Review article

Bibliometric and visual analysis of research on analgesia and total knee arthroplasty from 1990 to 2022

Dongping Wan [a,b], Rui Wang [b], Jie Wei [c], Qiang Zan [b], Lei Shang [d], Jianbing Ma [a], Shuxin Yao [a,**], Chao Xu [a,d,*]

[a] *Department of Knee Joint Surgery, Honghui Hospital, Xi'an Jiaotong University, Xi'an, Shaanxi Province, China*
[b] *The First Clinical Medical College, Shaanxi University of Chinese Medicine, Xianyang, China*
[c] *State Key Laboratory of Cancer Biology, Department of Pathology, The First Affiliated Hospital of Air Force Military Medical University, Xi'an, China*
[d] *Department of Health Statistics, Faculty of Preventive Medicine, The Air Force Military Medical University, Xi'an, China*

A R T I C L E   I N F O

A B S T R A C T

Background: In recent decades, there have been notable advancements in the field of analgesia and total knee arthroplasty (TKA). This study aims to employ bibliometric analysis to elucidate the prevailing research focal points and trends within analgesia and TKA from 1990 to 2022.
Material and methods: Relevant publications were retrieved from the Web of Science Core Collection. CiteSpace, VOSviewer, and Scimago Graphica were used for visualization and bibliometric analysis of countries, institutions, authors, journals, references, and keywords.
Results: A total of 2776 publications on analgesia and TKA were identified, with the United States having the highest number of publications. The University of Copenhagen was the most productive institution, and Kehlet, Henrik was the most prolific author. The Journal of Arthroplasty had the most publications and citations. The most common keywords were "TKA," "pain management," "postoperative pain," "Total hip arthroplasty (THA)," and "postoperative management." Keyword burst detection demonstrated that adductor canal block (ACB) was a recent research hotspot.
Conclusion: Our study revealed a sharp increase in global publications on analgesia and TKA, and this trend is expected to continue. Further research is necessary to determine the optimal regimen for multimodal analgesia, the ideal location and volume of ACB, and their clinical significance.

1. Introduction

Total knee arthroplasty (TKA) stands as a remarkably successful orthopedic procedure, providing effective relief for degenerative knee arthropathy, thereby enhancing patients' quality of life and activity levels [1]. As the global population continues to expand and age, there's a projected 40 % increase in the number of osteoarthritis diagnoses expected by 2035 [2]. Furthermore, it is estimated that by 2050, the United States will witness a substantial volume of Total knee replacement (TKR) procedures, potentially reaching 1,037, 474 cases [3]. Despite its impressive success rate, TKA is accompanied by a reported patient dissatisfaction rate as high as 20 % [4].

* Corresponding author. Department of Knee Joint Surgery, Honghui Hospital, Xi'an Jiaotong University, Xi'an, Shaanxi Province, China.
** Corresponding author.
 E-mail addresses: yaoshuxinHHH@126.com (S. Yao), 383697196@qq.com (C. Xu).

Inadequate pain management often plays a significant role in this, with moderate to severe pain affecting approximately 58 % of cases [5–7]. Recent years have seen extensive research into pain management techniques for TKA. A high-quality pain management model can expedite early recovery, shorten hospital stays, decrease potential postoperative complications, and enhance patients' quality of life and satisfaction [8]. The American Society of Anesthesiologists endorsed multimodal pain management in 2012 to maximize analgesia while minimizing potential adverse effects and opioid consumption [9]. Nevertheless, the optimal combination of analgesic interventions remains to be fully elucidated [10]. As a result, pain management in TKA continues to present a significant challenge for clinicians.

Unlike traditional reviews and meta-analyses, bibliometrics not only unveil research trends and performance relationships but also pinpoint research hotspots within specific domains [11]. In recent times, the utilization of bibliometrics has gained traction within the medical field. However, to the best of our knowledge, no prior study has presented a bibliometric analysis of analgesia and total knee arthroplasty (TKA). Thus, our objective is to conduct a bibliometric analysis encompassing research on analgesia and TKA spanning from 1990 to 2022. We aim to recognize prominent contributors and collaborative networks, evaluate influential journals, and discern prevailing research trends and potential hotspots within this evolving field.

2. Material and methods

2.1. Search strategy

The search strategy is depicted in Fig. 1. In this study, we conducted a comprehensive search for relevant publications within the Web of Science Core Collection (WoSCC) database. The search formula used was as follows: TS = ("analgesia" OR "pain management" OR "pain relief" OR "sequential analgesic analgesia" OR "surgical analgesia" OR "pain control") AND ("Total knee replacement" OR "total knee arthroplasty" OR "total knee joint arthroplasty" OR "total knee joint replacement" OR TKA OR TKR) AND Document types: (article OR review) AND Languages: (English), covering the timespan from 1990 to 2022. To ensure accuracy and to prevent potential database updates, this search was concluded on March 29, 2023.

2.2. Data analysis

The following software tools were employed for bibliometric analysis and visualization: Vosviewer 1.6.18, CiteSpace 6.1.R2, Scimago Graphica 1.0.18. Vosviewer was used to construct collaborative networks among countries, institutions, and the co-occurrence of keywords. CiteSpace was employed for analyzing dual-map overlays of journals, keyword timelines, reference bursts, and keyword bursts. Scimago Graphica was utilized for generating geographical visualizations. WPS Office 2021 was employed for the analysis of annual publications and citations. The H-index, impact factor (IF), and category quartiles were sourced from the 2021 Journal Citation Reports.
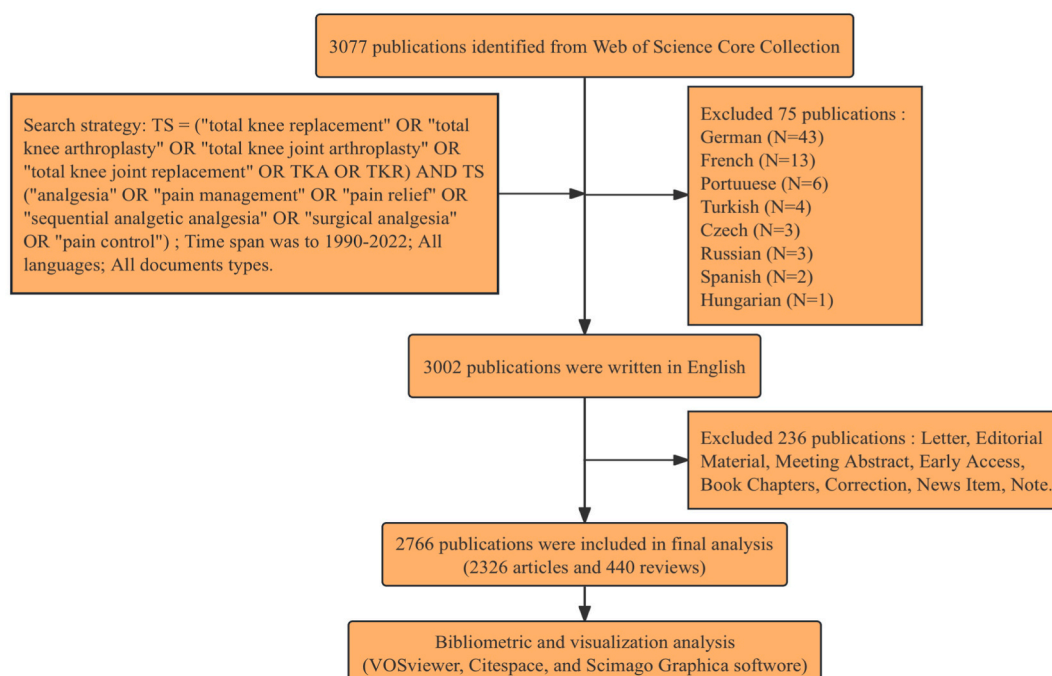

Fig. 1. Literature search process.

