represents the highest frequency. Fig. 7D. Top 20 keywords with the strongest citation bursts in synovial in osteoarthritis studies.

Table 6
Top 10 citations of synovial in osteoarthritis from 2013 to 2022.

Rank	Title	Total	First author	Year	Journal
1	Osteoarthritis as an inflammatory disease (osteoarthritis is not osteoarthrosis!)	915	Berenbaum, F.	2013	OSTEOARTHRITIS AND CARTILAGE
2	NETs Are a Source of Citrullinated Autoantigens and Stimulate Inflammatory Responses in Rheumatoid Arthritis	756	Khandpur, Ritika	2013	SCIENCE TRANSLATIONAL MEDICINE
3	Local clearance of senescent cells attenuates the development of post-traumatic osteoarthritis and creates a pro-regenerative environment	680	Jeon, Ok Hee	2017	NATURE MEDICINE
4	Low-grade inflammation as a key mediator of the pathogenesis of osteoarthritis	610	Robinson, William H.	2016	NATURE REVIEWS RHEUMATOLOGY
5	Inhibition of TGF-beta signaling in mesenchymal stem cells of subchondral bone attenuates osteoarthritis	582	Zhen, Gehua	2013	NATURE MEDICINE
6	Osteoarthritis: toward a comprehensive understanding of pathological mechanism	489	Chen, Di	2017	BONE RESEARCH
7	Defining inflammatory cell states in rheumatoid arthritis joint synovial tissues by integrating single-cell transcriptomics and mass cytometry	429	Zhang, Fan	2019	NATUREIMMUNOLOGY
8	MSC exosomes mediate cartilage repair by enhancing proliferation, attenuating apoptosis and modulating immune reactivity	416	Zhang, Shipin	2018	BIOMATERIALS
9	Damage-Associated Molecular Patterns in Inflammatory Diseases	407	Roh, Jong Seong	2018	IMMUNE NETWORK
10	Synovitis in osteoarthritis:current understanding with therapeutic implications	400	Mathiessen, Alexander	2017	ARTHRITIS RESEARCH&THERAPY

size of references to the same article. Node diameters are proportional to the total number of articles that have been cited in one publication. Nodes can be used to link the progression of a domain, and a thick purple ring indicates centrality. A burst of references is indicated by the red ringThe co-cited literature was divided into 10 clusters, which were synovial mesenchymal stem cells, toll-like receptors, serum levels, biochemical markers, articular cartilage, induced osteoarthritis, hand osteoarthritis, anterior cruciate ligament injury, exosome, and macrophage polarization (Fig. 8B). According to the timeline view of co-citation clustering, we found that

Fig. 8. A. Synovial in osteoarthritis research in recent 10 years. Fig. 8B. Cluster map of co-cited references of synovial in osteoarthritis studies in recent 10 years. Fig. 8C. Timeline of co-citations of synovial in osteoarthritis studies over the last 10 years. Fig. 8D. Top 20 literatures with the strongest citation burst of synovial in osteoarthritis research in recent 10 years.

