Available online at www.medicinescience.org

ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2024;13(2):485-98

Deciphering the complexity of cataract surgery: A bibliometric and science mapping analysis of research patterns and surgical developments- a 40-year perspective

Bilge Yurdakul

İdeal Göz Hospital, Department of Ophthalmology, Kayseri, Türkiye

Received 16 October 2023; Accepted 18 March 2024
Available online 01 June 2024 with doi: 10.5455/medscience.2023.10.211

Abstract

Cataract surgery, an integral facet of ophthalmological intervention, has experienced profound metamorphosis over the past 40 years. These shifts have been marked not only in the domain of surgical methodology but also within the conceptual framework that governs the understanding, diagnosis, and management of the condition. This research endeavors to articulate the contemporary landscape of cataract surgery, delineating its chronological evolution, emergent trends, and intricate interconnections, spanning a period of four decades. The methodology employed a thorough exploration and meticulous analysis of the Web of Science (WoS) database, concentrating specifically on cataract-related research from 1983 to 2022. The corpus, comprising 9574 articles, underwent rigorous examination through bibliometric and science mapping instruments, including Bibliometrix, to assay the patterns, significant authorships, journal participations, and theoretical architecture in the field of cataract studies. The inquiry revealed a compounded annual growth rate of 3.82% in cataract research, with a mean citation index of 23.18 per article. This corpus encompasses contributions from 90 journals. This study was integral to the identification of seminal researchers, authoritative institutions, and cornerstone publications. The analysis was segmented into four analytical domains: an exploration of the fundamental structure of articles, an evaluation of author and journal participation, a scrutiny of keyword deployment, and an analysis of conceptual paradigms, uncovering substantial thematic interconnections and trends. This analytical endeavor systematically deconstructs the multifarious nature of cataract surgery and affiliated research, thereby unveiling a rich, multidimensional field that extends its influence and applicability beyond ophthalmology to a myriad of interdisciplinary pursuits. As an academic synthesis, the insights garnered from this study provide an unparalleled reference for scholars, clinical practitioners, and policymakers who have deeply invested in cataract surgery. This signifies the field's progressive evolution over an extended temporal frame and critically elucidates prospective avenues for scholarly inquiry and practical application, thereby fulfilling a vital niche in contemporary medical literature.

Keywords: Cataract research, cataract surgery, science mapping, bibliometrix analysis

Introduction

Cataract, a pathological condition characterized by clouding of the eye's crystalline lens, poses significant challenges to the affected individual's daily functions such as reading, writing, and ambulation, subsequently deteriorating the quality of life [1,2]. Globally acknowledged as a principal cause of preventable blindness, cataracts continue to be a matter of serious concern despite concerted efforts to alleviate their burden [3]. Cataracts are a major cause of visual impairment globally and affect tens of millions of people. In the USA, cataracts affect approximately 24.4 million individuals aged 40 years and older, with projections suggesting an increase to 50 million by 2050. European data mirror this trend, reflecting an aging population [4,5]. Türkiye, aligning with global patterns, shows a significant prevalence, necessitating ongoing public health attention and resource allocation for effective management and treatment strategies [6].

The field of cataract treatment has been marked by remarkable strides, predominantly in surgical interventions. Although

CITATION
Yurdakul B. Deciphering the complexity of cataract surgery: A bibliometric and science mapping analysis of research patterns and surgical developments- a 40-year perspective. Med Science. 2024;13(2):485-98.

Corresponding Author: Bilge Yurdakul, İdeal Göz Hospital, Department of Ophthalmology, Kayseri, Türkiye
Email: bilgetokbay@gmail.com

DOI: 10.5455/medscience.2023.10.211

pharmaceutical approaches have made progress, surgery remains the gold standard in cataract management [7]. Spanning a rich history and witnessing rapid advancements, cataract surgery techniques have diversified into various forms such as phacoemulsification (Phaco), extracapsular cataract extraction (ECCE), and manual small-incision cataract surgery (MSICS), which is the most prevalent method [8,9].

These surgical advancements have resulted in a multitude of brilliant scientists and surgeons whose relentless pursuit of innovation has standardized modern cataract surgery worldwide, providing relief to millions [8,10]. However, quantifying these contributions and identifying the most influential works in the field of cataract surgery remains a complex task.

The concept of "citation" has often been employed as a surrogate marker for the significance of scientific work. A citation acknowledges a work's contribution and plays a vital role in determining a journal's impact factor (IF), which is defined as the ratio of citations in the present year to articles published in the preceding two years [10-12]. Therefore, citation analysis serves as a tool for assessing the relative importance of a medical journal.

Building on this foundational understanding, our study is pioneering in its efforts to conduct bibliometric analysis and science mapping to visualize the evolution of knowledge pertaining to cataract surgery. By analyzing a comprehensive collection of articles and research from a 40-year perspective, we aimed to cast a spotlight on the trends, significant contributors, and thematic progress in cataract research. This analytical approach promises to enrich the field's understanding and guide both present and future endeavors, thereby strengthening the global fight against this vision-threatening condition.

Material and Methods

Science mapping is a tool used to visualize and understand advancements in science and technology as well as scientists, journals, articles, and countries involved in these fields. Science maps provide a graphical representation of the evolution and change in science and technology and show how different fields of science are related and connected to each other [13].

Science maps are typically designed as themes or network maps. Theme maps show the subfields of a particular subject and explain how they are related to each other. Network maps show the branches that revolve around the main subject. Science maps also show how researchers, institutions, or countries working on a particular subject are related to each other [14].

Science maps are an important tool to guide research in science and technology and to conduct more efficient work in this area. In addition, science maps can help researchers, scientists, and other relevant parties better understand what topics they are working on and what they are developing.

The concept of bibliometrics refers to the quantitative analysis of data obtained from scientific articles published during a certain period using mathematical and statistical tools. It provides some clues about the scientific discipline, subject being studied, academic institutions, countries, authors, and author collaborations [5,15].

A workflow diagram designed for the scientific term “Cataract,” which is the topic of our study, is shown in Figure 1. The database used for our study is Web of Science (WoS), which is one of the most comprehensive and widely used databases for bibliometric analysis and literature searches [16].