3. Results

3.1. Literature development trends

Based on data from WoSCC, a total of 2766 publications related to analgesia and TKA were identified between 1990 and 2022. Among these, 2326 (84.09 %) were articles, and 440 (15.91 %) were reviews. Fig. 2 illustrates that the earliest relevant publication emerged in 1990, with only one publication that year. The total number of annual publications remained below 10 from 1990 to 1995. However, the number of relevant literature publications consistently increased from 2001 onwards. The yearly publication count has remained above 20, with 2021 being the most productive year, yielding 287 publications. Furthermore, citations have steadily increased each year, reaching a peak of 10,385 citations in 2021.

3.2. Countries and institutions analysis

A total of 66 countries and 2828 institutions have contributed to the relevant literature, and their specific geographic distribution and partnerships are presented in Fig. 3A and B. Table 1 and Fig. 3C display the top 10 countries with the highest number of relevant publications, led by the United States (n = 1,078, 35.38 %), followed by China (n = 414, 25.58 %), and Canada (n = 178, 7.59 %). In terms of average citation rates, Canada, Denmark, and the United States top the list, while the countries with the highest H-index are the United States, Canada, and Denmark. Interestingly, despite China ranking second in the number of publications, its average citation rate is comparatively lower, possibly due to the recent concentration of Chinese publications. Additionally, the National Cooperative Network (Fig. 3B) highlights that the United States has the most active collaborative relationships with China, Canada, the United Kingdom, and Denmark. Notably, publications from European and American countries tend to be older on average, while those from China, Australia, India, and Thailand are more recent. This establishes the United States as a dominant presence in the field of analgesia and TKA.

Table 2 presents the top ten institutions based on the number of academic outputs in this field. The University of Copenhagen boasts the highest number of publications (106 publications), followed by the University of Toronto (79 publications) and the University of California system (76 publications). When considering average citation rates, Harvard University, Rigshospitalet, and the University of California system lead the list, while the University of Copenhagen, Rigshospitalet, and the University of Toronto top the H-index rankings. Fig. 4 visually represents these institutions and reveals that partnerships are primarily established between organizations within the same country. Consequently, the Hospital for Special Surgery, University of Toronto, Sichuan University, and University of Copenhagen represent the most cooperative institutions in the United States, Canada, China, and Denmark, respectively.

3.3. Authors analysis

A total of 11,550 authors were identified as contributors to relevant literature, and the top 10 most prolific authors are listed in Table 3. Henrik Kehlet, affiliated with the University of Copenhagen, leads the list with the highest number of publications, totaling 56, followed by Brian M. Ilfeld from the University of California system, with 36 publications, and Edward R. Mariano from Stanford University, with 31 publications. When it comes to citations, the top three authors are Henrik Kehlet, with 3426 citations, Brian M. Ilfeld, with 2028 citations, and Henrik Husted, with 1993 citations. The top three authors with the highest average citation rates are Billy B. Kristensen, at 77.94, Henrik Husted, at 66.43, and Jorgen B. Dahl, at 64.54. In terms of the H-index, the leading authors are
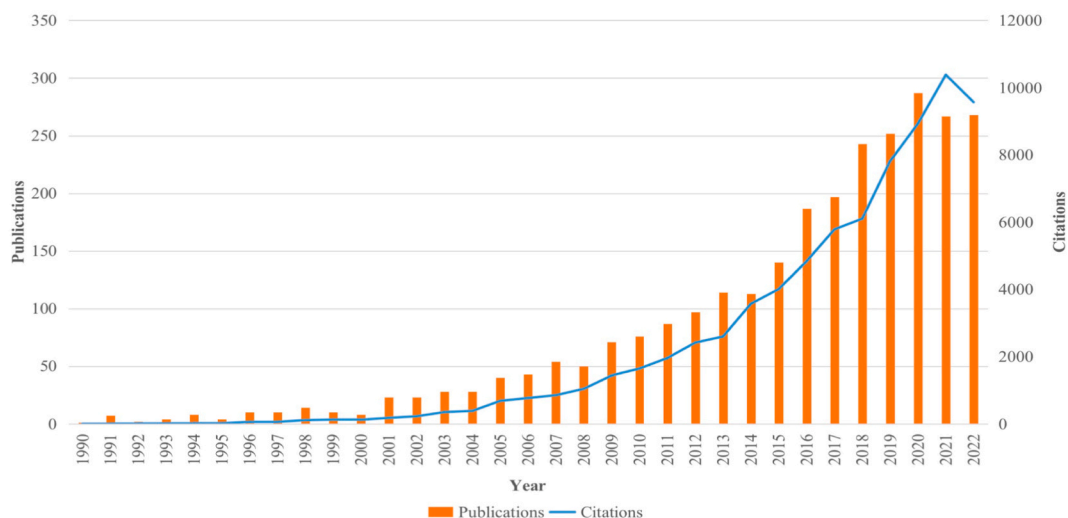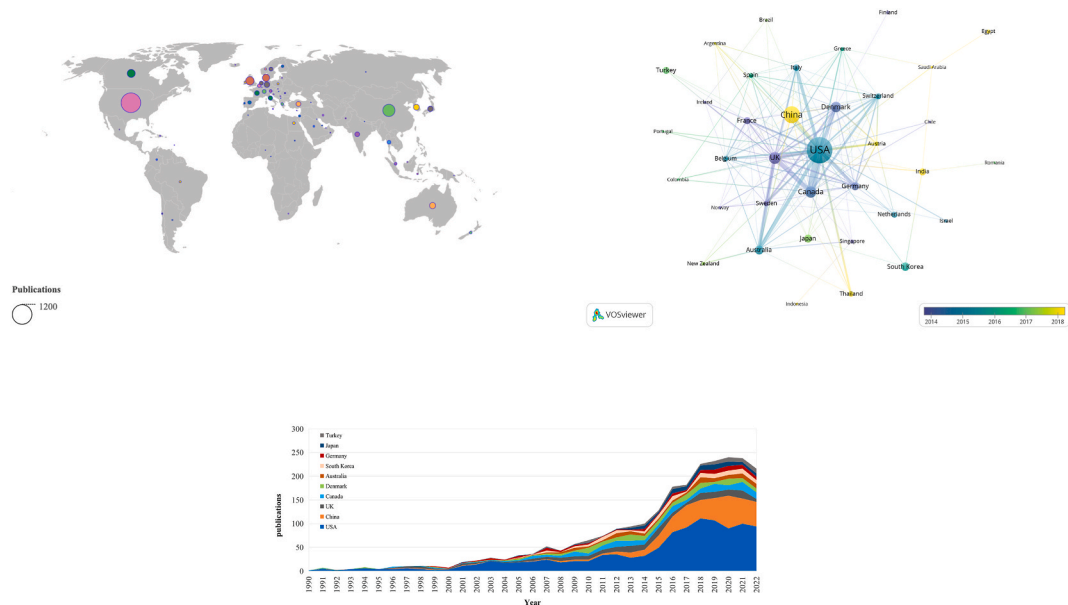

Fig. 2. The annual number of publications and citations on analgesia in total knee arthroplasty between 1990 and 2022.

