Original Article

Intraocular lens power calculation formulas: a scientometric analysis

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ABSTRACT

Background: The most accurate method of intraocular lens (IOL) power calculation in cataract surgery has not been determined, and further studies are needed to reach a consensus. The aim of this study was to assess publications related to IOL power calculation formulas, mapping their yearly trends, most productive authors, top publishing countries and institutions, and areas of specialization for IOL power formulas.

Methods: We conducted a comprehensive analysis of research articles published on the topic of IOL power calculation formulas. Using PubMed, we employed appropriate search terms and filtered the results for the period of January 1, 1946, to June 28, 2023. Data were analyzed using CiteSpace, VOSviewer, and Microsoft Excel programs. The visual representations of the collected data through the use of figures was provided to demonstrate the aspects of IOL power calculation research.

Results: We retrieved 5475 documents in the initial search. Analysis of these documents revealed an increase in the number of publications, from one publication in 1946 to 201 publications in 2023. The top three countries contributing to these publications were the United States, China, and Japan, collectively accounting for over 27% of the total articles. However, the two institutions with the highest contributions were located in the United Kingdom and Hungary, neither of which was among the top 10 countries in overall contributions. Overall 15 326 authors contributed to publications pertaining to IOL power calculation formulas. Among these authors, the most prolific contributors included Achim Langenbucher from Saarland University (Germany), Giacomo Savini from G.B. Bietti Foundation I.R.C.C.S. (Italy), and Kenneth J Hoffer from the University of California (United States). Saarland University emerged as the most productive institution, contributing equally to two distinct departments: the Dr. Rolf M. Schwiete Center for Limbal Stem Cell Research and Congenital Aniridia, as well as the Department of Experimental Ophthalmology. The School of Physical Science at the Open University in the United Kingdom engaged in partnership with various institutions including Eye & Laser Clinic Castrop Rauxel in Germany and Johannes Kepler University Linz in Austria. Among the top 10 keywords found in the publications were "cataract", "cataract surgery", and "intraocular lens".

Conclusions: This study represents the first scientometric analysis of publications related to IOL power calculation formulas. The study offers valuable insights into the geographic distribution, contributing authors, and emphasis of research on the IOL power calculation formulas. Further cooperation is essential to pinpoint the most suitable formula and to address gaps in our current understanding.

KEYWORDS

cataracts, cataract extractions, intraocular lenses, intraocular lens implantations, pseudoaphakia, biometric analysis, bibliometric analysis

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INTRODUCTION

The invention of the intraocular lens (IOL) aimed to counteract one of the most pervasive vision issues on a worldwide scale [1, 2]. Unfortunately, the outcomes were unsatisfactory, as patients continued to struggle with refractive error, a famously widespread visual impairment [1, 2]. Consequently, variety of formulas have been developed in an effort to assuage this challenge, considering that the mere act of implanting the IOL without properly correcting its power is insufficient [2]. Biometry, an application of mathematics to the biological sciences historically used to develop formulas and methods for calculating the optimum power of IOLs evolved [2, 3]. The relevance of precise IOL power calculations is highlighted by the need to realize the patient's desired postoperative refractive state, such as emmetropia [2].

The most accurate method for calculating refractive power for IOL implantation in cataract surgery has not been determined, and further studies are needed to reach consensus [4]. For instance, the Kane calculation formula has shown comparative superiority in estimating postoperative refraction. Newly modified formulas have also shown improvement [4]. For trifocal IOLs, the Olsen and Barrett formulas yield the best overall results, with the Kane and Olsen formulas being the most accurate for axial lengths up to 22.5 mm [5]. New-generation formulas outperform older ones for patients with myopia and short eyes according to two meta-analyses [6, 7]. The Barrett Universal II formula is most suitable for normal/long eyes, while the Haigis and EVO formulas are preferred for short eyes according to another study [8].

Since the introduction of IOLs, various techniques have been established to estimate the needed IOL power using diverse modalities including theoretical, numeric regression, and vergence equations [2]. Early on, the number of equations were few, including the Hoffer, Haigis, and Barrett, among others [3]. Subsequently, the development of new equations accelerated, requiring their categorization into four generations. The incorporation of artificial intelligence into this field has led to the development of novel equations [3, 9].