synovial substances and their expressions have become the hotspots related to synovial osteoarthritis (Fig. 8C). Finally, we analyzed the top 20 articles on the outbreak of citations of synovial for osteoarthritis, and found that most articles were located in JCR Q1, indicating that synovial was favored by scholars in high-level journals of osteoarthritis research (Fig. 8D).
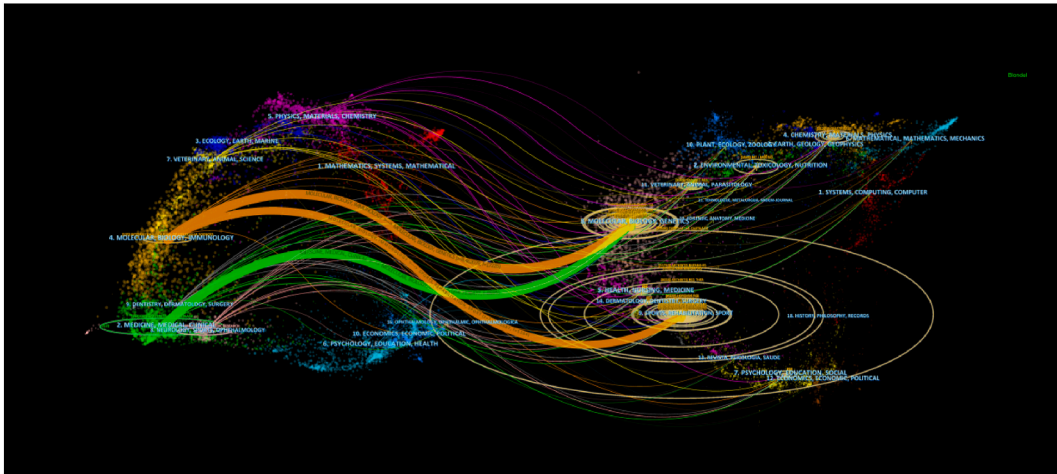
3.9. Dual map

Fig. 9 shows the synovial studies in osteoarthritis was in the dual map. The research published in journals is displayed on the left side of the dual map, while the journals in which these published studies were cited are displayed on the right side. The lines connecting them indicate the relationships between the journals' citations. The line consists of two yellow lines and one green line. The research published in medicine is represented by the green line; research published in molecular biology and immunology is represented by the yellow line; immunology articles were cited by studies published in molecular, biology, genetics, and sports, rehabilitation, sport.

4. Discussion

Osteoarthritis is the most prevalent type of arthritis and a major contributor to disability. Osteoarthritis is an age-related disease that has the highest incidence of bone and joint diseases worldwide, specifically osteoarthritis of the knee and hip, and is one of the primary causes of disability in the world [13]. It has a significant impact on individual well-being and increases the economic burden on society and individuals. Therefore, more research is needed to guide the prevention, diagnosis and treatment of OA [14–16]. Articular cartilage degeneration, marginal osteophyte formation, subchondral osteosclerosis, and synovial inflammation are pathological features of osteoarthritis. The influence of subchondral bone and cartilage on osteoarthritis was the primary focus of earlier research [17]. This paper conducted bibliometric analysis on the influence of synovial membrane on osteoarthritis.

The amount of research on the function of synovial membrane in osteoarthritis that has been published has increased over the past ten years, suggesting that synovial membrane's impact on the condition is growing. A total of 5738 articles on synovial in osteoarthritis have been published in the past 10 years. China has published the most articles, this may have something to do with population size and financial input. It is also worth noting that the majority of the top 20 active institutions carrying out this research are based in Europe and the US, which illustrates how well-equipped these countries are to carry out basic and clinical medical research due to a wealth of advanced equipment, specialized researchers, and sufficient funding. At the same time, it shows the urgent need for exploring the relationship between synovial and osteoarthritis in these countries. In most countries, the central value is less than 0.1,

Fig. 9. Synovial studies in osteoarthritis was in the dual map. The left side of the dual map shows studies published in journals and the right side shows the journals in which these published studies were cited.

demonstrating that countries are not closely linked with researchers. In terms of institutions, Duke Univ published the most articles, China Med Univ ranked second, Univ Calgary third, Univ Med Ctr Utrecht fourth and Southern Med Univ fifth. The central value of most institutions is less than 0.1, indicating that researchers are not closely connected among different institutions. In terms of Tang, Chih-Hsin published 53 articles at most.

In terms of published journals, OSTEOARTHRITIS AND CARTILAGE ranked first, ARTHRITIS RESEARCH THERAPY ranked second, JOURNAL OF ORTHOPAEDIC RESEARCH ranked third, The majority of journals published in JCR Q1 illustrate the role of synovial in osteoarthritis and are welcomed by high level journals. The majority of published journals and active institutes are based in Europe and the US, suggesting that these regions have the financial and resources means to conduct extensive research on synovial in osteoarthritis. English is the world common language, which will make it easier for research towards the world and will be highly influenced by more researchers.