Fig. 3. Co-authorship analysis of countries on analgesia in TKA. (A) Geographic distribution map displaying the global distribution of analgesia in TKA. The size of the concentric circle represented the number of articles published by each country. (B) Cooperation networks across countries. The size of the concentric circle represented the number of articles published by each country and the thickness of the connecting lines indicated the degree of cooperation between countries. The circle has color shadows representing different average publication years. Yellow circles indicate that the average publication time is later than blue circles. (C) The top 10 prolific countries.

Table 1
The top ten countries with the highest productivity.

Rank	Country	Publications	Citations	Average Citations	HI
1	USA	1078	35306	32.75	89
2	China	414	5438	13.14	34
3	UK	197	7586	38.51	48
4	Canada	178	9853	55.35	51
5	Denmark	142	7685	54.12	51
6	Australia	106	3438	32.43	30
7	South Korea	97	1559	16.07	23
8	Germany	88	2494	28.34	25
9	Japan	81	1135	14.01	20
10	Turkey	66	469	7.11	13

Table 2
The top ten institutions with the highest productivity.

Rank	Institutions	Publications	Citations	Average Citations	HI
1	University of Copenhagen (Denmark)	106	5872	55.4	47
2	University of Toronto (Canada)	79	3871	49	34
3	University of California System (USA)	76	4235	55.72	31
4	Rigshospitalet (Denmark)	69	4350	63.04	38
5	Hospital for Special Surgery (USA)	64	2571	40.17	27
6	Harvard University (USA)	62	4577	73.82	23
7	Mayo Clinic (USA)	62	2046	33	28
8	Sichuan University (China)	54	572	10.59	13
9	Jefferson University (USA)	52	2768	53.23	18
10	US Department of Veterans Affairs (USA)	52	2632	50.62	21

Henrik Kehlet, with an H-index of 34, followed by Brian M. Ilfeld, with an H-index of 25, and Henrik Husted, with an H-index of 20. It's worth noting that Henrik Kehlet has the highest number of publications, citations, and H-index, indicating that his research has garnered significant recognition among fellow scholars. Additionally, according to the collaborative network of authors depicted in Fig. 5, Henrik Kehlet had the closest research collaboration with Henrik Husted.
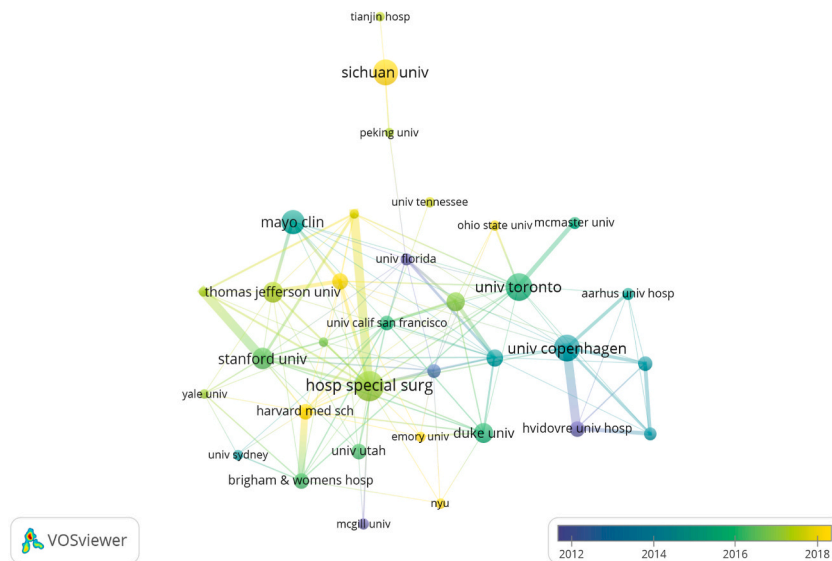
Fig. 4. Visualization of institutions analysis. Cooperation networks across institutions. The size of the concentric circle represented the number of articles published by each institution and the thickness of the connecting lines indicated the degree of cooperation between institutions. The circle has color shadows representing different average publication years. Yellow circles indicate that the average publication time is later than blue circles.

Table 3
The top ten authors with the highest productivity.

Rank	Authors	Institutions	Publications	Citations	Average Citations	HI
1	Kehlet, Henrik	University of Copenhagen	56	3426	61.18	34
2	Ilfeld, Brian M.	University of California System	36	2028	56.33	25
		University of California San Diego				
3	Mariano, Edward R.	Stanford University	31	977	31.52	17
4	Husted, H.	University of Copenhagen	30	1993	66.43	20
5	Mont, Michael a.	Sinai Hospital of Baltimore	27	764	28.3	14
6	Dahl, Jorgen B.	University of Copenhagen	24	1549	64.54	19
7	Mathiesen, Ole	University of Copenhagen	22	1241	56.41	14
8	Della Valle, Craig J.	Rush University	21	944	44.95	12
9	Brull, Richard	University of Toronto	20	916	45.8	17
10	Kristensen, Billy B.	University of Copenhagen	18	1403	77.94	16

3.4. Journals analysis

A total of 459 journals published relevant literature on this topic. The top ten journals accounted for 975 publications, with the Journal of Arthroplasty being the most prolific, with 308 publications. It was followed by Regional Anesthesia and Pain Medicine with 109 publications, and Anesthesia and Analgesia with 99 publications (Table 4). Among the top three most cited journals were the Journal of Arthroplasty with 9327 citations, followed by Anesthesia and Analgesia with 6973 citations, and Clinical Orthopaedics and Related Research with 5646 citations. Seven of the top ten journals belonged to Q1 (highest quality) categories. The top three journals for impact factors were the British Journal of Anesthesia (IF = 11.719), Anesthesia and Analgesia (IF = 6.627), and Journal of Bone and Joint Surgery American Volume (IF = 6.558). The dual map of this journal showed the two main citation paths (Fig. 6). It is worth noting that publications from medicine/medical/clinical journals were mainly cited by rehabilitation/sports journals in the context of analgesia and TKA research.

3.5. Top references analysis

Fig. 7 displays the top 25 references with the most pronounced citation bursts, consisting of 24 articles and 1 review. The majority of these references witnessed citation bursts before 2018, with the initial burst occurring in 2000 and the most recent in 2020. Notably, none of these references have maintained sustained influence for more than five years after their citation burst. Only one reference, published in 2018, remains highly influential as of 2022. Among the top 25 references, Acta Orthopaedica has the highest number of publications (5), followed by Anesthesiology (4) and Journal of Arthroplasty (4). The article titled 'Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery: a case study of 325 patients [12],' published in
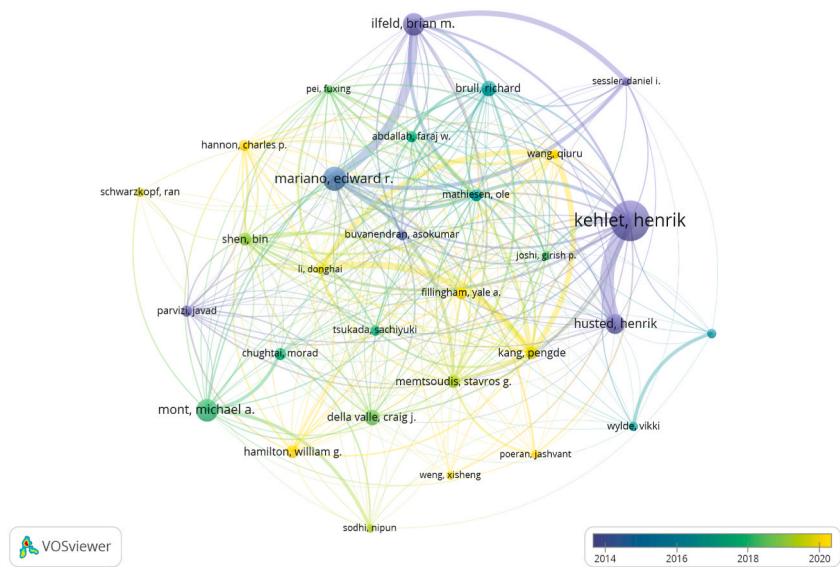
Fig. 5. Visualization of authors analysis. Cooperation networks across authors. The size of the concentric circle represented the number of articles published by each author and the thickness of the connecting lines indicated the degree of cooperation between authors. The circle has color shadows representing different average publication years. Yellow circles indicate that the average publication time is later than blue circles.