Most recently, with technological advancement, the pace of formula development and publishing has accelerated. Multiple new formulas are published on the internet, whereas decades ago, few developed formulas required specialized skills for incorporation into biometric devices [10-12].

Bibliometric analysis is a widely accepted and popular quantitative method for analyzing large datasets from articles across diverse fields [13]. Various bibliometric tools, such as Gephi, Bibliometrix R, VOSviewer, and CiteSpace are used to analyze trends, identify major contributors, explore central themes, and investigate frontiers of research in a given field [14]. In this scientometric study, we assessed publications related to IOL power calculation formulas, mapping their yearly trends, most productive authors and research groups, top publishing countries and institutions, and areas of specialization for IOL power formulas.

METHODS

This scientometric study used bibliometric analysis to identify trends in published research related to IOL power calculation formulas. Additionally, it found the major contributing authors, institutions, and countries associated with papers on IOL research.

We used a bibliometric approach to articles indexed in PubMed. We incorporated a systematic search strategy followed by analysis using both CiteSpace (version 6.2.R2, Drexel University, Philadelphia, PA, USA) and VOSviewer 1.6.19 (Centre for Science and Technology Studies, Leiden University, The Netherlands). Finally, a descriptive analysis was performed using Microsoft Excel 2019 (Microsoft Corporation, Redmond, WA, USA).

Two independent reviewers (A.T. and S.A.A) conducted a literature search using the following search terms: ((Lenses, Intraocular[MeSH Terms]) OR (IOL) OR (Cataract[MeSH Terms]) AND ((biometry[MeSH Terms]) OR (calculation) OR (Power)), and both author keywords and MeSH terms were used in the search strategy. We included articles of all categories, in all languages, published from January 1, 1946, to June 28, 2023. A total of 5475 publications were included, with no restrictions on language, field, or article type. Data were obtained from each citation PMID (the unique identification number in PubMed) using PubMed to NBIB format and download_.txt format.

CiteSpace (6.2.R2), VOSviewer (1.6.19), and Microsoft Excel 2019 were used to perform bibliometric analysis and visualization. CiteSpace is a Java application for visualizing and analyzing emerging trends and changes in the scientific literature [15]. We used the CiteSpace to visualize maps of author and country distributions. The CiteSpace parameters were as follows: timespan (January 1, 1946, to June 28, 2023), "years per slice" set to 1, term source (title, abstract, author, keywords, and keywords plus), pruning (none), node type (chosen one at a time), and selection criteria (top 100% objects). Other parameters followed the default settings. The nodes in CiteSpace have different colors, and node size is proportional to the occurrence frequency [16].

The CiteSpace uses betweenness centrality to measure the extent to which paths in the network may go through the node [17]. A node with a high betweenness centrality would be particularly informative in understanding why two clusters are connected [18].

VOSviewer is another bibliometric software program used for constructing and viewing bibliometric maps, displaying items in certain types of clusters and various density colors [17]. We used VOSviewer to visualize a map of co-occurring keywords and a map of institutions. The links in VOSviewer indicate co-occurrence, and the thickness of the links depends on the strength values. That is, thicker lines indicate a stronger link [19].

Microsoft Excel tables were created to display information about productive countries, authors, institutions, and keywords used in this study. Keywords serve as valuable tools for summarizing research hotspots and their primary directions [20]. All data were extracted from PubMed, a publicly available and unrestricted database that requires no permission for use of information.

RESULTS

From 1946 to 2023, global annual publication increased remarkably, surging from one publication in 1946 to a substantial 201 publications in 2023 (Figure 1).

A total of 5475 documents originated from 204 countries. The leading countries contributing literature related to IOL power calculation formulas were the United States of America (USA) with 884 publications (16.1%), followed by China with 384 publications (7.0%), Japan with 229 publications (4.2%), and Germany with 214 publications (3.9%) (Table 1).

Figure 2 illustrates international collaboration within this field using a CiteSpace visualization map, wherein each node represents a country and the node size corresponds to the number of publications. The links between nodes depict collaborative efforts. An analysis of the publication distribution by country highlights that China, the USA, and Germany exhibit the highest betweenness centrality, indicating their significant role in connecting various collaborators. Notably, the centrality of China surpassed 0.1, underscoring its substantial impact in the field.