Finally, dual map shows that the studies involved in synovial in osteoarthritis published in medicine, medical, clinical articles were cited by studies published in molecular, biology, genetics, the studies published in molecular biology, immunology articles were cited by studies published in molecular, biology, genetics, and sports, rehabilitation, sport. Looking at the three main paths in the journal dual map, it is clear that the study of the relationship between synovial and osteoarthritis is a multidisciplinary endeavor. In terms of institutional sponsorship, the National Natural Science Foundation gave the most, but Europe and the United States gave the most.

Regarding keyword co-occurrence, research before 2017 focused on the expression of synovial in osteoarthritis, studies from 2017 to 2019 focused on the clinical effect of synovial on osteoarthritis, and studies after 2019 focused on the role of synovial in the treatment of osteoarthritis."human articular cartilage" had the largest keyword outbreak from 2013 to 2015, and "clinical trials" had the largest keyword outbreak from 2015 to 2019. The largest keyword outbreak in 2020–2022 was "exosome". In terms of citation, Berenbaum, F. had the most articles cited. Most of the citations were located in JCR Q1, demonstrating the high influence on synovial in osteoarthritis studies. In terms of co-cited literature, it was divided into 10 clusters, which were synovial mesenchymal stem cells, toll-like receptors, serum levels, biochemical markers, articular cartilage, induced osteoarthritis, hand osteoarthritis, anterior cruciate ligament injury, exosome, and macrophage polarization. According to the time line view of co-citation clustering, we found that synovial substances and their expressions have become the hotspots related to synovial osteoarthritis. Our keyword analysis revealed the expression of synovial genes and pathways in osteoarthritis, the role of synovial membranes in osteoarthritis diagnosiss, the influence of targeted synovial membranes in the treatment of osteoarthritis, the clinical effect of synovial membranes on osteoarthritis, and the role of synovial membranes in the pathology of osteoarthritis as five distinct clusters of synovial membranes in osteoarthritis.

Regarding the expression of synovial genes and pathways in osteoarthritis, Previous studies have shown that the increase of hypoxia-inducing factor 1 alpha, STC1, S100A8,S100A9, MMP-3, BMP-6, IL-6, IL-8, CXCL5, CXCL6, CXCL16, CXCL2 and CXCL1 genes in synovium contributes to the development of osteoarthritis [18–21]. Changes in the expression level of pathways in synovial also affect the generation of osteoarthritis. For example, the activation of PI3k/Akt and NF-κB pathways can promote the generation of synovitis and induce osteoarthritis [22,23], and the activation of Wnt/β-catenin signaling pathway in synovial cells can promote the fibrosis of synovitis and thus promote the generation of osteoarthritis [24].

Regarding the role of synovial markers in the osteoarthritis diagnosis, many products are released through synovial membrane into synovial fluid and serum as synovial membrane. First, in a clinical study of OA patients with synovitis, it was found that excessive expression of matrix metalloproteinases promoted the cleavage of type I and III collagen into C1M and C3M collagenous degradation fragments in synovial cells and their release into human serum and synovial fluid [24]. The same study also indicated that increased C1M and C3M levels in vivo could be used as a reference index for OA joint synovial inflammation [25]. Secondly, the infiltration of macrophages and other inflammatory cells in synovium can promote the production of vascular endothelial growth factor and thus develop into OA [26]. Clinical studies in patients with osteoarthritis suggested that high expression of vascular endothelial growth