Table 4
The top ten journal with the highest productivity.

Rank	Journal	Publications	Citations	IF (2021)	JCR (2021)
1	Journal of Arthroplasty	308	9327	4.435	Q1
2	Regional Anesthesia and Pain Medicine	109	4287	5.564	Q1
3	Anesthesia and Analgesia	99	6973	6.627	Q1
4	Medicine	87	1082	1.817	Q3
5	Clinical Orthopaedics and Related Research	85	5646	4.837	Q1
6	Journal of Knee Surgery	62	536	2.501	Q2
7	Journal of Bone and Joint Surgery-American Volume	60	4200	6.558	Q1
8	Knee Surgery Sports Traumatology Arthroscopy	59	1685	4.114	Q1
9	British Journal of Anesthesia	54	3239	11.719	Q1
10	Knee	52	1225	2.423	Q3

IF Impact Factor, JCR Journal Citation Reports.
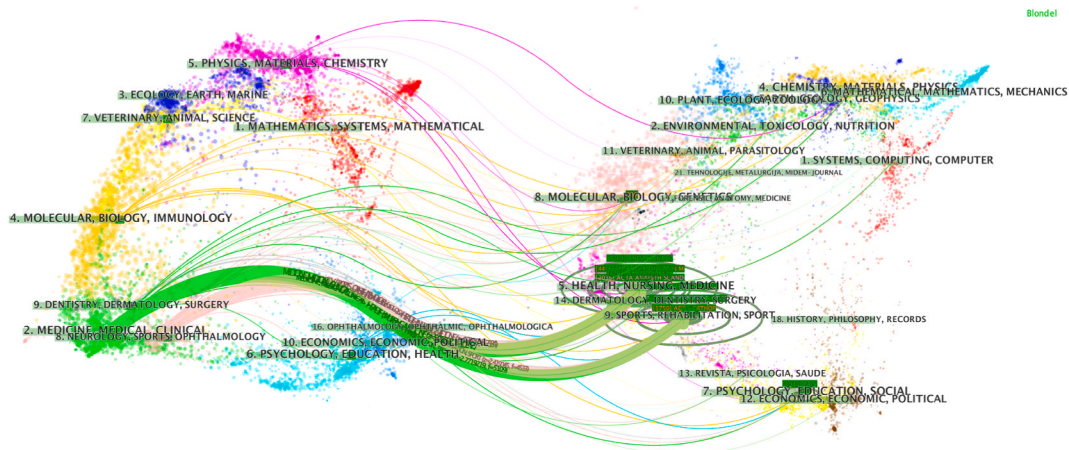
Fig. 6. A dual-map overlay of journals related to research on analgesia in TKA. The citing journals are on the left, the cited journals are on the right, and color paths indicate citation relationships.

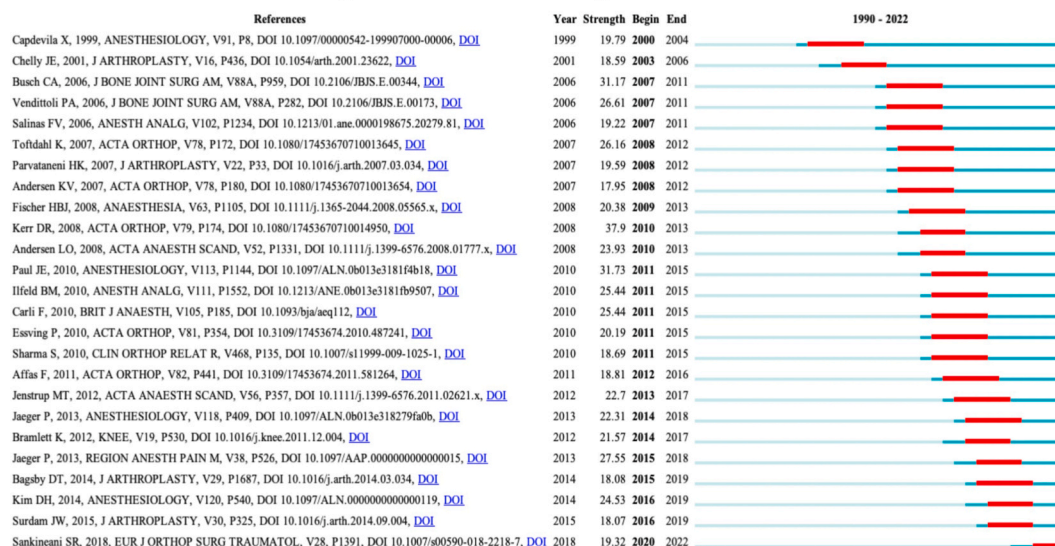## Top 25 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	1990 - 2022
Capdevila X, 1999, ANESTHESIOLOGY, V91, P8, DOI 10.1097/00000542-199907000-00006, DOI	1999	19.79	2000	2004	
Chelly JE, 2001, J ARTHROPLASTY, V16, P436, DOI 10.1054/arth.2001.23622, DOI	2001	18.59	2003	2006	
Busch CA, 2006, J BONE JOINT SURG AM, V88A, P959, DOI 10.2106/JBJS.E.00344, DOI	2006	31.17	2007	2011	
Vendittoli PA, 2006, J BONE JOINT SURG AM, V88A, P282, DOI 10.2106/JBJS.E.00173, DOI	2006	26.61	2007	2011	
Salinas FV, 2006, ANESTH ANALG, V102, P1234, DOI 10.1213/01.ane.0000198675.20279.81, DOI	2006	19.22	2007	2011	
Toftdahl K, 2007, ACTA ORTHOP, V78, P172, DOI 10.1080/17453670710013645, DOI	2007	26.16	2008	2012	
Parvataneni HK, 2007, J ARTHROPLASTY, V22, P33, DOI 10.1016/j.arth.2007.03.034, DOI	2007	19.59	2008	2012	
Andersen KV, 2007, ACTA ORTHOP, V78, P180, DOI 10.1080/17453670710013654, DOI	2007	17.95	2008	2012	
Fischer HBJ, 2008, ANAESTHESIA, V63, P1105, DOI 10.1111/j.1365-2044.2008.05565.x, DOI	2008	20.38	2009	2013	
Kerr DR, 2008, ACTA ORTHOP, V79, P174, DOI 10.1080/17453670710014950, DOI	2008	37.9	2010	2013	
Andersen LO, 2008, ACTA ANAESTH SCAND, V52, P1331, DOI 10.1111/j.1399-6576.2008.01777.x, DOI	2008	23.93	2010	2013	
Paul JE, 2010, ANESTHESIOLOGY, V113, P1144, DOI 10.1097/ALN.0b013e3181f4b18, DOI	2010	31.73	2011	2015	
Ilfeld BM, 2010, ANESTH ANALG, V111, P1552, DOI 10.1213/ANE.0b013e3181fb9507, DOI	2010	25.44	2011	2015	
Carli F, 2010, BRIT J ANAESTH, V105, P185, DOI 10.1093/bja/aeq112, DOI	2010	25.44	2011	2015	
Essving P, 2010, ACTA ORTHOP, V81, P354, DOI 10.3109/17453674.2010.487241, DOI	2010	20.19	2011	2015	
Sharma S, 2010, CLIN ORTHOP RELAT R, V468, P135, DOI 10.1007/s11999-009-1025-1, DOI	2010	18.69	2011	2015	
Affas F, 2011, ACTA ORTHOP, V82, P441, DOI 10.3109/17453674.2011.581264, DOI	2011	18.81	2012	2016	
Jenstrup MT, 2012, ACTA ANAESTH SCAND, V56, P357, DOI 10.1111/j.1399-6576.2011.02621.x, DOI	2012	22.7	2013	2017	
Jaeger P, 2013, ANESTHESIOLOGY, V118, P409, DOI 10.1097/ALN.0b013e318279fa0b, DOI	2013	22.31	2014	2018	
Bramlett K, 2012, KNEE, V19, P530, DOI 10.1016/j.knee.2011.12.004, DOI	2012	21.57	2014	2017	
Jaeger P, 2013, REGION ANESTH PAIN M, V38, P526, DOI 10.1097/AAP.0000000000000015, DOI	2013	27.55	2015	2018	
Bagsby DT, 2014, J ARTHROPLASTY, V29, P1687, DOI 10.1016/j.arth.2014.03.034, DOI	2014	18.08	2015	2019	
Kim DH, 2014, ANESTHESIOLOGY, V120, P540, DOI 10.1097/ALN.0000000000000119, DOI	2014	24.53	2016	2019	
Surdam JW, 2015, J ARTHROPLASTY, V30, P325, DOI 10.1016/j.arth.2014.09.004, DOI	2015	18.07	2016	2019	
Sankineani SR, 2018, EUR J ORTHOP SURG TRAUMATOL, V28, P1391, DOI 10.1007/s00590-018-2218-7, DOI	2018	19.32	2020	2022	