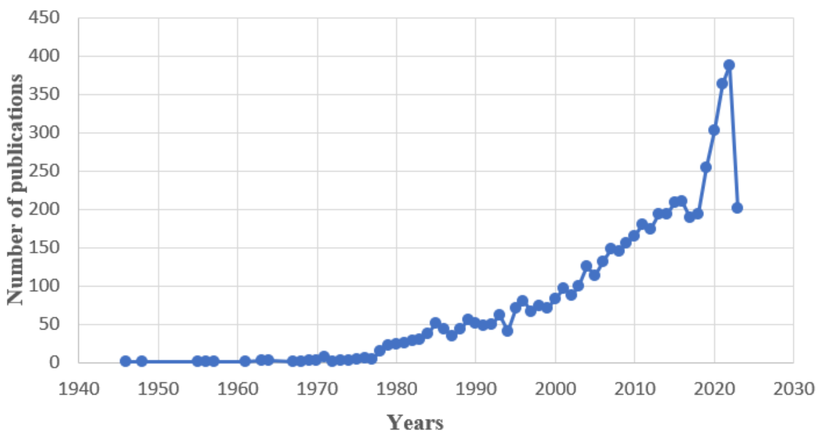

Figure 1. Global number of publications from 1946 to 2023.

Table 1. Ten most productive countries for research in intraocular lens power calculation formulas

Rank	BC	Number of Records	BC	Percentage (%)
1	USA	884	0.1	16.1
2	China	384	0.11	7.0
3	Japan	229	0.02	4.2
4	Germany	214	0.05	3.9
5	Spain	197	0.04	3.6
6	India	169	0.01	3.1
7	Italy	136	0.01	2.5
8	Australia	114	0.02	2.1
9	Austria	108	0.01	2.0
10	Korea	88	0.01	1.6

Note: BC indicates betweenness centrality.

The institution with the highest number of publications in this field was the Open University in the United Kingdom (UK), accounting for 27 (0.49% of the total), followed by Semmelweis University in Hungary with 22 publications (0.40%) and Eye & Laser Clinic Castrop Rauxel in Germany with 21 publications (0.38%) (Table 2). Saarland University emerged as the most productive institution, contributing equally to two distinct departments: the Dr. Rolf M. Schwiete Center for Limbal Stem Cell Research and Congenital Aniridia, as well as the Department of Experimental Ophthalmology. The distribution of institutions and their collaborative relationships were visualized using VOSviewer, wherein each node represents an institution and the connecting lines illustrate collaboration and their relationships. However, the collaboration between institutions was somewhat limited. The School of Physical Science at the Open University in the UK engaged in partnership with various institutions including Eye & Laser Clinic Castrop Rauxel in Germany and Johannes Kepler University Linz in Austria. Figure 3 provides a detailed view of institutional relations.

In our study, a total of 15 326 authors contributed to publications pertaining to IOL power calculation formulas. Among these authors, the most prolific contributors included Achim Langenbucher (85 articles) from Saarland University (Germany), Giacomo Savini (71 articles) from G.B. Bietti Foundation I.R.C.C.S. (Italy),