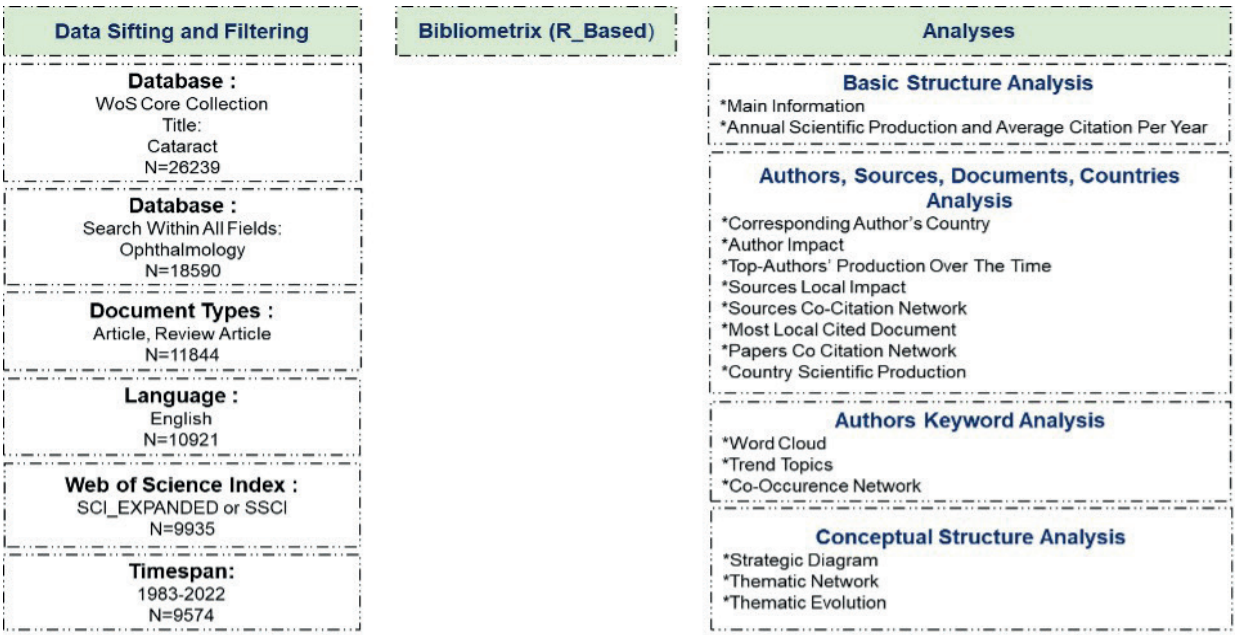


Figure 1. Workflow diagmram

DOI: 10.5455/medscience.2023.10.211

The search was conducted using the WoS database on April 4, 2023. In the next stage, data extracted from the database were filtered and refined. When publications with the title "Cataract" were searched in the WoS database, 26239 articles were identified. The WoS category was set to ophthalmology to exclude articles from outside the field, resulting in 18590 articles. For publication types, "Article and Review Article" were selected, and a total of 11844 articles were obtained. When the language was set to "English," 10921 articles were reached, and when the WoS index was set to "SCI_EXPANDED or SSCI," 9935 articles were reached. This study was limited to a 40-year article history from 1983 to 2022, resulting in a dataset of 9574 articles for bibliometric analysis. As the year 2023 is still ongoing, the years 1980 to 1982, which are the initial period records of the data, were not included in the study.

In our study, 9574 articles were analyzed in four sections. The first section involved a basic structural analysis of articles in the field of cataract. The second section focused on the analysis of authors, journals, articles, and countries. The third section analyzes the author keywords, and the fourth section focuses on conceptual structure analysis.

There was no need for keyword merging in the keyword analysis; therefore, no keyword merging was performed. Figure presents the workflow of the science mapping.

Ethical Consideration

The Bibliometrix program was used to analyze the data. Bibliometrix is one of the latest open-source software programs developed on the R platform to perform bibliometric analyses [17]. The bibliometric analysis presented in our study utilizes publicly accessible data sourced from the open-access Web of Science database, thereby obviating the need for ethical approval or institutional permission.

Results

Basic Structure Analysis

Main information

A total of 9574 articles on our research topic of Cataract were published in 90 journals between 1983 and 2022. The annual growth rate of articles was 3.82%. The average number of citations per article was 23.18.

In total, 95356 references were included in the articles. 23683 authors were included in the articles. The number of authors with single-author articles was 437 and the number of single-author articles was 564. The average number of coauthors per article was 4.77. 7481 author keywords were used in this study. The other statistical information is presented in Table 1.

Annual scientific production and average citation per year

The annual scientific publication quantities and average citation counts produced in the research area of the Cataract between 1983 and 2022 were obtained using Bibliometrix, as presented in Table 1.

Table 1. Main information

Description	Results
Main information about data	
Timespan	1983:2022
Sources (Journals, books, etc)	90
Documents	9574
Annual growth rate %	3.82
Document average age	15.8
Average citations per doc	23.18
References	95356
Document contents	
Keywords plus (ID)	7706
Author's keywords (DE)	7481
Authors	
Authors	23683
Authors of single-authored docs	437
Authors collaboration	
Single-authored docs	564
Co-authors per doc	4.77
International co-authorships %	14.95
Document types	
Article	8462
Article; early access	54
Article; proceedings paper	612
Article; retracted publication	2
Review	438
Review; book chapter	2
Review; early access	4

The number of scientific publications produced in a year in the field of cataract research has shown an increasing trend overall, despite fluctuations from 1983 to 2022. While 101 articles were produced in 1983, this number will reach 436 in 2022. The highest number of articles was produced in 2022 (436) and the lowest number was produced in 1984 (83).

In our study, the R^2-Reliability Coefficient, trend line, and equation were added to the graph of the quantities of scientific articles produced annually. The reliability coefficient was close to 1, with a value of 0.966, and although there were fluctuations in the annual publication amounts, the trend line represented the data at a very good level. The equation representing the trend line in the graph is as follows:

Upon reviewing the data on annual average citations, it appears that no particular year's articles garnered a significantly higher citation count compared to others, suggesting consistent recognition across time. The peak in average citations was noted in 2015 and 2019, each with an average of 2.5 citations per article. A closer analysis from 1983 to 2019 reveals a trend in which more recent articles tend to accumulate citations rapidly, hinting at their relevance and the scientific community's interest

DOI: 10.5455/medscience.2023.10.211

in newer studies. This trend may also reflect the increasing accessibility and dissemination of scientific research in the digital age. It is anticipated that articles published post-2019 may currently exhibit lower citation counts, which can be attributed to their recent entry into scholarly conversation, giving them less exposure and opportunities to be cited. This is a common temporal pattern in bibliometrics, where newer articles naturally have lower citation counts owing to their recent publication. For articles published in 2019, an average citation count of 2.5 may reflect early recognition, but this figure is expected to grow as these articles continue to circulate and contribute to their respective fields. Moving forward, the analysis of citation trends should consider the time factor to allow for a fair assessment of the impact and influence of an article (Figure 2).

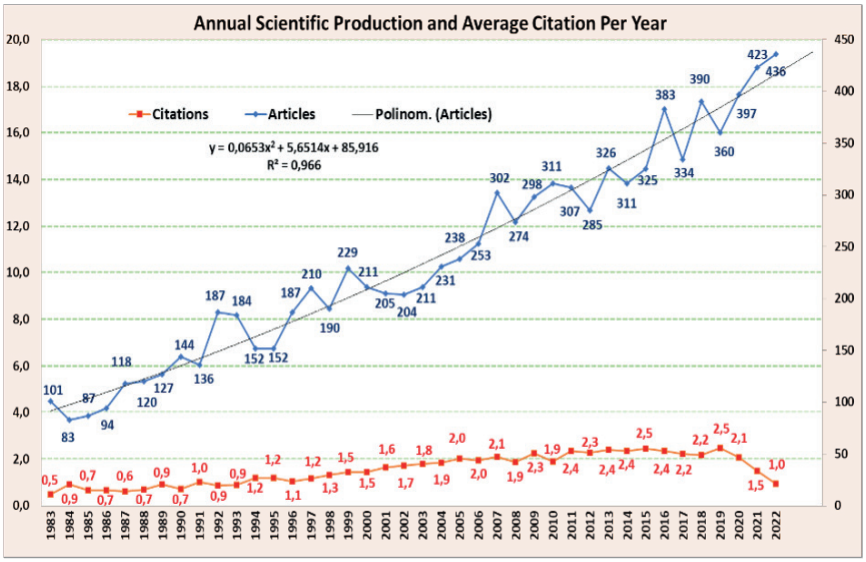


Figure 2. Annual scientific production and average citation per year

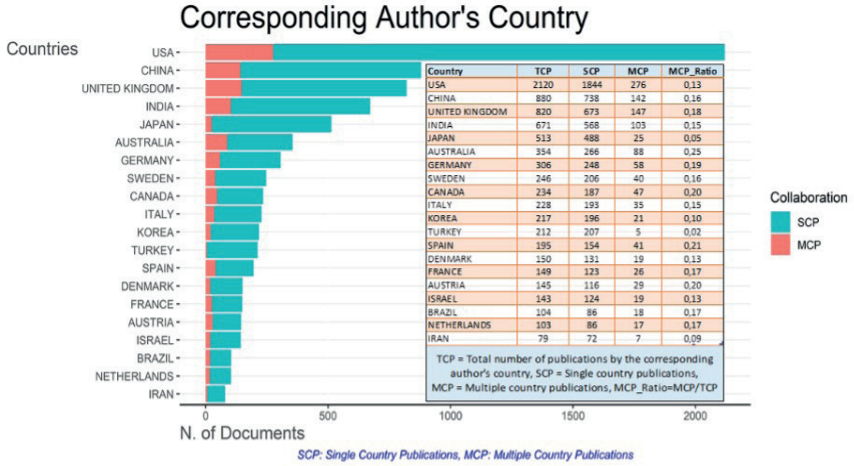
Authors, Sources, Documents, Countries Analysis

Corresponding author's country

To examine the details of the cataract research area in terms of countries, the top 20 countries of the corresponding authors are shown in Figure 3, which is obtained from Bibliometrix based on publication ranking. The top five leading countries in terms of the number of articles in the cataract research area are the United States (2120), China (880), the United Kingdom (820), India (671), and Japan (513).