factor promoted the development of osteoarthritis. Thirdly, elevated leptin expression in individuals with metabolic syndrome could enhance the interaction between chondrocytes and synovial fibroblasts, which may indirectly trigger the release of IL-6 by synovial fibroblasts in an IL-6-dependent manner [27]. The high expression of IL-6 has been confirmed in clinical studies as a basis for the diagnosis of osteoarthritis [28]. Similarly, high mobility group protein B1 is highly expressed in OA synovial cells, and promotes the high expression of inflammatory factors such as NF-kb and IL-6, which are released into human serum and synovial fluid to promote OA [29]. Lubricin is a glycoprotein secreted by synovial fibroblasts and found in synovial membrane and synovial fluid. It protects cartilage cells by reducing friction in the joints. Researchers found that reduced expression was associated with the development of osteoarthritis[30]. Finally, human cartilage glycoprotein-39 can be secreted by synovial cells and may be released in synovial fluid and serum leading to OA production [31].

The following are synovial's clinical effects on osteoarthritis: First, clinical research has shown a correlation between knee pain and synovitis in individuals with osteoarthritis of the hip and knee [32]. Researchers have looked into the connection between specific joint pathology identified by MRI in patients with osteoarthritis (OA) and knee pain. They made note of the connection between knee pain and synovitis. Also MRI showed the severity of the synovial, the increasing pain of hip OA. Therefore, contrast enhanced-MRI has shown that peri-patellar region are correlated with the severity of the knee pain. Secondly, clinical studies have also confirmed that synovial inflammation is associated with knee dysfunction [33]. The patient with knee OA showed the functional impairment and disability. Finally, synovitis is associated with cartilage loss that promotes osteoarthritis [34]. Researchers have shown that synovitis will predict the loss of cartilage in next 3 months, another researchers proved that the inflammation of synovial may predict cartilage defect in over next 3 years.

The therapeutic effect of targeted synovial on osteoarthritis can be reflected in the following four aspects. First, synovial mesenchymal stem cells can treat osteoarthritis. Synovial mesenchymal stem cells can be used as a source of chondrocytes for cartilage repair because they possess the trilineage potential to differentiate into fat, bone, or cartilage cells, as demonstrated by numerous studies. It has since been determined that SF-MSC transplantation to the afflicted joints, to restore the degraded chondrocytes and encourage regeneration, is a feasible cell therapy for OA. Exosomes derived from human synovial mesenchymal stem cells reduced the inflammatory process and apoptosis, degeneration, and degradation in chondrocytes caused by IL-1β. Exosomes secreted by synovial mesenchymal stem cells can effectively treat osteoarthritis by inhibiting synovitis [35]. *In vitro*, MSCs stimulated anti-inflammatory M2 polarization and prevented the activation of pro-inflammatory M1 macrophages. MSCs are linked to converting TNF-a and IL-1 inflammatory cytokines into immunosuppressive IL-10 production by macrophages, reducing joint inflammation and encouraging cartilage regeneration. Secondly, synovial M2-type macrophages have a therapeutic effect on osteoarthritis by inhibiting synovitis [36]. M2 macrophages participate significantly in tissue repair. The switch to M2 macrophages in the lesion may help heal the injured articular cartilage to treat OA. A type 1 to type 2 immune response, linked to M2 macrophages and the presence of IL-4 and IL-10 cytokines, may occur in the synovial microenvironment due to moderate physical activity, according to available data. Patients with OA may benefit from a protective environment in their joints thanks to these changes. It has been demonstrated that M2 macrophages aid in collagen turnover to maintain extracellular matrix homeostasis. Additionally, it has been demonstrated that M2 macrophages maintain extracellular matrix homeostasis by promoting collagen turnover. Furthermore, platelet-rich plasma has been shown to reduce synovitis thickness and treat osteoarthritis with synovitis [37]. Platelet-rich plasma can effectively improve pain and function and reduce adverse reactions. It has been documented that type B synoviocytes produce substantially high levels of hyaluronic acid following the addition of PRP during knee arthroplasty for osteoarthritis. Additionally, PRP stimulates synoviocytes to produce hepatocyte growth factor, which is known to reduce inflammation within the synovial membrane. Finally, many drugs can be used to treat osteoarthritis by targeting synovium, such as chondroitin sulfate, hyaluronic acid, baicalin, pirfenidone [38]. They can lower the inflammation cytokines in synovial fluid and decrease the inflammation of synovial in OA patients.