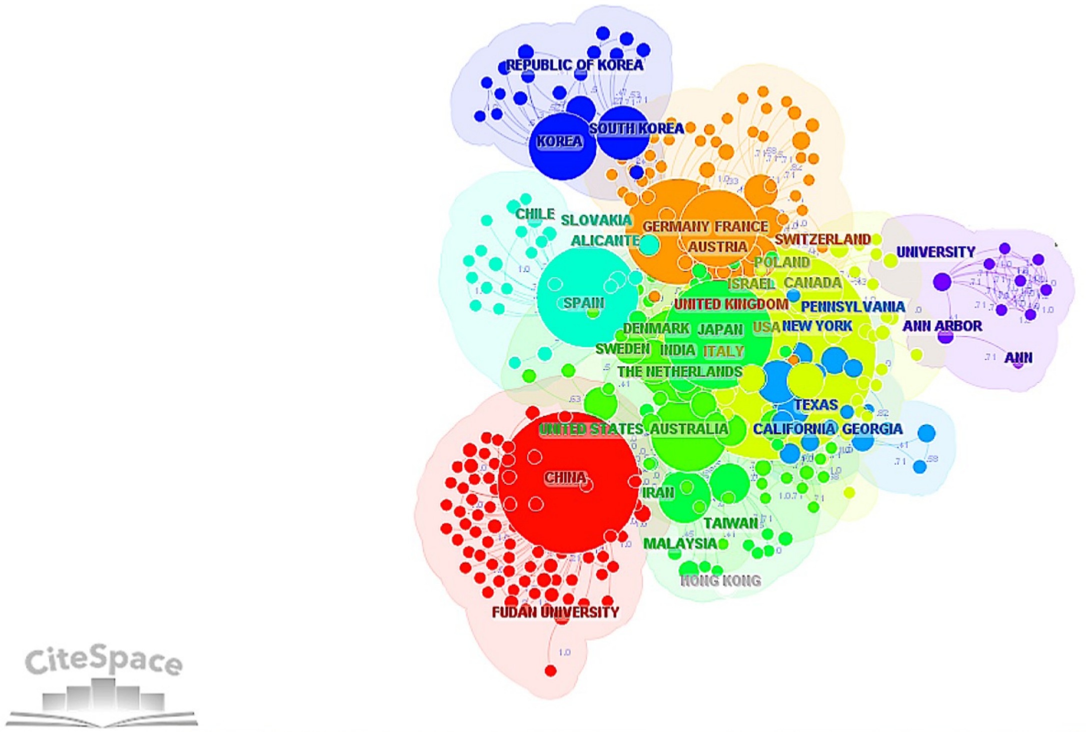

Figure 2. Visualization map of countries/cities/universities in studies of intraocular lens power calculation formulas.

Table 2. Institutions in studies of intraocular lens power calculation

Rank	Institution	Country	Number of Records	Percentage (%)
1	The Open University (School of Physical Sciences)	United Kingdom	27	0.49
2	Semmelweis University (Department of Ophthalmology)	Hungary	22	0.40
3	Eye & Laser Clinic Castrop Rauxel (Augen- & Laserklinik Castrop-Rauxel)	Germany	21	0.38
4	Saarland University (Dr. Rolf M. Schwiete Center for Limbal Stem Cell Research and Congenital Aniridia)	Germany	20	0.37
5	Saarland University (Department of Experimental Ophthalmology)	Germany	20	0.37
6	Keio University School of Medicine (Department of Ophthalmology)	Japan	16	0.29
7	Johannes Kepler University Linz (Department of Ophthalmology)	Austria	15	0.27
8	Sun Yat-sen University (Zhongshan Ophthalmic Center)	China	15	0.27
9	University of Alicante (Department of Optics, Pharmacology and Anatomy)	Spain	15	0.27
10	Korea University College of Medicine (Department of Ophthalmology)	South Korea	13	0.24

and Kenneth J Hoffer (67 articles) from the University of California (USA) (Table 3). Figure 4 presents a more comprehensive visualization of author distribution. In this image, each node represents an author within clusters, each cluster is identified by a certain color, and the links signify cooperative relationships between authors. Achim Langenbucher and Giacomo Savini had the greatest number of publications, despite belonging to different clusters. Seven clusters were found, each representing a group of researchers who published together in the same area. The red cluster features Kenneth J Hoffer, Giacomo Savini, and David P Pinero. In the dark orange cluster are Achim Langenbucher, Oliver Findl, Peter Hoffman, and Nora Szentmary. The light orange cluster includes Graham D Barrett, Jinhai Huang, and Jack X Kane. The green cluster represents Jorge L Alio and David Madrid-costa. The pink cluster includes Jyoti Khadka, Konard Pesudovs, and Vijaya K Gothawal. Within the light blue cluster are Jeff H Pettey, Gregory D Kramer, and David J Apple. Finally, the white cluster includes Brent A Kramer and John P Berdahl.

Table 4 highlights the most frequently recurring keywords in the study. The top three keywords, with their respective frequencies, were cataract (n = 231), cataract surgery (n = 189), and intraocular lens (n = 127). In Figure 5, the keyword frequency map, generated using VOSviewer, reveals six distinct clusters, each denoted by a specific color. The figure displays clusters in red, blue, and green representing three primary research directions. The red cluster features keywords such as axial length, myopia, high myopia, epidemiology, refractive error, and anterior chamber depth. These terms collectively encapsulate one research direction. Green clusters comprise keywords such as cataract, intraocular lens, refractive surgery, presbyopia, and IOL, representing another distinct research direction. The blue cluster includes cataract surgery, keratometry, optical biometry, and IOL calculation,