Fig. 7. Top 25 references with the most citation burst analgesia in TKA from 1990 to 2022.

2008, holds the top position in terms of citation burst value (strength = 37.9). In the last five years, the most highly cited reference with a citation burst value of 24.53 is 'Adductor canal block versus femoral nerve block for total knee arthroplasty: a prospective, randomized, controlled trial [13],' published in 2014.
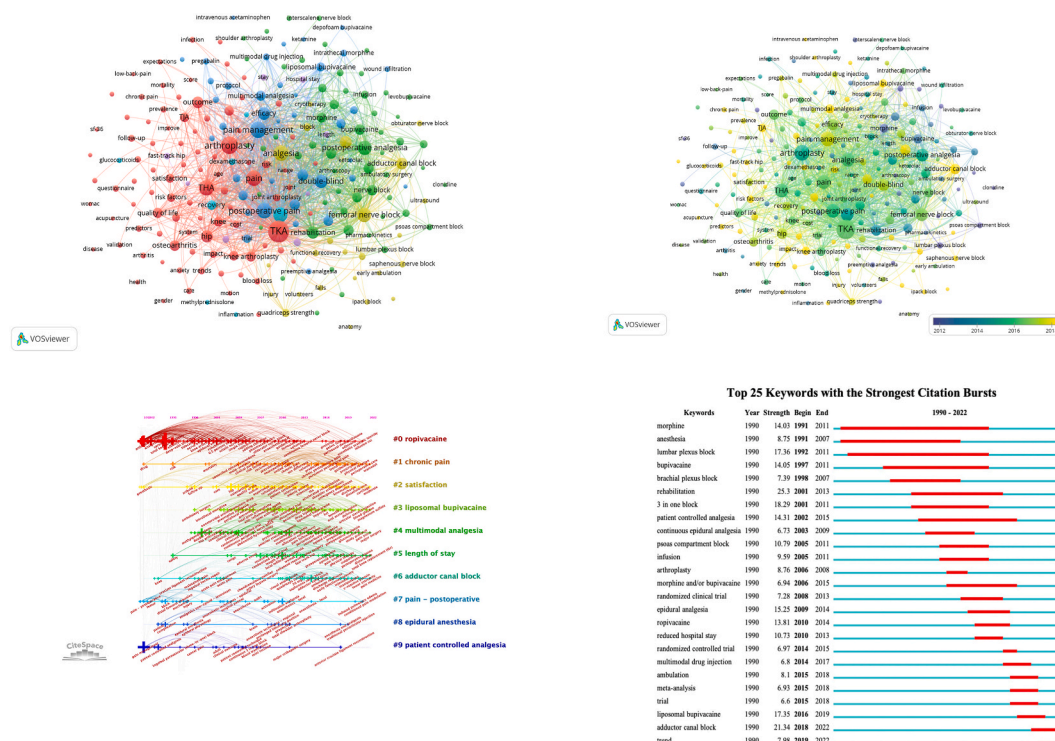

Fig. 8. Visualization of keywords. (A) Cooperation networks of keywords on analgesia in TKA. Different clusters are represented by different colors. (B) Mapping time distribution of keywords on analgesia in TKA. The circle has color shadows representing different average publication years. Yellow circles indicate that the average publication time is later than blue circles. (C) The timeline graph of keywords. (D) Top 25 keywords with the most citation burst analgesia in TKA from 1990 to 2022.

3.6. Keywords analysis

Fig. 8A and B presents our analysis of 224 keywords that occurred more than 15 times using VOSviewer software. In Fig. 8A, Cluster 1 (red) primarily pertains to outcome studies of TKA; Cluster 2 (yellow) is mainly associated with analgesic methods; Cluster 3 (blue) focuses on comprehensive pain management, while Cluster 4 (green) is centered on postoperative analgesia research. The top five keywords by frequency are TKA, pain management, postoperative pain, total hip arthroplasty (THA), and postoperative analgesia, underscoring the predominant focus on postoperative pain management in TKA and analgesia research. In Fig. 8B, VOSviewer uses color shades to indicate different average publication years. Yellow keywords signify a more recent average publication time compared to blue keywords. Notable keywords with a yellow color and substantial nodes include multimodal analgesia, liposomal bupivacaine, periodic injection, additive canal block, and local infiltration analgesia, signifying the current research emphasis on analgesic methods, particularly within the context of multimodal analgesia. Fig. 8C demonstrates the evolving timeline of keywords, highlighting consistent researcher interest in ropivacaine, patient satisfaction, length of stay, periodic anesthesia, and patient-controlled management. Moreover, Fig. 8D lists the top 25 keywords with the most significant citation bursts, revealing that 'morphine' is the earliest and enduring keyword in citation bursts. The top five keywords with the most robust citation burst values are rehabilitation, adductor canal block (ACB), 3-in-one block, lumbar plexus block, and liposomal bupivacaine. It's worth noting that 'ACB' is a recently popular keyword, as shown in Fig. 8D.