Regarding the role of synovial in osteoarthritis pathology, previous studies have pointed out that the aggregation of inflammatory cells and the expression of inflammatory mediators in synovium are important factors in the pathogenesis of osteoarthritis, and chronic inflammation of synovium can promote the generation and progression of osteoarthritis [39]. Synovial endothelial cell proliferation, moderate inflammatory cell infiltration and neovascularization were observed in patients with osteoarthritis, and the proliferative thickness of synovial tissue was significantly correlated with the degree of inflammatory cell infiltration [6].

5. Strength and defect

This study is the first to comprehensively, objectively and intuitively analyze the literature related to the influence of synovial on osteoarthritis and its development trend, which can offer a thorough reference for scholars working on this topic. Furthermore, we examine various facets of research hotspots using a range of bibliometric software, which enabled us to produce more precise and impartial results. The study inevitably has certain shortcomings. First, this study may not have covered all relevant literature., and other databases were not explored as the WoSCC database is a reliable, extensive, and varied database. Additionally, the study only included original research and reviews, and the language was limited to English to facilitate the interpretation of the results. This may have decreased the number of publications retrieved and led to some being missed. Another drawback of this study is that the bibliometric software was unable to differentiate between manuscripts using human and animal models. Lastly, there is a chance that some of the data's authors share the same name, and that some hold honorary positions or part-time jobs at various universities. Nevertheless, we think that this study effectively captures the present situation and overall direction of this field's research. This work provides a foundation for orthopaedic surgeons and related researchers to promptly identify areas of interest and new research directions in the impact of synovial on osteoarthritis.

Data availability statement

The original citation data used in this article were downloaded from Web of Science, an open public database at https://www.webofscience.com/.

CRediT authorship contribution statement

Guangtao Han: Conceptualization, Data curation, Project administration, Resources, Software. **Lijun Cai:** Data curation, Formal analysis. **Bohua Li:** Investigation. **Qianhao Li:** Formal analysis. **Yue luo:** Software, Supervision, Validation, Writing – original draft. **Qiuru Wang:** Writing – original draft, Writing – review & editing. **Pengde Kang:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

References

[1] B. Abramoff, F.E. Caldera, Osteoarthritis: pathology, diagnosis, and treatment options, Med. Clin. 104 (2) (2020) 293–311.

[2] J Wang, Y Sun, J Liu, B Yang, T Wang, Z Zhang, X Jiang, Y Guo, Y Zhang, Roles of long non-coding RNA in osteoarthritis (Review), Int J Mol Med 48 (1) (2021 Jul) 133.

[3] A. Bernetti, F. Agostini, F. Alviti, N. Giordan, F. Martella, V. Santilli, M. Paoloni, M. Mangone, New viscoelastic hydrogel hymovis MO.RE. Single intra-articular injection for the treatment of knee osteoarthritis in sportsmen: safety and efficacy study results, Front. Pharmacol. 12 (2021) 673988.

[4] C.R. Scanzello, S.R. Goldring, The role of synovitis in osteoarthritis pathogenesis, Bone 51 (2) (2012) 249–257.

[5] E. Charlier, C. Deroyer, F. Ciregia, et al., Chondrocyte dedifferentiation and osteoarthritis (OA), Biochem. Pharmacol. 165 (2019) 49–65.

[6] C.T. Appleton, What's pain (sensitization) got to do with it? Microgliosis may be a treatment target in osteoarthritis-related pain sensitization, Osteoarthritis Cartilage 25 (2017) 613–615.

[7] F.W. Roemer, M. Kassim Javaid, A. Guermazi, et al., Anatomical distribution of synovitis in knee osteoarthritis and its association with joint effusion assessed on non-enhanced and contrast-enhanced MRI, Osteoarthritis Cartilage 18 (2010) 1269–1274.