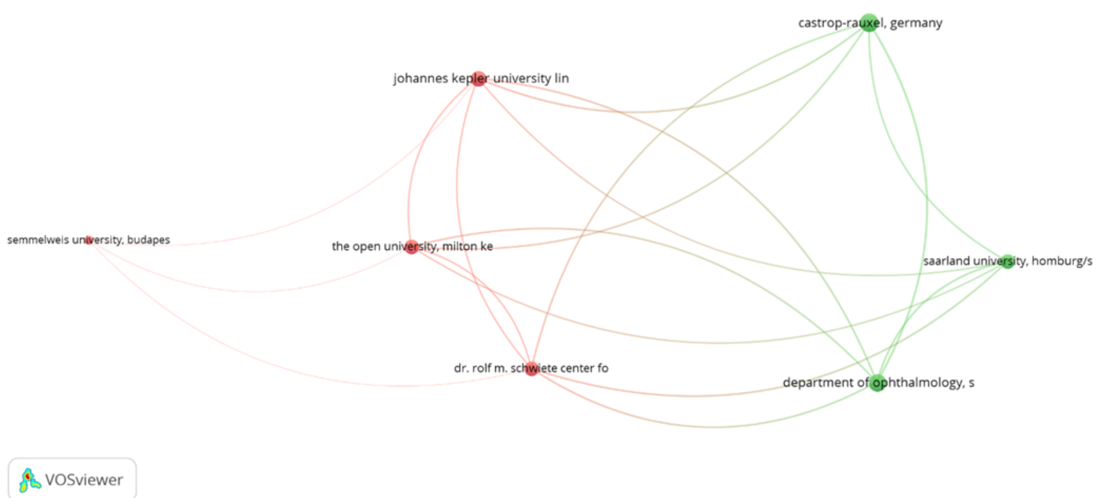

Figure 3. Most productive institutions for research in intraocular lens power calculation formulas. Note: the VOSviewer did not show Keio University, Sun Yat-sen University, University of Alicante, and Kore University College of Medicine in this figure. However, together with these, all institutions are listed in Table 2.

Table 3. Ten most productive authors in research of intraocular lens power calculation formula

Rank	Author	Institute (country)	Record	Documents	H-index
1	Achim Langenbucher	Saarland University (Germany)	884	85	47
2	Giacomo Savini	G.B. Bietti Foundation I.R.C.C.S. (Italy)	384	71	51
3	Kenneth J Hoffer	University of California (USA)	229	67	45
4	Douglas D Koch	Baylor College of Medicine (USA)	214	51	63
5	Li Wang	Baylor College of Medicine (USA)	197	50	45
6	Oliver Findl	Karl-Landsteiner Institute (Austria)	169	43	67
7	Nora Szentmary	Saarland University (Germany)	136	34	24
8	Peter Hoffmann	Eye & Laser Clinic Castrop Rauxel (Germany)	114	32	16
9	Alan Cayless	The Open University (Scotland)	108	30	9
10	Gerd U Auffarth	Heidelberg University (Germany)	88	27	46

Note: Record, number of records published by the authors; Document, number of records published by the author pertaining to our study's topic; the source for H-index calculation was ResearchGate, from the authors' profiles.

Figure 4. Visualization map of authors of studies pertaining to intraocular lens power calculation. Each node in the network represents an author, with larger nodes representing more publications. Different colors refer to clusters of close cooperation; Achim Langenbucher and Giacomo Savini had the greatest number of publications despite belonging to different clusters. Seven clusters were found, each representing a group of researchers who published together in the same area. However, these clusters had limited communication with each other. The network analysis revealed distinctive clusters of authors. 1) The red cluster features Kenneth J Hoffer, Giacomo Savini, and David P Pinero. 2) In the dark orange cluster are Achim Langenbucher, Oliver Findl, Peter Hoffman, and Nora Szentmary. 3) The light orange cluster includes Graham D Barrett, Jinhai Huang, and Jack X Kane. 4) The green cluster represents Jorge L Alio and David Madrid-costa. 5) The pink cluster includes Jyoti Khadka, Konard Pesudovs, and Vijaya K Gothawal. 6) Within the light blue cluster are Jeff H Pettey, Gregory D Kramer, and David J Apple. 7) Finally, the white cluster includes Brent A Kramer and John P Berdahl.