4. Discussion

In this study, we used bibliometric methods to explore the development trends and research hotspots in the fields of analgesia and TKA from the perspectives of publication output, countries, institutions, authors, journals, most influential references, and keyword analysis. This study provides references and suggestions for further research by scholars.

Between 1990 and 2022, academic publications in the fields of analgesia and TKA consistently increased, indicating robust academic growth and enduring researcher interest. This suggests that research in analgesia and TKA is likely to continue as a prominent area in the future. Results from the country analysis, as seen in Fig. 3A, underscore the dominant position of the United States in analgesia and TKA research. Notably, while China ranks second in the number of publications, its total citations and H-index lag behind other countries. For example, despite China having twice as many publications as the United Kingdom (UK), the UK outperforms China in terms of citation impact and H-index, as detailed in Table 1. This disparity may be attributed to the prevalence of more recent publication years in China, as demonstrated in Fig. 3B. Moreover, an examination of international collaboration networks reveals that the United States maintains the highest number of partnerships with other countries, as depicted in Fig. 3B. Nonetheless, global publication distribution remains uneven among countries, excluding the United States. Among 66 countries, only five have more than 100 publications, with the top ten countries contributing 88.47 % of the total publications. Consequently, promoting cooperation and exchange among countries is crucial to address this imbalance.

In the realm of institutions, the University of Copenhagen emerges as the most influential academic institution in the fields of analgesia and TKA. Of the top ten institutions for publications, six are from the United States, two from Denmark, one from Canada, and one from China. This highlights the significant academic impact of institutions in Europe and the United States. In collaborative networks among authors, there is evident cooperation among institutions within the same country, while multinational institutions engage in fewer collaborations. Furthermore, European and American institutions tend to publish earlier, in contrast to the more recent average publication times of Sichuan University. Consequently, research institutions worldwide should prioritize enhancing mutual cooperation and exchanges to augment their academic influence in this field.

Regarding authors, Henrik Kehlet is a prominent figure with a substantial number of publications and citations, confirming his significant contributions to this field. Kehlet's research primarily centers on pain management within the context of rapid TKA, encompassing studies on analgesic methods, analgesics, and postoperative complications. For instance, Kehlet et al. [14] investigated the correlation between peripheral nerve block (PNB) and early discharge and readmission rates. They conducted a comprehensive analysis using multiple logistic regression to assess the impact of PNB on length of stay (LOS), considering LOS greater than 1 day, LOS exceeding 4 days, and the 30-day readmission rate. Their findings revealed that the routine use of PNB in TKA was not linked to early discharge or 30-day readmission. In another randomized double-blind controlled trial, Kehlet et al. [15] compared the effects of preoperative high-dose intravenous dexamethasone ($1 \ mg/kg^{-1}$) with a moderate dose of dexamethasone ($0.3 \ mg/kg^{-1}$) in TKA patients characterized as high pain responders, with a preoperative pain catastrophizing score exceeding 20. This investigation assessed the presence of moderate to severe pain during walking 24 h post-surgery, as well as leg elevation pain at 24 and 48 h. Their study demonstrated that, in comparison to low-dose dexamethasone, high-dose dexamethasone can reduce moderate to severe pain 24 h after TKA surgery and enhance the recovery of high pain responders.

The core journal in the realm of analgesia and TKA is the Journal of Arthroplasty, distinguished by its substantial number of publications and citations. Previous bibliometric studies on literature have similarly acknowledged the Journal of Arthroplasty as the foremost publication in the domain of joint arthroplasty [16]. Following closely are the second and third-ranked journals in terms of publication volume: Regional Anesthesia and Pain Medicine, and Anesthesia and Analgesia, respectively. This indicates that high-impact publications in this field extend beyond journals solely dedicated to joint replacement or orthopedics, encompassing anesthesia and pain journals as well. This diversification effectively contributes to the advancement of various disciplines.

The current research indicates that the top 25 references with citation bursts serve as valuable tools for identifying references that reflect researchers' interests within specific fields during particular timeframes [17]. As of 2022, the most intriguing reference for researchers is 'Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery: a

case study of 325 patients' [12]. This study provides a comprehensive account of the evolution of local infiltration analgesia (LIA) for hip and knee joint replacement surgery. The research demonstrates that LIA offers an optimal approach to pain control, mobilization time, and morphine dosage following knee and hip surgery. This discovery substantiates the progression of multimodal analgesia after knee and hip surgery, a critical element in enhancing patient outcomes. Additionally, in the past five years, the reference with the highest citation burst value is 'Adductor canal block versus femoral nerve block for total knee arthroplasty: a prospective, randomized, controlled trial' [13]. This study suggests that, in comparison to the femoral nerve block (FNB), the ACB demonstrates early relative preservation of quadriceps strength 6–8 h after anesthesia, and it is equally effective in providing analgesia and managing opioid intake. Consequently, these studies have garnered significant attention from scholars recently.

The analysis of co-occurrence keywords highlights a strong association between analgesia and TKA, with a particular emphasis on analgesic strategies, medications, and methods. An examination of keyword trends over time underscores that the primary focus for TKA candidates and clinical practitioners has been on multimodal analgesia. This focus is attributed to its close connection with factors such as patient satisfaction, LOS, and postoperative recovery. Multimodal analgesia entails the utilization of two or more pain relief approaches customized to different pain pathways to achieve optimal pain relief effects, all while aiming to reduce the use of opioids and associated complications [9]. Although the advantages of multimodal analgesia have been demonstrated in joint replacement surgeries, further high-quality evidence is required to ascertain the optimal regimen for implementing multimodal analgesia [18,19].

The time evolution analysis of keywords indicates that ropivacaine (#0) and liposomal bupivacaine (#4) are the primary analgesic drugs under investigation. Currently, bupivacaine and ropivacaine are commonly employed for postoperative pain management in TKA [20]. Ropivacaine, characterized as a long-acting amide local anesthetic, is extensively used in local anesthesia and possesses the potential to become the standard for postoperative pain relief in TKA [21]. Nevertheless, in recent years, scholars have shown interest in a novel form of bupivacaine. In 2011, the United States Food and Drug Administration (FDA) sanctioned liposomal bupivacaine for local administration [22]. This innovative local anesthetic encases bupivacaine within polycystic liposomes [23], delaying drug release and allowing sustained release for up to 72 h following injection [24], thereby prolonging the duration of analgesia [25]. While liposomal bupivacaine demonstrates improved control of postoperative pain, reduced analgesic dosage, lower opioid-related adverse reactions (ORAEs), and shorter hospital stays compared to traditional bupivacaine injection [26], no significant differences have been observed in terms of pain relief, functional outcomes, patient satisfaction, and LOS when compared to ropivacaine [24,27]. Consequently, further high-quality evidence is necessary to explore the potential advantages of utilizing perineural liposomal bupivacaine over non-liposomal bupivacaine for PNB.

The citation burst of keywords underscores the current focal point of interest in ACB, a relatively recent analgesic method that has emerged as a potential gold standard alternative to FNB [28,29]. ACB has been reported to offer equivalent, effective analgesia while preserving quadriceps function more effectively than FNB, contributing to improved walking ability and faster functional recovery [29–31]. However, ongoing debates among anesthesiologists in clinical practice revolve around the precise location of the adductor canal (AC), the optimal injection site for ACB, and the appropriate injection volume.