Regarding single-country authors, the United States (1844), China (738), the United Kingdom (673), India (568), and Japan (488) are prominent, whereas among multi-country authors, the United States (276), the United Kingdom (147), China (142), India (103), and Australia (88) stand out.

The MCP ratio was obtained by dividing the number of publications from multiple countries by the total number of publications from all countries. Australia had the highest MCP ratio (0.25) followed by Spain (0.21). Türkiye is ranked 12th on the list, with 207 single-country publications, 5 multi-country publications, and 212 publications in the cataract research area (Figure 3).



Country	TCP	SCP	MCP	MCP_Ratio
USA	2120	1844	276	0,13
CHINA	880	738	142	0,16
UNITED KINGDOM	820	673	147	0,18
INDIA	671	568	103	0,15
JAPAN	513	488	25	0,05
AUSTRALIA	354	266	88	0,25
GERMANY	306	248	58	0,19
SWEDEN	246	206	40	0,16
CANADA	234	187	47	0,20
ITALY	228	193	35	0,15
KOREA	217	196	21	0,10
TURKEY	212	207	5	0,02
SPAIN	195	154	41	0,21
DENMARK	150	131	19	0,13
FRANCE	149	123	26	0,17
AUSTRIA	145	116	29	0,20
ISRAEL	143	124	19	0,13
BRAZIL	104	86	18	0,17
NETHERLANDS	103	86	17	0,17
IRAN	79	72	7	0,09

TCP = Total number of publications by the corresponding author's country, SCP = Single country publications, MCP = Multiple country publications, MCP_Ratio=MCP/TCP

Figure 3. Corresponding authors' country distributions

DOI: 10.5455/medscience.2023.10.211

Author ımpact metrics

Figure 4 presents the metrics of the top 20 authors who made substantial contributions to cataract research between 1983 and 2022. The analysis encompassed the total number of publications (NP), total citations (TC), h-index, and g-index, providing a multifaceted view of their scholarly impact. The h-index, devised by Jorge Hirsch, indicates the influence and productivity of a researcher's publications [18]. An h-index of X signifies that a researcher has X publications, each of which has been cited at least X times. This metric balances the quantity and quality of scientific output, with higher values indicating a consistent record of highly cited studies. Noteworthy among our study's subjects are Lundstrom M. [19] with an h-index of 35, Mitchell P. [20] at 33, Stenevi U. [21] with 30, Klein R. [22] at 28, and Klein BEK. [23], with a score of 27. These figures reflect their enduring influence on the field of cataract research, underlined by a significant number of publications that have garnered substantial citations, thereby marking the quality and impact of their scholarly contributions.

The g-index, introduced by Leo Egghe in 2006, is another measure of the impact of a researcher's publications. It considers the number of highly cited publications, giving them more weight than less cited ones [24]. The authors with the highest g-index values in our study are Mitchell P (55), Lundstrom M (54), Stenevi U (52), Wang JJ (50), and Sparrow JM (45).

The authors with the highest total number of citations are Klein BEK (4202), Klein R (3984), Javitt JC (3657), Tielsch JM (3357), and Mitchell P (3267). In terms of the number of publications, the authors with the most publications are Lundstrom (81), Mitchell (77), and Wang (67).

When the total number of publications and h-index values of the authors were examined together, it was observed that some authors had very close values for both. The closer the values, the more likely it is that the author has produced more quality publications. When conducting evaluations, it is more sensible to focus on authors with high h-index values. Lundstrom obtained a considerable h-index value of 35 with 81 publications, while Klein obtained an h-index value of 28 with 38 publications. Similarly, Javitt JC obtained an h-index value of 25 in 29 publications and Johnstone RL obtained an h-index value of 22 in 27 publications (Figure 4).

It is possible to say that Lundstrom M. [19], Mitchell P. [20], Stenevi U. [25], Klein R. [22], Klein BEK [23], Wang JJ. [26], Sparrow JM. [27], Javitt JC. [28], Tielsch JM. [29], and Johnstone RL. 30 are the most effective authors in terms of Cataract titled articles.

Author	h_index	g_index	TC	NP
LUNDSTROM M	35	54	3093	81
MITCHELL P	33	55	3267	77
STENEVI U	30	52	2739	53
KLEIN R	28	38	3984	38
KLEIN BEK	27	39	4202	39
WANG JJ	27	50	2661	67
FINDL O	25	40	1679	56
JAVITT JC	25	29	3657	29
SPARROW JM	25	45	2200	45
ALIO JL	24	34	1421	34
DICK HB	24	42	1786	47
HEJTMANCIK JF	24	34	1902	34
SCHEIN OD	24	36	3179	36
TAYLOR HR	24	40	2636	40
ROCHTCHINA E	23	36	1356	42
TIELSCH JM	23	28	3357	28
WILSON ME	23	36	1449	54
JOHNSTON RL	22	27	2049	27
LAMBERT SR	22	38	1521	49
STARK WJ	22	31	1438	31

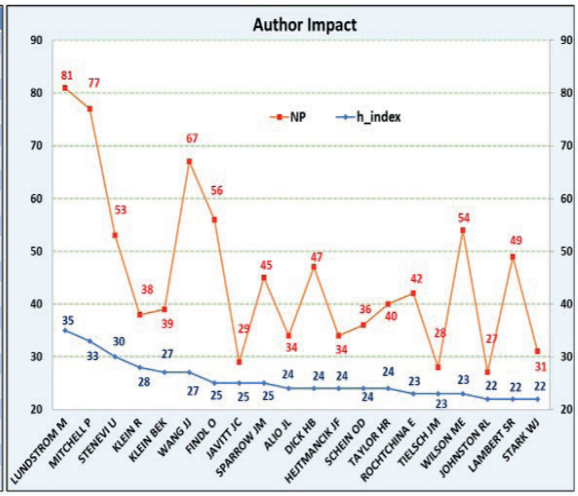


Figure 4. The impacts of the authors

Top-authors' production over the time

Figure 5 displays the publications of authors who have prepared articles in the field of cataracts over time. When the length of the publication line is examined, Menapace R (1988-2022), Sparrow JM (1986-2020), and Taylor HR (1986-2020) are the authors who have published on the topic of cataract for the longest duration, which spans 34 years. Among these authors, Menapace R's publication process is ongoing. When the production of authors is examined over time, 18 of the top 20 authors have a production span of more than 21 years (Figure 5.)

The circles in the figures represent the number of publications produced in that year. The darkness of the circle indicates the total number of citations the author received at the beginning of that year. LU Y produced the most articles in one year, with 12 publications in 2016. Klein BEK were the authors who received the most citations with 52.65 in 2001.

In the most recent year, 2022, Lundstrom M and Mitchell P produced the highest number of articles with 5, while Lundstrom M received the highest annual citation with a value of 7.5.