[8] T. Hügle, J. Geurts, What drives osteoarthritis?-synovial versus subchondral bone pathology, Rheumatology 56 (2017) 1461–1471.

[9] G.M. Khalil, C.A. Gotway Crawford, A bibliometric analysis of U.S.-based research on the behavioral risk factor surveillance system, Am. J. Prev. Med. 48 (2015) 50–57.

[10] F. Zhou, T. Zhang, Y. Jin, et al., Worldwide tinnitus research: a bibliometric analysis of the published literature between 2001 and 2020, Front. Neurol. 13 (2022) 828299.

[11] F. Zhou, B. Yu, J. Luo, et al., Global trends in the research on benign paroxysmal positional vertigo: a 20-year bibliometric and visualization analysis, Front. Neurol. 13 (2022) 1046257.

[12] F. Zhou, T. Zhang, Y. Jin, et al., Emerging trends and research foci in allergic rhinitis immunotherapy from 2002 to 2021: a bibliometric and visualized study, Am J Transl Res 14 (2022) 4457–4476.

[13] C.H. Chou, V. Jain, J. Gibson, et al., Synovial cell cross-talk with cartilage plays a major role in the pathogenesis of osteoarthritis, Sci. Rep. 10 (2020) 10868.

[14] M.H.M. Yunus, A. Nordin, H. Kamal, Pathophysiological perspective of osteoarthritis, Medicina (Kaunas) 56 (2020) 614.

[15] M. Geyer, C. Schönfeld, Novel insights into the pathogenesis of osteoarthritis, Curr. Rheumatol. Rev. 14 (2018) 98–107.

[16] T.M. Griffin, Scanzello, CR Innate inflammation and synovial macrophages in osteoarthritis pathophysiology, Clin. Exp. Rheumatol. 37 (2019) 57–63.

[17] Y.A. Rim, Y. Nam, J.H. Ju, The role of chondrocyte hypertrophy and senescence in osteoarthritis initiation and progression, Int. J. Mol. Sci. 21 (2020) 2358.

[18] L. Zhang, L. Zhang, Z. Huang, Increased HIF-1α in knee osteoarthritis aggravate synovial fibrosis via fibroblast-like synoviocyte pyroptosis, Oxid. Med. Cell. Longev. 2019 (2019) 6326517.

[19] P.L. van Lent, A.B. Blom, R.F. Schelbergen, Active involvement of alarmins S100A8 and S100A9 in the regulation of synovial activation and joint destruction during mouse and human osteoarthritis, Arthritis Rheum. 64 (2012) 1466–1476.

[20] J. Chwastek, M. Kędziora, M. Borczyk, M. Korostyński, K. Starowicz, Inflammation-driven secretion potential is upregulated in osteoarthritic fibroblast-like synoviocytes, Int. J. Mol. Sci. 23 (2022) 11817.

[21] A. Scharstuhl, E.L. Vitters, P.M. van der Kraan, W.B. van den Berg, Reduction of osteophyte formation and synovial thickening by adenoviral overexpression of transforming growth factor beta/bone morphogenetic protein inhibitors during experimental osteoarthritis, Arthritis Rheum. 48 (2003) 3442–3451.

[22] S. Liu, C. Cao, Y. Zhang, et al., PI3K/Akt inhibitor partly decreases TNF-α-induced activation of fibroblast-like synoviocytes in osteoarthritis, J. Orthop. Surg. Res. 14 (2019) 425.

[23] P. Lepetsos, K.A. Papavassiliou, A.G. Papavassiliou, Redox and NF-κB signaling in osteoarthritis, Free Radic. Biol. Med. 132 (2019) 90–100.