The AC is a conduit extending from the apex of the femoral triangle to the adductor space, enclosed by the anterolateral vastus medialis, posteromedial adductor magnus, and superiorly by the sartorius and adductor magnus tendons. Despite a consensus on its boundaries, there exists variability in the nerves traversing the AC, including the saphenous, obturator, medial femoral cutaneous, and medial femoral nerves [32]. Additionally, the presence of multiple injectable neurovascular cavities in the thigh and the adhesion of part of the neurovascular sheath to the wall of the inferior ventricular canal can affect the distribution of intraventricular injections [33], intensifying debates concerning the optimal ACB site. Traditional methods for determining the optimal block location for proximal ACB involve injecting local anesthesia into the middle of the thigh, guided by anatomical markers located at the midpoint between the anterior superior iliac spine (ASIS) and the base of the patella [34]. Nevertheless, recent research employing ultrasound guidance indicates that the proximal end of the AC is positioned at the distal extremity of the midpoint of the thigh, implying that the proximal ACB block essentially amounts to a femoral triangle block (FTB), which can lead to quadriceps femoris muscle paralysis [32]. The utilization of ultrasound-guided technology has improved ACB location determination, although divergent opinions persist regarding the optimal puncture site [35–37]. Discovering the ideal location for ACB remains a subject for future research.

Furthermore, the choice of the appropriate local anesthetic volume is critical in ACB to ensure adequate filling of the canal while preventing proximal diffusion into the femoral triangle [38]. Clinical evidence also suggests that a low FTB dose may omit intermediate femoral cutaneous nerves and the medial femoral cutaneous nerve, while excessive dosage can lead to proximal diffusion of local anesthetics in the femoral triangle [33,39]. In summary, future research on ACB should concentrate on determining the optimal injection location and volume, as well as exploring potential clinical distinctions in selecting various analgesic regions.

5. Conclusion

This study, employing bibliometric analysis, offers a comprehensive overview of the realm of analgesia and TKA. It is anticipated that interest in this field will continue to grow. The United States stands out as a significant contributor, emphasizing the need for increased international collaboration across continents. The University of Copenhagen emerges as the most influential academic institution, Henrik Kehlet as the foremost influential author, and the Journal of Arthroplasty as the preeminent academic journal in this domain. Furthermore, ACB presents itself as a potential area of future development and a research hotspot in analgesia and TKA. Additional research endeavors should target the optimization of multimodal analgesia regimens, the identification of the ideal ACB location and volume, and the exploration of their clinical implications.

6. Limitations

To the best of our knowledge, this study represents the inaugural bibliometric analysis of analgesia and TKA. It's imperative to acknowledge certain limitations inherent in our work. While the WoSCC database is widely regarded as a paramount bibliometric data source, it's plausible that some eligible publications from other databases were inadvertently excluded. Furthermore, our study's cutoff date for publication was December 31, 2022; nevertheless, WoSCC undergoes continuous updates, potentially leading to the omission of more recent publications. Despite these limitations, we maintain that our study can effectively serve as a valuable resource for presenting research priorities and emerging trends in the field of analgesia and TKA.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

CRediT authorship contribution statement

DongPing Wan: Writing – original draft, Visualization, Software, Methodology, Investigation, Data curation, Conceptualization. **Rui Wang:** Writing – original draft, Validation, Software, Investigation, Data curation. **Jie Wei:** Writing – original draft, Validation, Project administration, Investigation, Formal analysis, Data curation. **Qiang Zan:** Writing – review & editing, Validation, Supervision, Conceptualization. **Lei Shang:** Validation, Supervision, Resources, Funding acquisition, Conceptualization. **Jianbing Ma:** Supervision, Software, Resources, Project administration, Data curation. **Shuxin Yao:** Writing – review & editing, Supervision, Resources, Project administration, Data curation, Conceptualization. **Chao Xu:** Writing – review & editing, Supervision, Software, Resources, Project administration, Funding acquisition, Data curation, Conceptualization.

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.

Acknowledgments

References

[1] A.J. Carr, O. Robertsson, S. Graves, et al., Knee replacement, Lancet (London, England) 379 (2012) 1331–1340, https://doi.org/10.1016/S0140-6736(11)60752-6.

[2] R.C. Lawrence, D.T. Felson, C.G. Helmick, et al., Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II, Arthritis Rheum. 58 (2008) 26–35, https://doi.org/10.1002/art.23176.

[3] A. Klug, Y. Gramlich, M. Rudert, et al., The projected volume of primary and revision total knee arthroplasty will place an immense burden on future health care systems over the next 30 years, Knee Surg. Sports Traumatol. Arthrosc. 29 (2021) 3287–3298, https://doi.org/10.1007/s00167-020-06154-7.

[4] R. Gunaratne, D.N. Pratt, J. Banda, et al., Patient dissatisfaction following total knee arthroplasty: a systematic review of the literature, J. Arthroplasty 32 (2017) 3854–3860, https://doi.org/10.1016/j.arth.2017.07.021.

[5] M.J. DeFrance, G.R. Scuderi, Are 20% of patients actually dissatisfied following total knee arthroplasty? A systematic review of the literature, J. Arthroplasty 38 (2023) 594–599, https://doi.org/10.1016/j.arth.2022.10.011.

[6] A. Klasan, D.A. Rice, M.T. Kluger, et al., A combination of high preoperative pain and low radiological grade of arthritis is associated with a greater intensity of persistent pain 12 months after total knee arthroplasty, Bone Joint Lett. J 104-B (2022) 1202–1208, https://doi.org/10.1302/0301-620X.104B11.BJJ-2022-0630.R1.

[7] S. Summers, N. Mohile, C. McNamara, et al., Analgesia in total knee arthroplasty: current pain control modalities and outcomes, J Bone Joint Surg Am 102 (2020) 719–727, https://doi.org/10.2106/JBJS.19.01035.

[8] F.-J. Xiong, W. Zhao, S.-J. Jia, et al., Effect of oral pre-emptive analgesia on pain management after total knee arthroplasty: a protocol for systematic review and meta-analysis, BMJ Open 13 (2023) e070998, https://doi.org/10.1136/bmjopen-2022-070998.

[9] Practice guidelines for acute pain management in the perioperative setting: an updated report by the American Society of Anesthesiologists Task Force on Acute Pain Management, Anesthesiology 116 (2012) 248–273, https://doi.org/10.1097/ALN.0b013e31823c1030.

[10] P.M. Lavand'homme, H. Kehlet, N. Rawal, G.P. Joshi, Pain management after total knee arthroplasty: PROcedure SPEcific Postoperative Pain ManagemenT recommendations, Eur. J. Anaesthesiol. 39 (2022) 743–757, https://doi.org/10.1097/EJA.0000000000001691.

[11] D. Mukherjee, W.M. Lim, S. Kumar, N. Donthu, Guidelines for advancing theory and practice through bibliometric research, J. Bus. Res. 148 (2022) 101–115, https://doi.org/10.1016/j.jbusres.2022.04.042.

[12] D.R. Kerr, L. Kohan, Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery: a case study of 325 patients, Acta Orthop. 79 (2008) 174–183, https://doi.org/10.1080/17453670710014950.

[13] D.H. Kim, Y. Lin, E.A. Goytizolo, et al., Adductor canal block versus femoral nerve block for total knee arthroplasty: a prospective, randomized, controlled trial, Anesthesiology 120 (3) (2014) 540–550, https://doi.org/10.1097/ALN.0000000000000119.

[14] A. Harsten, H. Kehlet, P. Ljung, S. Toksvig-Larsen, Total intravenous general anaesthesia vs. spinal anaesthesia for total hip arthroplasty: a randomised, controlled trial, Acta Anaesthesiol. Scand. 59 (2015) 298–309, https://doi.org/10.1111/aas.12456.