DOI: 10.5455/medscience.2023.10.211

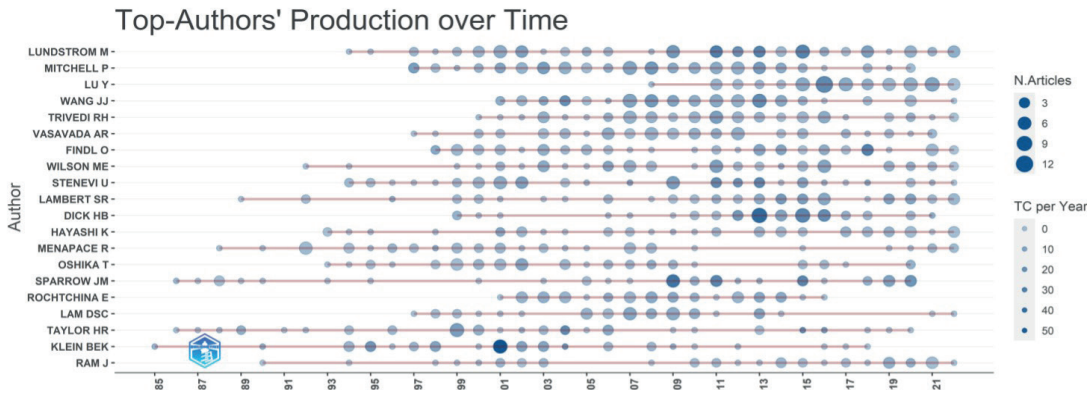


Figure 5. Top-authors' productions over time

Sources local impact

Table 2 displays the top 20 journals ranked by the total number of publications (local source impact). The top 20 journals accounted for 74.31% (7115/9574) of the published articles (Table 2).

The Journal of Cataract and Refractive Surgery represented 17.91% (1715/9574) of all articles, while ophthalmology represented 5.64% (540/9574) of all articles. The journal with the highest number of citations in publications with the title "Cataract" was the Journal of Cataract and Refractive Surgery with 45,024 citations. The second highest-cited journal is Ophthalmology with 540 citations.

Furthermore, an analysis of the citation count per article was conducted to show the ratio between the citation count and number of documents for each journal. The Archives of Ophthalmology had the highest average citation value per article [31].

Ophthalmology had the highest h-index value, with a score of 96. It also has a good publication output, with a value of 540. Clinical and Experimental Ophthalmology, which ranks last in the table with 161 publications, has a good h-index value of 28.

Table 2. Sources local impact

Source	NP	TC	TC/NP	H_Index	PY_Start
Journal of Cataract and Refractive Surgery	1715	45024	26.25	86	1986
Ophthalmology	540	29792	55.17	96	1983
British Journal of Ophthalmology	538	17709	32.92	67	1917
American Journal of Ophthalmology	440	14561	33.09	62	1983
Eye	395	8264	20.92	44	1881
Investigative Ophthalmology & Visual Science	350	13908	39.74	60	1983
Acta Ophthalmologica	309	4403	14.25	34	1923
Indian Journal of Ophthalmology	296	1950	6.59	23	2008
Experimental Eye Research	276	8726	31.62	49	1983
Molecular Vision	243	5795	23.85	40	1999
European Journal of Ophthalmology	240	2257	9.40	24	1991
Archives of Ophthalmology	238	13207	55.49	61	1983
Bmc Ophthalmology	220	1560	7.09	20	2008
Graefes Archive for Clinical and Experimental Ophthalmology	206	3322	16.13	28	1854
Current Eye Research	201	3967	19.74	33	1983
Ophthalmic Surgery and Lasers	199	3267	16.42	30	1983
International Ophthalmology	189	1324	7.01	17	1978
Current Opinion in Ophthalmology	186	4109	22.09	36	1990
International Journal of Ophthalmology	173	1073	6.20	15	2008
Clinical and Experimental Ophthalmology	161	2780	17.27	28	2000

NP: number of publications, TC: total citations, TC/NP: citations per paper, PY_Start: publication year starting

DOI: 10.5455/medscience.2023.10.211

The Indian Journal of Ophthalmology, which started publishing in 2008, has become influential in the field in a short time, with 296 publications, 1950 citations, and an h-index value of 23, according to the evaluation based on the year of publication.

Sources co-citation network

The Journals Co-citation Network was analyzed by examining the citations of articles published in journals that have published articles titled "Cataract." As shown in Figure 6, the common citation network of the top 30 journals was divided into two node clusters, represented by blue and red circles. Each circle represents the journal.

The blue cluster is the largest set, consisting of 25 journals. When looking at the size of the circles, Ophthalmology, Am J Ophthalmol, Arch Ophthalmol-Chic, J Cataract Refr Surg, Brit J Ophthalmol, Invest Ophth Vis Sci, and Eye are the journals with the most commonly cited articles among all journals. The red cluster consisted of five journals; however, no journal had a dominant position in the common citation network (Figure 6).

When the thickness of the lines between the circles was examined, it was observed that the articles published in the journals Ophthalmology- Am J Ophthalmol, Ophthalmology- Arch Ophthalmol-Chic, Am J Ophthalmol- Arch Ophthalmol-Chic, Ophthalmology- J Cataract Refr Surg, Am J Ophthalmol- J Cataract Refr Surg, Ophthalmology- Brit J Ophthalmol, Am J Ophthalmol- Brit J Ophthalmol received the highest number of co-citations compared to other articles.

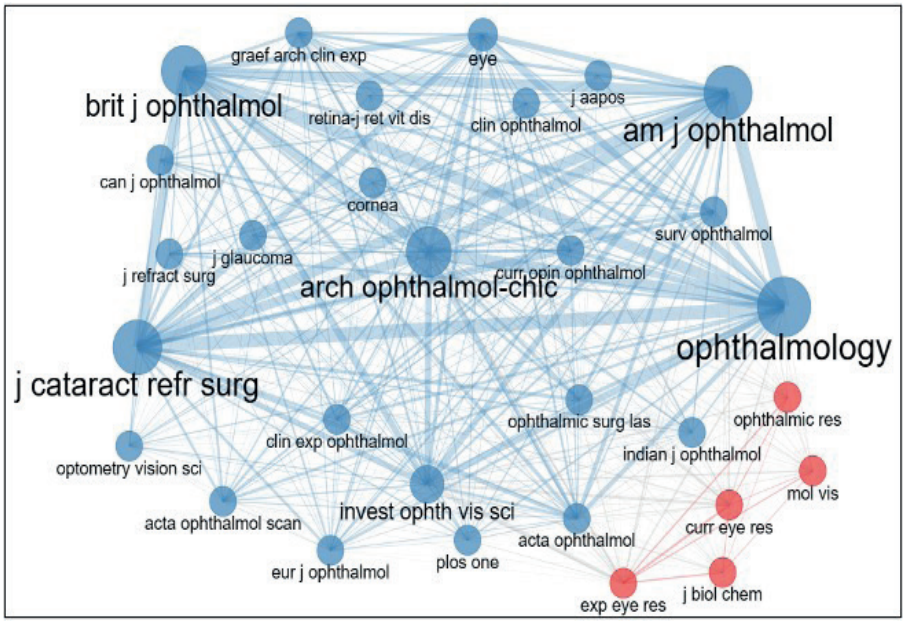


Figure 6. Citation network for cataract cirgeru studies

Most local cited document

The purpose of citation analysis was to identify the most cited articles in the field of cataract research and the connections among them. Citation analysis is commonly used to investigate the intellectual structure and developmental dynamics of a particular research field. The top 20 publications with the highest number of local citations (LC) in the field of cataract research are presented in descending order in Table 3.