[24] B. Liao, M. Guan, Q. Tan, et al., Low-intensity pulsed ultrasound inhibits fibroblast-like synoviocyte proliferation and reduces synovial fibrosis by regulating Wnt/β-catenin signaling, J Orthop Translat 30 (2021) 41–50.

[25] A.S. Siebuhr, K.K. Petersen, L. Arendt-Nielsen, et al., Identification and characterisation of osteoarthritis patients with inflammation derived tissue turnover, Osteoarthritis Cartilage 22 (2014) 44–50.

[26] J.Y. Ko, M.S. Lee, W.S. Lian, et al., MicroRNA-29a counteracts synovitis in knee osteoarthritis pathogenesis by targeting VEGF, Sci. Rep. 7 (1) (2017) 3584.

[27] M. Yan, J. Zhang, H. Yang, Y. Sun, The role of leptin in osteoarthritis, Medicine (Baltim.) 97 (14) (2018) e0257.

[28] M.J. Pearson, D. Herndler-Brandstetter, M.A. Tariq, et al., IL-6 secretion in osteoarthritis patients is mediated by chondrocyte-synovial fibroblast cross-talk and is enhanced by obesity, Sci. Rep. 7 (2017) 3451.

[29] X. Ke, G. Jin, Y. Yang, et al., Synovial fluid HMGB-1 levels are associated with osteoarthritis severity, Clin. Lab. 61 (2015) 809–818.

[30] S. Huang, K.A. Thomsson, C. Jin, et al., Truncated lubricin glycans in osteoarthritis stimulate the synoviocyte secretion of VEGFA, IL-8, and MIP-1α: interplay between O-linked glycosylation and inflammatory cytokines, Front. Mol. Biosci. 9 (2022) 942406.

[31] S. Zivanović, L.P. Rackov, D. Vojvodić, D. Vucetić, Human cartilage glycoprotein 39–biomarker of joint damage in knee osteoarthritis, Int. Orthop. 33 (2009) 1165–1170.

[32] X. Wang, D.J. Hunter, X. Jin, C. Ding, The importance of synovial inflammation in osteoarthritis: current evidence from imaging assessments and clinical trials, Osteoarthritis Cartilage 26 (2018) 165–174.

[33] M. Sowers, C.A. Karvonen-Gutierrez, J.A. Jacobson, Y. Jiang, M. Yosef, Associations of anatomical measures from MRI with radiographically defined knee osteoarthritis score, pain, and physical functioning, J Bone Joint Surg Am 93 (2011) 241–251.

[34] F.W. Roemer, A. Guermazi, D.T. Felson, et al., Presence of MRI-detected joint effusion and synovitis increases the risk of cartilage loss in knees without osteoarthritis at 30-month follow-up: the MOST study, Ann. Rheum. Dis. 70 (2011) 1804–1809.

[35] J. Zhang, Y. Rong, C. Luo, W. Cui, Bone marrow mesenchymal stem cell-derived exosomes prevent osteoarthritis by regulating synovial macrophage polarization, Aging (Albany NY) 12 (2020) 25138–25152.

[36] H. Zhang, D. Cai, X. Bai, Macrophages regulate the progression of osteoarthritis, Osteoarthritis Cartilage 28 (2020) 555–561.

[37] J.D. Tucker, L.L. Goetz, M.B. Duncan, et al., Randomized, placebo-controlled analysis of the knee synovial environment following platelet-rich plasma treatment for knee osteoarthritis, Pharm. Manag. PM R 3 (2021) 707–719.

[38] C.H. Lee, C.F. Chiang, F.C. Kuo, et al., High-molecular-weight hyaluronic acid inhibits IL-1β-induced synovial inflammation and macrophage polarization through the GRP78-NF-κb signaling pathway, Int. J. Mol. Sci. 22 (2021) 11917.

[39] J. Shen, Y. Abu-Amer, R.J. O'Keefe, A. McAlinden, Inflammation and epigenetic regulation in osteoarthritis, Connect. Tissue Res. 58 (2017) 49–63.