[15] N.I. Nielsen, H. Kehlet, K. Gromov, et al., High-dose steroids in high pain responders undergoing total knee arthroplasty: a randomised double-blind trial, Br. J. Anaesth. 128 (2022) 150–158, https://doi.org/10.1016/j.bja.2021.10.001.

[16] C. Li, H. Wu, Z. Sun, et al., Global publication trends and research hotspots of revision hip and knee arthroplasty: a 21-year bibliometric approach, J. Arthroplasty 37 (2022) 974–984, https://doi.org/10.1016/j.arth.2022.01.022.

[17] F. Wu, J. Gao, J. Kang, et al., Knowledge mapping of exosomes in autoimmune diseases: a bibliometric analysis (2002-2021), Front. Immunol. 13 (2022) 939433, https://doi.org/10.3389/fimmu.2022.939433.

[18] B.S. Kandarian, N.M. Elkassabany, M. Tamboli, E.R. Mariano, Updates on multimodal analgesia and regional anesthesia for total knee arthroplasty patients, Best Pract. Res. Clin. Anaesthesiol. 33 (2019) 111–123, https://doi.org/10.1016/j.bpa.2019.02.004.

[19] W. Kampitak, W. Kertkiatkachorn, S. Ngarmukos, et al., Comparison of analgesic efficacies of the iPACK (interspace between the popliteal artery and capsule of the posterior knee) and genicular nerve blocks used in combination with the continuous adductor canal block after total knee arthroplasty: a randomized clinical trial, J. Arthroplasty (2023), https://doi.org/10.1016/j.arth.2023.03.018.

[20] A. Malige, A.N. Pellegrino, K. Kunkle, et al., Liposomal bupivacaine in adductor canal blocks before total knee arthroplasty leads to improved postoperative outcomes: a randomized controlled trial, J. Arthroplasty 37 (2022) 1549–1556, https://doi.org/10.1016/j.arth.2022.03.073.

[21] Y. Tao, S.-Q. Zheng, T. Xu, et al., Median effective volume of ropivacaine 0.5% for ultrasound-guided adductor canal block, J. Int. Med. Res. 46 (2018) 4207–4213, https://doi.org/10.1177/0300060518791685.

[22] M.E. McCann, Liposomal bupivacaine, Anesthesiology 134 (2021) 139–142, https://doi.org/10.1097/ALN.0000000000003658.

[23] P. Chahar, K.C. Cummings, Liposomal bupivacaine: a review of a new bupivacaine formulation, J. Pain Res. 5 (2012) 257–264, https://doi.org/10.2147/JPR.S27894.

[24] N. Hussain, R. Brull, B. Sheehy, et al., Perineural liposomal bupivacaine is not superior to nonliposomal bupivacaine for peripheral nerve block analgesia, Anesthesiology 134 (2021) 147–164, https://doi.org/10.1097/ALN.0000000000003651.

[25] K. Candiotti, Liposomal bupivacaine: an innovative nonopioid local analgesic for the management of postsurgical pain, Pharmacotherapy 32 (2012) 19S–26S, https://doi.org/10.1002/j.1875-9114.2012.01183.x.

[26] M.A. Mont, W.B. Beaver, S.H. Dysart, et al., Local infiltration analgesia with liposomal bupivacaine improves pain scores and reduces opioid use after total knee arthroplasty: results of a randomized controlled trial, J. Arthroplasty 33 (2018) 90–96, https://doi.org/10.1016/j.arth.2017.07.024.

[27] J.-J. Chen, Y.-C. Wu, J.-S. Wang, C.-H. Lee, Liposomal bupivacaine administration is not superior to traditional periarticular injection for postoperative pain management following total knee arthroplasty: a meta-analysis of randomized controlled trials, J. Orthop. Surg. Res. 18 (2023) 206, https://doi.org/10.1186/s13018-023-03699-4.

[28] M.U. Vora, T.A. Nicholas, C.A. Kassel, S.A. Grant, Adductor canal block for knee surgical procedures: review article, J. Clin. Anesth. 35 (2016) 295–303, https://doi.org/10.1016/j.jclinane.2016.08.021.

[29] D. Li, Z. Yang, X. Xie, et al., Adductor canal block provides better performance after total knee arthroplasty compared with femoral nerve block: a systematic review and meta-analysis, Int. Orthop. 40 (2016) 925–933, https://doi.org/10.1007/s00264-015-2998-x.

[30] M.-J. Kuang, J.-X. Ma, L. Fu, et al., Is adductor canal block better than femoral nerve block in primary total knee arthroplasty? A grade analysis of the evidence through a systematic review and meta-analysis, J. Arthroplasty 32 (2017), https://doi.org/10.1016/j.arth.2017.05.015.

[31] D. Li, G.-G. Ma, Analgesic efficacy and quadriceps strength of adductor canal block versus femoral nerve block following total knee arthroplasty, Knee Surg. Sports Traumatol. Arthrosc. 24 (2016) 2614–2619, https://doi.org/10.1007/s00167-015-3874-3.

[32] W.Y. Wong, S. Bjørn, J.M.C. Strid, et al., Defining the location of the adductor canal using ultrasound, Reg. Anesth. Pain Med. 42 (2017) 241–245, https://doi.org/10.1097/AAP.0000000000000539.

[33] G.E. Woodworth, A. Arner, S. Nelsen, et al., Pro and con: how important is the exact location of adductor canal and femoral triangle blocks? Anesth. Analg. 136 (2023) 458–469, https://doi.org/10.1213/ANE.0000000000006234.

[34] J. Lund, M.T. Jenstrup, P. Jaeger, et al., Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results, Acta Anaesthesiol. Scand. 55 (2011) 14–19, https://doi.org/10.1111/j.1399-6576.2010.02333.x.

[35] C. Romano, A. Lloyd, S. Nair, et al., A randomized comparison of pain control and functional mobility between proximal and distal adductor canal blocks for total knee replacement, Anesth. Essays Res. 12 (2018) 452–458, https://doi.org/10.4103/aer.AER_17_18.

[36] Y. Fei, X. Cui, S. Chen, et al., Continuous block at the proximal end of the adductor canal provides better analgesia compared to that at the middle of the canal after total knee arthroplasty: a randomized, double-blind, controlled trial, BMC Anesthesiol. 20 (2020) 260, https://doi.org/10.1186/s12871-020-01165-w.

[37] I. Jaremko, K. Lukaševič, Š. Tarasevičius, et al., Comparison of 2 peripheral nerve blocks techniques for functional recovery and postoperative pain management after total knee arthroplasty: a prospective, double-blinded, randomized trial, Med. Sci. Mon. Int. Med. J. Exp. Clin. Res. 27 (2021) e932848, https://doi.org/10.12659/MSM.932848.

[38] P. Jæger, M.T. Jenstrup, J. Lund, et al., Optimal volume of local anaesthetic for adductor canal block: using the continual reassessment method to estimate ED95, Br. J. Anaesth. 115 (2015) 920–926, https://doi.org/10.1093/bja/aev362.

[39] E.J. Yee, Z.A. Gapinski, M. Ziemba-Davis, et al., Quadriceps weakness after single-shot adductor canal block: a multivariate analysis of 1,083 primary total knee arthroplasties, J Bone Joint Surg Am 103 (2021) 30–36, https://doi.org/10.2106/JBJS.19.01425.