Local citation shows the number of times a paper has been cited by articles within the same dataset of 9574 articles in WoS. Global citations, on the other hand, show how many times a paper has been cited in the WoS database. Steinberg's 1994 paper has received 181 local citations, followed by Congdon's 2004 paper with 175, Nagy's 2009 paper with 154, Barry's 2007 paper with 152, and Leske's 1991 paper with 148. In terms of global citations, Steinberg's 1994 paper received 727 citations, followed by Truscott's 2005 paper with 597, Barry's 2007 paper with 578, Leske's 1991 paper with 475, and Congdon's 2004 paper with 414 citations.

The initial publications in the study period have more time to receive citations, while the publications involved in the process towards the end of the time frame do not have enough time to receive sufficient citations. To eliminate the negative effects of the short time intervals after the publications in the later years of the process and to show the influence of the publication years of the articles, definitions of Annual Local Citations (LC/YYP) and Annual Global Citations (GC/YYP) were developed. The article with the highest LC/YYP value (11,000) is Nagy Z's 2009 article, and the article with the highest GC/YYP value (36,125) is Barry P's 2007 article (Table 3).

Another concept developed for authors with the most citations is Local Citation Percentage. The article with the highest local

DOI: 10.5455/medscience.2023.10.211

citation percentage is Parks (1993), with a value of 68.15%. The local citation percentage was obtained by dividing the number of local citations by the number of global citations.

It is possible to say that Nagy Z 2009, which was published most recently and collected the highest statistical data, is the most influential article in cataract research.

We can say that the most influential articles in the field of cataract research are Steinberg EP 1994 [32], Congdon N 2004 [33], Nagy Z 2009 [34], Barry P 2007, Leske MC 1991, Truscott RJW 2005, and Parks MM 1993. The three referenced articles significantly contribute to the understanding of the impact and management of cataracts. Steinberg et al.'s work in 1994 introduced the VF-14 index, a vital tool for gauging the functional impairment in cataract patients, aiding in the assessment of treatment outcomes [9]. Congdon et al., in 2004, offered a comprehensive analysis of the causes and prevalence of visual impairment in the U.S., highlighting cataract as a leading factor, thereby informing public health strategies [33]. Lastly, Nagy et al.'s 2009 study provided an early clinical evaluation of femtosecond lasers in cataract surgery, marking a technological advancement in surgical precision and patient outcomes [34].

Table 3. Most local cited document

Document	YP	LC	LC/YYP	GC	GC/YYP	LC/GC Ratio %
Steinberg EP, 1994, Arch Ophthalmol-Chic-a	1994	181	6.241	727	25.069	24.90
Congdon N, 2004, Arch Ophthalmol-Chic	2004	175	9.211	414	21.789	42.27
Nagy Z, 2009, J Refract Surg	2009	154	11.000	371	26.500	41.51
Barry P, 2007, J Cataract Refr Surg	2007	152	9.500	578	36.125	26.30
Leske MC, 1991, Arch Ophthalmol-Chic	1991	148	4.625	475	14.844	31.16
Powe NR, 1994, Arch Ophthalmol-Chic-a	1994	131	4.517	317	10.931	41.32
Mitchell P, 1997, Ophthalmology	1997	131	5.038	280	10.769	46.79
Desai P, 1999, Brit J Ophthalmol	1999	115	4.792	264	11.000	43.56
Lambert SR, 1996, Surv Ophthalmol	1996	112	4.148	243	9.000	46.09
Steinberg EP, 1994, Ophthalmology	1994	108	3.724	224	7.724	48.21
Klein BEK, 1990, Ophthalmology	1990	101	3.061	275	8.333	36.73
Taban M, 2005, Arch Ophthalmol-Chic	2005	101	5.611	390	21.667	25.90
Reddy MA, 2004, Surv Ophthalmol	2004	98	5.158	188	9.895	52.13
Truscott RJW, 2005, Exp Eye Res	2005	96	5.333	597	33.167	16.08
Keech RV, 1989, Am J Ophthalmol	1989	95	2.794	150	4.412	63.33
Parks MM, 1993, Ophthalmology	1993	92	3.067	135	4.500	68.15
barry P, 2006, J Cataract Refr Surg	2006	92	5.412	285	16.765	32.28
Narendran N, 2009, Eye	2009	92	6.571	198	14.143	46.46
Jaycock P, 2009, Eye	2009	88	6.286	186	13.286	47.31
Foster A, 1997, J Cataract Refr Surg	1997	85	3.269	188	7.231	45.21

YP: year of publication, YYP: year 2023-year of publication, GC: global citations, LC: local citations

Papers co-citation network

The Paper Co-citation Network was analyzed by examining the common citations of publications in cataract literature. As shown in Figure 7, the co-citation network of the top 30 articles was divided into four clusters represented by blue, red, green, and purple circles. Each circle represents an article, and each color represents a cluster. The presence of a connecting line between the circles representing articles indicates a relationship between them. The thickness of the line between circles represents the intensity of the relationship.

The article with the highest number of co-citations was Chylack LT 1993, which is in the blue cluster. This article has received more citations than any other article in the network.

There were nine articles in the red cluster, five in the green cluster, and three in the purple cluster. When the thickness of the lines between circles is examined, the articles with the highest number of co-citations together are Steinberg EP 1994-1- Steinberg EP 1994-2, Nagy Z 2009- Freidman NJ 2011, Nagy Z 2009- Kranitz K 2011, Kranitz K 2011- Freidman NJ 2011, and Klein BEK 1992- Mitchell P 1997 (Figure 7).

DOI: 10.5455/medscience.2023.10.211

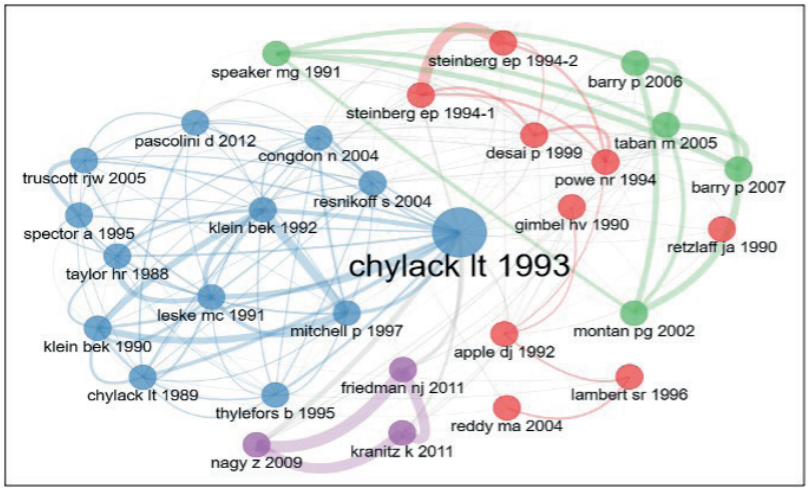


Figure 7. The most influential article network

Authors Keyword Analysis

Word cloud

The keywords used to describe the article were determined by the authors. Considering that these keywords represent the article, analyzing them is considered significant for identifying the current topics and themes of the research area [35].

The keyword frequency (number of occurrences) of the cataract research area was obtained using Bibliometrics. The word cloud is a graphical representation of the latest concepts in the cataract research area.

Through the word cloud, it becomes easier to identify overlapping areas and analyze keywords that have been on the agenda in these areas over the years [36].

The larger the keywords, the more frequently they were used in the dataset. Figure 9 presents the top 20 most frequent keywords determined by the article authors in the table and the top 50 in the word cloud. The most frequently used keywords were cataract, cataract surgery, phacoemulsification, glaucoma, and lenses (Table 4).