Table 4. Top 20 keywords related to intraocular lens power calculation formulas

Rank	Keyword	Frequency	Total link strength
1	Cataract	231	241
2	Cataract surgery	189	204
3	Intraocular lens	127	157
4	Astigmatism	95	134
5	Biometry	94	142
6	Axial length	93	155
7	Phacoemulsification	84	113
8	IOL power calculation	61	80
9	Keratometry	45	77
10	Myopia	45	56
11	Anterior chamber depth	44	76
12	Intraocular lens power	38	45
13	Toric intraocular lens	33	47
14	Intraocular lens power calculation	32	36
15	Optical biometry	31	54
16	Refractive error	31	42
17	High myopia	29	40
18	Refractive surgery	28	40
19	Presbyopia	27	27
20	Prediction error	26	44

Note: The total link strength attribute indicates the total strength of the co-occurrence links of a given keyword with other keywords [21], representing the number of publications in which two keywords occur together [22].

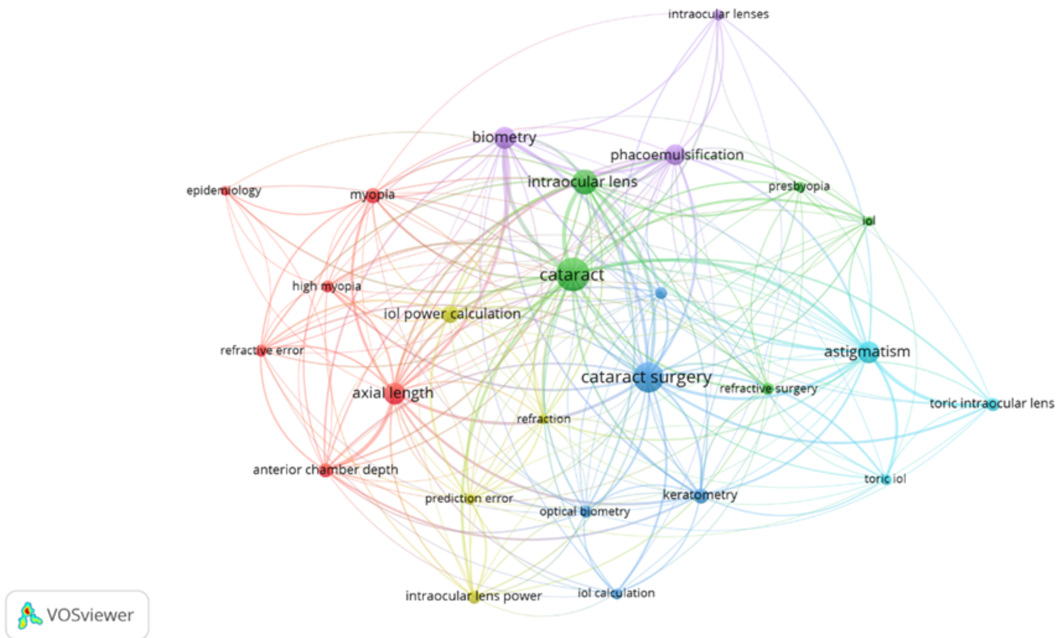

Figure 5. Visualization map of co-occurring keywords pertaining to intraocular lens power calculation formulas. The size of each circle represents the weight of a keyword. The color of the circles represents the respective cluster class. This figure displays six clusters of red, green, blue, yellow, violet, and light blue, indicating six research directions.1) The red cluster features keywords such as axial length, myopia, high myopia, epidemiology, refractive error, and anterior chamber depth. These terms collectively encapsulate one research direction. 2) Green clusters comprise keywords such as cataract, intraocular lens, refractive surgery, presbyopia, and IOL, representing another distinct research direction. 3) The blue cluster includes cataract surgery, keratometry, optical biometry, and IOL calculation, delineating a third prominent research direction. 4) The yellow cluster encompasses refraction, prediction error, IOL power calculation, and intraocular lens power. 5) The violet cluster includes biometry, intraocular lenses, and phacoemulsification. 6) The light blue cluster encompasses astigmatism and toric intraocular lens.

delineating a third prominent research direction. The yellow cluster encompasses refraction, prediction error, IOL power calculation, and intraocular lens power. The violet cluster includes biometry, intraocular lenses, and phacoemulsification. The light blue cluster encompasses astigmatism and toric intraocular lens (Figure 5).