Table 4. Word cloud terms frequencies

Terms	Frequency
Cataract	1168
Cataract surgery	1037
Phacoemulsification	488
Glaucoma	157
Lens	149
Congenital cataract	142
Cataract extraction	139
Intraocular lens	138
Intraocular pressure	122
Visual acuity	115
Endophthalmitis	100
Astigmatism	86
Epidemiology	83
Age-related cataract	81
Surgery	71
Extracapsular cataract extraction	68
Complications	60
Diabetes	56
Pediatric cataract	56
Vitrectomy	55

DOI: 10.5455/medscience.2023.10.211

Trend topics

The graph in Figure 10 shows the popularity of the keywords selected by the authors and the years in which they became popular. The top two keywords used at least five times each year are visualized (Figure 8).

Keywords used in cataract research have evolved over time. During the period of 1991-1994, the most used key terms were Self-Sealing Incision, Glare, Aldose Reductase Inhibitor, Flurbiprofen, Sodium Hyaluronate, Cataract Classification, and Extracapsular Cataract Extraction. However, recently, the trend has shifted towards keywords such as Manual Small-Incision Cataract Surgery, Msics, Minimally Invasive Glaucoma Surgery, COVID 19, Dry Eye, Ophthalmology, Femtosecond Laser-Assisted Cataract Surgery, and Axial Length. When considering the size of the circles in the graph, it can be observed that the cataract key term was most frequently used in 2013, Cataract Surgery in 2014, and phacoemulsification in 2015.

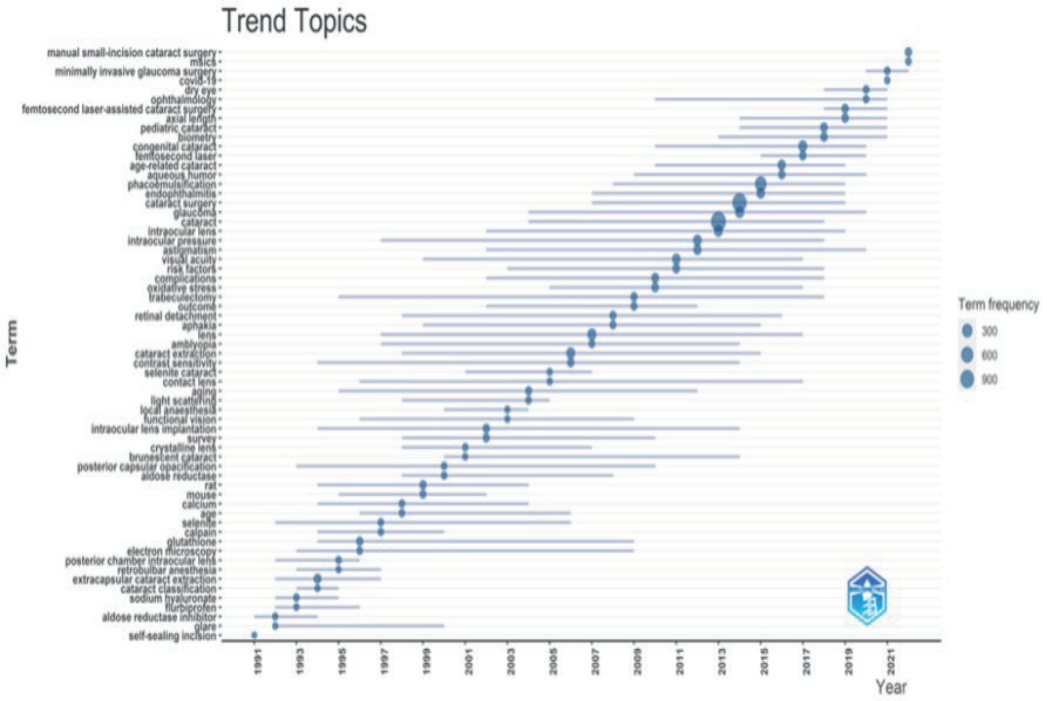


Figure 8. Trend topics for cataract surgery

Conceptual Structure Analysis

Strategic diagram

The strategic diagram containing each sub-period of the cataract research, generated by Bibliometrix using the top 250 author keywords repeated at least six times, is presented in Figure 12. The most frequently repeated keywords were then grouped into theme clusters. The three most repeated keywords represent each cluster. The size of the circles is proportional to the frequency of corresponding keyword usage.

In analyses conducted through thematic mapping, research themes can be visualized using networks that are resolved across multiple time periods, allowing for the identification of their dynamics (Schöggl et al., 2020).

The strategic diagram reflects the interactions between the factors identified in each research topic over time. This diagram is a static description of the network structure of a research field [37,38].

The strategic diagram was divided into four quadrants representing different interpretations of the themes. Each quadrant was interpreted independently. For this purpose, two parameters–centrality and density–were identified. The density parameter represents the y-axis, and the centrality parameter represents the x-axis, representing the thematic map. The more central a selected theme is, the more important it is, and the denser it is, the more it has completed its development [39].

The thematic development of cataract research between 1983 and 2022 was analyzed from a dynamic perspective. The research period (1983-2022) was divided into four sub-periods based on document count and time window. Although dividing the time periods into equal time intervals is more common, the first sub-period was determined to be 21 years (1983-2004) due to limited publications in the early years, the second sub-period was 9 years (2005-2013), the third sub-period was 6 years (2014-2019), and the fourth sub-period was 3 years (2020-2022).

DOI: 10.5455/medscience.2023.10.211

The Motor Themes, which represent the high density and high centrality required for the development and work area, are the 1st quarter theme located in the upper right of the thematic map. The Niche Themes, which represent highly developed but isolated high-density and low centrality, are the 2nd quarter theme located in the upper left of the thematic map. The Emerging or Declining Themes, which have low centrality and density values that are newly emerging or declining, are the 3rd quarter theme located in the lower left of the thematic map. The Basic Themes, which have been extensively researched and have well-developed internal connections with low density and high centrality, are the 4th quarter theme located in the lower right of the thematic map [13,38].

Examining the recent period of 2020-2022, it can be observed:

Motor Themes are the first quarter of themes and consist of one cluster. The first cluster consists of keywords Congenital Cataract, Astigmatism, and Intraocular Lens, which represent the focal point and emphasis of the research area. Motor Themes are central and well-developed themes systematically addressed by researchers over a long period of time.

Niche Themes are second-quarter themes and consist of four clusters. The first cluster consisted of the keywords Glaucoma, Intraocular Pressure, Minimally Invasive Glaucoma Surgery, the second cluster consisted of Epidemiology, Artificial Intelligence, Deep Learning, the third cluster consisted of Aqueous Humor, Inflammation, and the fourth cluster consisted of Cataracts and Oxidative Stress. These themes are peripheral and advanced, with well-developed internal connections and marginal external importance.

Emerging or Declining Themes were the third quarter themes and consisted of two clusters. The first cluster consists of the keywords Glaucoma, Intraocular Pressure, Minimally Invasive Glaucoma Surgery, and the second cluster consists of Vitrectomy, Case Report, Flacs. These themes were peripheral and underdeveloped, with weak internal and external connections, representing emerging or declining topics.

Basic Themes are the fourth-quarter themes and consist of four clusters. The first cluster consists of Cataract, Phacoemulsification, and Lens; the second cluster consists of Cataract Surgery, Endophthalmitis, and Age-Related Cataract; the third cluster consists of Manual Small-Incision Cataract Surgery, Visual Acuity, Msics; and the fourth cluster consists of Vitrectomy, Case Report, Flacs. These themes may be active research topics that have matured over time.

Thematic evolution

To examine the changes and development of cataract themes over the years, in addition to the four-period Strategic Diagram, a four-period Thematic Evolution Mapping visualized in Figure 14 was created (Figure 10).

The size of the nodes represents the number of keywords, whereas the flow lines between nodes indicate the evolution direction of the theme clusters over time. A theme that develops over sub-periods can be considered a thematic field [5].

When analyzing the diagram, there were four themes in the first period, six themes in the second period, seven themes in the third period, and nine themes in the fourth period. The keyword "Cataract," which is the subject of our study, appeared in all four periods of the thematic map. In the period to 2005-2013, the Cataract theme was nourished by the sub-themes of Cataract and Lens, while in the period–2014-2019, it was nourished by the sub-themes of Phacoemulsification and Cataract. In the period–2020-2022, it was nourished by its own subthemes.

Along with the Cataract theme, other themes emerged as follows: Cataract Surgery, Phacoemulsification, and Lens in the period–1983-2004; Intraocular Lens, Phacoemulsification, Cataract Surgery, Congenital Cataract, and Oxidative Stress in the period–2005-2013; Congenital Cataract-Related Cataract, Cataract Surgery, Astigmatism, Glaucoma, and Cataract Extraction in the period–2014-2019; and Congenital Cataract, Cataract Surgery, Aqueous Humor, Glaucoma, Epidemiology, Vitrectomy, and Manual Small-Incision Cataract Surgery in the period–2020-2022.

Discussion

This manuscript delivers an unparalleled bibliometric examination and science mapping analysis that chronicles the evolution of research paradigms, surgical methodologies, and technological advancements in cataract surgery spanning four decades from 1983 to 2022. This comprehensive dissection is of seminal importance; it not only serves as a pioneering endeavor within the annals of ophthalmic literature but also provides an indispensable academic resource for clinicians, researchers, and policymakers. Herein, we illuminate how our research findings provide actionable insights and implications for future studies in the field of cataract surgery.

In the initial period (1983-2004), the thematic structure was relatively limited, characterized by the concentration of foundational elements, such as cataract surgery itself, lens technology, and phacoemulsification. The emphasis on these foundational themes aligns with the technological and surgical advancements of the era, reflecting the scientific community's efforts to establish and refine basic procedures and techniques in cataract management [19,33].

The second period (2005-2013) showed an expansion of themes with the integration of intraocular lenses, congenital cataracts, and oxidative stress, and continued focus on phacoemulsification. This expansion signifies a broader exploration of pathophysiology and surgical variations, indicating a transition towards specialized practices and the incorporation of novel technological advances, such as artificial intelligence and deep learning, particularly in diagnostics and surgical planning [1,7].

The third period (2014-2019) further refined these themes, with an apparent emphasis on specific aspects, such as congenital cataract-

DOI: 10.5455/medscience.2023.10.211

related cataracts, astigmatism, and glaucoma. The coalescence of sub-themes, such as phacoemulsification with cataracts, reflects the ongoing refinement in surgical techniques and the recognition of cataract surgery as a multifaceted intervention that interfaces with other ophthalmological concerns. The emergence of themes such as astigmatism and glaucoma underscores increasing awareness of the interconnectedness of eye disorders [31].

The final period (2020-2022) provided the most recent insights into the thematic network of cataract surgery research, with an even more diversified spectrum of focus areas, including congenital cataracts, aqueous humor, epidemiology, vitrectomy, and manual small-incision cataract surgery. The inclusion of epidemiological themes has led to growing interest in population-based approaches to cataract management, acknowledging the global burden of the disease. The prominence of themes like congenital cataract and small-incision cataract surgery reflects a shift toward personalized and minimally invasive procedures [9,27].

Thematic evolution mapping underscores the dynamic nature of cataract research, showing how foundational themes have nourished subthemes over time, forming a complex web of interrelated topics. The strategic diagram, revealing the interactions between the factors identified in the research over time, assists in interpreting the relative importance and developmental state of these themes. The motor, niche, emerging or declining, and basic themes each tell a story of evolution, maturation, innovation, and perhaps even potential future directions [9].

The emergence of 'motor themes,' 'niche themes,' 'emerging or declining themes,' and 'basic themes' provides a robust schematic through which research foci can be hierarchically organized. For instance, the identification of 'motor themes' like 'intraocular lenses' or 'phacoemulsification' can signal their foundational importance and, as such, could influence the prioritization of research grants and clinical trials [31].

Our study captures the noteworthy inclusion of artificial intelligence and deep learning in cataract surgery, particularly in the realm of diagnostics and surgical planning. The advent of these computational technologies has opened a gateway for interdisciplinary collaboration. Researchers in machine learning could benefit from these insights by venturing into domain-specific modifications tailored for ophthalmic applications.

Eye surgeons and clinicians can extract actionable insights from this comprehensive overview into the development and application of emerging trends such as minimally invasive glaucoma surgery, artificial intelligence in diagnosis, and personalized approaches to congenital cataracts. Furthermore, researchers can recognize areas that may benefit from further investigation, such as the relationships between oxidative stress and cataract formation, integration of deep learning into surgical planning, and long-term outcomes of specific surgical techniques [9,31].

Based on an extensive survey of the extant literature, the present analysis represents an unprecedented and comprehensive bibliometric exploration of the domains of cataract pathology and surgical intervention. As an amalgamation of pivotal findings and emerging trends, this study was engineered to serve as an invaluable, solitary source of information renewal for clinicians and medical practitioners. Centralizing a diverse array of research perspectives and empirical data facilitates efficient utilization of time, which is often considered an irreplaceable asset in the clinical environment [9,31].

Simultaneously, the encompassing nature of this analysis not only elucidates the present landscape of cataract research, but also prognosticates the vectors along which future inquiries and innovations are most likely to advance. By meticulously delineating state-of-the-art methodologies, prevailing paradigms, and unresolved challenges, this study contributes an indispensable roadmap for guiding subsequent scholarly endeavors. It identifies thematic gaps and uncharted territories, thereby demarcating domains that remain ripe for exploration and further scholarly cultivation [25].

As the inaugural and most expansive bibliometric analysis focuses specifically on cataract surgery, this work is intended to serve as a cornerstone in the academic edifice of ophthalmic research. It offers an encapsulated yet exhaustive compendium that obviates the need for piecemeal information retrieval. Researchers can now engage with a single comprehensive article to gain a multidimensional understanding of historical trends, current methodologies, and future directions in cataract surgery.

This study represents more than a bibliometric and science mapping analysis; it is a monumental academic artifact that heralds a new epoch in the study of cataract surgery. Its robust scope and depth make it a pivotal reference point that not only informs current clinical and research strategies, but also shapes the contours of future scholarly inquiries. This analysis elucidates the labyrinthine and synergistic nature of cataract research, acting as a meta-narrative that synthesizes disparate studies into a coherent, actionable framework. Consequently, it is an invaluable resource offering prospective directives for the ever-evolving field of cataract surgery.

Chronological Advancements in Cataract Surgery: Key Takeaways

1983-2004: Foundational period

- Focus on basic cataract surgery techniques, lens technology, and phacoemulsification,
- Significant advancements in establishing and refining cataract management procedures.

2005-2013: Expansion and specialization

- Integration of intraocular lenses and exploration of congenital cataracts and oxidative stress,
- Continued improvement in phacoemulsification techniques,

DOI: 10.5455/medscience.2023.10.211

- Beginning of technological integration with the adoption of AI and deep learning for diagnostics and planning.

2014-2019: Refinement and interdisciplinary integration

- Emphasis on specific conditions, such as congenital cataracts, astigmatism, and glaucoma,
- Recognition of cataract surgery as a multifaceted procedure interconnected with broader ophthalmological concerns.

2020-2022: Diversification and population-based approaches

- Inclusion of epidemiological themes reflecting a shift toward understanding cataract surgery within a global health context,
- Focus on personalized, minimally invasive procedures, such as small-incision cataract surgery.

Identifying Persisting Gaps and Future Research Avenues

Need for longitudinal studies

- Further investigation into the long-term outcomes of current surgical techniques,
- Relationship between oxidative stress and cataract formation.

Technological and methodological innovations

- Integration and implications of artificial intelligence and machine learning in ophthalmic diagnostics and surgery,
- Development of less invasive glaucoma surgeries and their impact on patient care.