DISCUSSION

In the developmental history of IOL power calculation, an increasing number of formulas have been devised [6-8] to improve precision and accuracy, aiming to avoid the adverse effects caused by miscalculation [23]. The current study analyzed and mapped the research in the field of IOL power calculation formulas, providing insight into the pace of formula development since the 1940s, and revealing the rapid increase in the last few years. We identified the main contributors to the field, including countries, institutions, and authors. Finally, with accelerating research and development in the field of IOL power calculation formulas, we mapped the primary topics the formulas currently cover.

The rapid evolution of technology has resulted in the development of numerous highly specialized IOL power calculation formulas that are tailored to various factors. For instance, a recent review highlighted the emergence of 15 new formulas for calculating IOL power during the five-year period between 2016 and 2021 [24]. Additionally, another recent review assessed the progress in these formulas and observed significant advancements in the field, particularly with the integration of artificial intelligence. This has led to the creation of more specialized and accurate formulas for determining IOL power [25].

The marvelous advancements in IOL power calculation and the emergence of various formulas have greatly expanded the scope of studies in this field. This is evident from the rapid and exponential increase in the number of publications. The USA, China, and Japan were the top three countries contributing to research on IOL power calculation formulas. Likewise, these three countries were among the top four in terms of research contributions on "cataract" [26]. A recent bibliometric study focused on the topic of "cataract," which was also the most frequent keyword in our study [26]. This highlights that the USA and the other European countries possess developed economies, robust data management practices, and strong academic systems [27, 28]. The USA and Europe were major contributors to global research trends in the field of ophthalmology, despite the impressive increase in research output from Asian countries [29].

The Open University, specifically the School of Physical Sciences in the UK, unexpectedly emerged as the leading institution in terms of the highest number of publications on IOL power calculation formulas. Interestingly, the USA, which ranked first in terms of research contributions, had no institutions within the top 10. Conversely, Semmelweis University's Department of Ophthalmology in Hungary attained the second position, despite the fact that neither the UK nor Hungary was among the top 10 countries in terms of research output. While the most productive institute hailed from the UK, three German institutes were ranked among the top 10 productive institutes, collectively contributing more records (n = 61, 1.1%) than the UK alone. This aligns with Germany's standing as the fourth most productive country in articles related to IOL power calculation formulas. Recently, a bibliometric study on highly cited articles in the field of ophthalmology identified the USA, UK, and Germany as the most productive countries [30].

The criteria for evaluation of authors include their number of published articles and h-index [31]. Analysis of the most productive authors may help to find the distribution of publications [32]. In terms of individual authors, the most productive ones hailed from Germany and the USA, which is consistent with their positions among the 10 top-ranked countries. While the USA was reported as the most productive country, and the UK had the most productive institution, it is noteworthy that Germany boasted a higher number of productive authors.

Based on an analysis of the relevant literature, Professor Achim Langenbucher from Saarland University, Germany, appeared most frequently in the field. This individual's main research directions are eye surgeries, cataracts, and evaluating the accuracy of the most commonly used IOL power calculation formulas [33]; describing the impact of formula constants on predicted refraction and limitations of constant optimization for classical and modern IOL power calculation formulas [34]; and investigation of the characteristics of surgically induced astigmatism after standardized microincision cataract surgery with a superior limbal incision [35].

Professor Oliver Findl, from the Karl-Landsteiner Institute in Austria, had the highest h-index. His research directions include the efficacy and safety of various ophthalmological methods and IOLs, including an exploration of the characteristics of online IOL calculation tools [36], and evaluation of the astigmatism-reducing effect of toric IOLs for low amounts of corneal astigmatism [37].

The network analysis revealed distinct clusters of authors, each with unique research interests, and each cluster represented authors who published together. In the red cluster, authors delved into keratometry measurements, with notable contributions from both Giacomo Savini and Kenneth J Hoffer, who were ranked as the second and third most productive authors, respectively, and found within the same cluster [38]. Authors in the dark orange cluster shared a common interest in optical coherence tomography [38, 39]. Interestingly, Nora Szentmary and Achim Langenbucher collaborated on several articles within this theme [39, 40], potentially attributable to a shared institutional affiliation. Meanwhile, the light orange cluster focused on assessing the accuracy of different IOL power calculation formulas [41, 42]. The green cluster authors concentrated on research related to keratoconus and keratoplasty procedures [43, 44]. The pink cluster authors primarily explored aspects of quality assessment for ophthalmological patients [45, 46]. Authors in the light blue cluster mainly focused on phacoemulsification devices [47] along with capsular bag opacification [48]. Lastly, the white cluster encompassed authors primarily engaged in exploring various aspects of the toric IOLs [49, 50].

Our investigation focused on the prevalence and distribution of research articles concerning the development of IOL power calculation formulas. Six clusters were identified, representing six frontiers in IOL power calculation. The first cluster encompassed myopia, axial length, and refractive error. Numerous studies have evaluated various IOL formulas for use in patients with myopia. These studies aimed to predict postoperative refractive outcomes [51-53]. The second cluster encompassed presbyopia, refractive surgery, and IOLs. Various refractive surgeries are used for presbyopia correction, including IOL implantation. Consequently, a number of studies have investigated the effectiveness of various IOLs in addressing presbyopia [54, 55]. In addition, a study compared the clinical results of presbyopia-correcting IOLs that combine the extended depth of focus and bifocal profiles with a standard monofocal IOL [56].

The third cluster comprised cataract surgery, IOL power calculation, and keratometry. Dry eyes can reportedly affect the reliability of keratometry measurements before cataract surgery, consequently affecting the accuracy of IOL power calculations [57]. The fourth cluster included the subjects of refraction, prediction error, and IOL power calculation. Notably, a study compared the mean prediction error and the accuracy of predictability of IOL power calculation in pediatric patients after cataract surgery with primary implantation of an IOL using SRK II versus Pediatric IOL Calculator for pediatric IOL calculation, yielding a statistically insignificant difference [58].

The fifth cluster included biometry, IOLs, and phacoemulsification. Phacoemulsification, a method of cataract surgery, involves emulsifying the crystalline lens of the eye using ultrasonic energy and replacing it with an IOL implant. Advances in techniques and equipment have significantly increased the popularity of phacoemulsification, enhancing safety and efficiency [59]. The last cluster encompassed astigmatism and toric IOLs. Toric IOLs are considered the most productive way of correcting corneal astigmatism in a patient undergoing cataract surgery [60]; thus, some studies have explored different aspects of toric IOLs in astigmatism correction [37, 60, 61].

To our knowledge, this study is the first bibliometric analysis focused on the trends in articles related to IOL power calculation formulas. CiteSpace and VOSviewer were the analytical tools used in this study. Both are bibliometric tools based on Java that help researchers by decoding complex data sets through visualization techniques. Each has different strengths, and their dual application in data analysis could yield a more comprehensive and accurate understanding of the data. One key limitation of our study is that we only utilized a high-quality filter when retrieving publications from the PubMed database, neglecting to collect records from other databases such as Web of Science and Scopus. This could potentially limit the comprehensiveness of our findings. Additionally, we acknowledge the importance of screening the articles found on the search. However, despite our best efforts, "false positive" articles may have been included. This usually does not affect the overall patterns found in bibliometric studies, as the aim of bibliometric analysis is to reveal patterns rather than to delve into individual study results. We did not conduct an analysis of citations, which can serve as a measure of the impact of published articles. These limitations should be acknowledged and addressed in future studies. Further investigation is essential to pinpoint the most suitable formulas, addressing gaps in our current understanding. Future research should place emphasis on toric IOLs, advancements in phacoemulsification techniques, and the development of more precise IOL power calculation formulas.

CONCLUSIONS

This study provides valuable insights, including details on potential collaborators and prevalent research topics, and it serves as a reference for more extensive and in-depth research. Since 1946, an increasing number of studies have been conducted, reflecting ongoing scientific progress in developing more accurate formulas. This evolution is also marked by formula specialization, in which certain formulas are applied to specific populations, such as myopic patients. The leading countries contributing literature related to IOL power calculation formulas were the USA, followed by China, Japan, and Germany. Our findings represent a summary of the current state of IOL power calculation research, holding significant implications for guiding future investigative directions.

ETHICAL DECLARATIONS

Ethical approval: This study was an observational bibliometric analysis, and no ethical approval was required.
Conflict of interest: None.

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