Personalized medicine and surgical approaches

- Focused research on congenital cataracts and patient-specific interventions,
- Exploration of the role of genetics in cataract development and treatment response.

Conclusion

This comprehensive analysis delineates the rich tapestry of cataract surgery research from 1983 to 2022, showcasing an evolving field that has continually adapted to technological innovations, clinical challenges, and changing needs of patients. By synthesizing these themes, our study provides a roadmap for future research and clinical practice, highlighting the intricate interplay between historical progression, current methodologies, and prospective directions in cataract surgery.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The bibliometric analysis presented in our study utilizes publicly accessible data sourced from the open-access Web of Science database, thereby obviating the need for ethical approval or institutional permission.

References

1. Pan C-W, Liu H, Sun H-P, Xu Y. Increased difficulties in managing stairs in visually impaired older adults: a community-based survey. PLoS One. 2015;10:e0142516.
2. Charette C, Blanchet S, Maganaris CN, et al. Community-dwelling older adults with mild cognitive impairments show subtle visual attention costs when descending stairs. Hum Mov Sci. 2020;69:102561.
3. Keeffe J, Taylor HR, Fotis K, et al. Prevalence and causes of vision loss in Southeast Asia and Oceania: 1990–2010. Br J Ophthalmol. 2014;98:586-91.
4. Hashemi H, Pakzad R, Yekta A, et al. Global and regional prevalence of age-related cataract: a comprehensive systematic review and meta-analysis. Eye. 2020;34:1357-70.
5. Sönmez FT, Tabur A. Bibliometric study on geriatric emergencies: intellectual structure, prominent themes, and future-directing topics: bibliometric study on geriatric emergencies. Medical Science and Discovery. 2023;10:855-67.
6. Duman R, Cevik SG, Cevik MT, Duman R. Prevalence of corneal astigmatism and axial length in cataract surgery candidates in Turkey. The Eur Res J. 2017;3:25-9.
7. Wu F, Wang S, Zhu J, et al. Public impact, prevention, and treatment of cataracts. Sci China Life Sci. 2015;58:1157-9.
8. Debas HT, Donkor P, Gawande A, et al., editors. Essential Surgery: Disease Control Priorities, Third Edition (Volume 1). Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2015 Apr 2.
9. Lu A, Li K, Su G, Yang P. Revealing academic evolution and frontier pattern in the field of uveitis using bibliometric analysis, natural language processing, and machine learning. Ocul Immunol Inflamm. 2023:1-16.
10. Yan X, Guan C, Mueller A, et al. Outcomes and projected impact on vision restoration of the China Million Cataract Surgeries Program. Ophthalmic Epidemiol. 2013;20:294-300.
11. Feng J, Jan C, Peng Y, et al. Retrospective analysis of cataract surgery outcomes in China from 2009 to 2018: from a national registry system data. BMJ Open. 2023;13:e070989.
12. Zabidin NS, Belayutham S, Ibrahim CKIC. A bibliometric and scientometric mapping of Industry 4.0 in construction. J Inf Technol Constr. 2020;25:287-307.
13. Chen C, Chen C. Mapping scientific. Frontiers. Springer; 2003;5:342-6.
14. Bankar RS, Lihitkar SR. Science mapping and visualization tools used for bibliometric and scientometric studies: a comparative study. J Adv Libr Sci. 2019;6:382-94.
15. Aria M, Cuccurullo C. Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics. 2017;11:959-75.
16. Van Raan A. Measuring science: basic principles and application of advanced bibliometrics. In: Glänzel W, Moed HF, Schmoch U, Thelwall M, eds, Springer Handbook of Science and Technology Indicators. Springer Verlag. 2019;237-80.
17. Leydesdorff L. World shares of publications of the USA, EU-27, and China compared and predicted using the new Web of Science interface versus Scopus. Profesional de la Información. 2012;21:43-9.
18. Hirsch JE. An index to quantify an individual's scientific research output. Proceedings of the National academy of Sciences. 2005;102:16569-72.
19. Lundström M, Stenevi U, Thorburn W. The Swedish national cataract register: a 9-year review. Acta Acta Ophthalmol Scand. 2002;80:248-57.

20. Mitchell P, Cumming RG, Attebo K, Panchapakesan J. Prevalence of cataract in Australia: the Blue Mountains eye study. Ophthalmology. 1997;104:581-8.

21. Johansson B, Lundström M, Montan P, et al. Capsule complication during cataract surgery: long-term outcomes: Swedish capsule rupture study group report 3. J Cataract Refract Surg. 2009;35:1694-8.

22. Klein R, Klein BE, Wong TY, et al. The association of cataract and cataract surgery with the long-term incidence of age-related maculopathy: the Beaver Dam eye study. Arch Ophthalmol. 2002;120:1551-8.

23. Klein BE, Klein R, Lee KE, Grady LM. Statin use and incident nuclear cataract. JAMA. 2006;295:2752-8.

24. Egghe L. Theory and practise of the g-index. Scientometrics. 2006;69:131-52.

25. Triepels RJ, Segers MH, Rosen P, et al. Development of machine learning models to predict posterior capsule rupture based on the EUREQUO registry. Acta Ophthalmol. 2023;101:644-50.

26. Bao F, Lopes BT, Zheng X, et al. Corneal biomechanics losses caused by refractive surgery. Curr Eye Res. 2023;48:137-43.

27. Donachie PH, Barnes BL, Olaitan M, et al. The Royal College of Ophthalmologists' National Ophthalmology database study of cataract surgery: report 9, risk factors for posterior capsule opacification. Eye. 2023;37:1633-9.

28. Lieu AC, Jun JH, Afshari NA. Intracameral antibiotics during cataract surgery: efficacy, safety, and cost–benefit considerations. Curr Opin Ophthalmol. 2024;35:50-6.

29. Zafar S, Dun C, Srikumaran D, et al. National physician-level endophthalmitis rates for cataract surgery among medicare beneficiaries in the United States: 2011-2019. Ophthalmology. 2023;130:872-4.

30. Cicinelli MV, Buchan JC, Nicholson M, et al. Cataracts. Lancet. 2023;401:377-89.

31. Kaplan AT. Bibliometric analysis of the most cited articles on congenital cataract from 1980 to 2022. J Health Sci Med / JHSM. 2023;6:106-10.

32. Steinberg EP, Tielsch JM, Schein OD, et al. The VF-14: an index of functional impairment in patients with cataract. Arch Ophthalmol. 1994;112:630-8.

33. Congdon N, O'Colmain B, Klaver C, et al. Causes and prevalence of visual impairment among adults in the United States. Arch Ophthalmol. 2004;122:477-85.

34. Nagy Z, Takacs A, Filkorn T, Sarayba M. Initial clinical evaluation of an intraocular femtosecond laser in cataract surgery. J Refract Surg. 2009;25:1053-60.

35. Zheng J, He L, Zhong J. Effect of femtosecond laser-assisted arcuate keratotomy versus toric intraocular lens implantation on correction of astigmatism in cataract surgery: a systematic review and meta-analysis. Lasers in Medical Science. 2023;38:225.

36. Han X, Zhang J, Liu Z, et al. Real-world visual outcomes of cataract surgery based on population-based studies: a systematic review. Br J Ophthalmol. 2023;107:1056-65.

37. Thakkar RN, Kioutchoukova IP, Griffin I, et al. Mapping the glymphatic pathway using imaging advances. J. 2023;6:477-91.

38. Afşin H. Assessing metastasis through positron emission tomography (PET): an in-depth analysis and mapping of thematic clusters and prevailing topics in nuclear medicine research: mapping metastasis: a PET analysis in nuclear medicine research. Medical Science and Discovery. 2023;10:803-17.

39. Nasir NI. Assessment of low vision and blindness in children with multiple handicaps. Journal of Patuakhali Medical College. 2023;2:14-7.