Publication trends of primary angle-closure disease during 1991-2022: a bibliometric analysis

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Abstract

● **AIM:** To perform a bibliometric analysis in the field of primary angle-closure disease (PACD) research to characterize current global trends and compare contributions from different countries, institutions, journals, and authors.

● **METHODS:** All PACD-related publications from 1991 to 2022 from the Web of Science Core Collection database were extracted. Microsoft Excel and VOSviewer were used to collect publication data, analyze publication trends, and visualize relevant results.

● **RESULTS:** A total of 1721 publications with 34 591 citations were identified. China produced the most publications (554) while ranking third in citations (8220 times). The United States contributed the most citations (12 315 times) with publications (362) ranking second. The *Investigative Ophthalmology Visual Science* was the most productive journal concerning PACD, and Aung Tin was the author with the highest number of publications in the field. Keywords were classified into three clusters, epidemiology and pathogenesis research, optical coherence tomography (OCT) and other imaging examinations, and glaucoma surgery treatment. Genome-wide association, susceptibility loci, OCT, and combined phacoemulsification have become new hot research topics in recent years since 2015.

● **CONCLUSION:** China, the United States, and Singapore make the most outstanding contributions in the field of PACD research. OCT, combined phacoemulsification, and gene mutation-related study, are considered the potential focus for future research.

● **KEYWORDS:** primary angle-closure disease; bibliometric analysis; publication trends; citations

INTRODUCTION

Glaucoma is the leading cause of irreversible blindness worldwide[1]. It is estimated that 76 million people were affected by glaucoma in 2020. Among them, approximately 25 million have primary angle-closure glaucoma (PACG) type[2]. Although less common than primary open angle glaucoma (POAG), studies showed that PACG carried a three-fold increase in the risk of severe visual impairment or blindness on average, more than 25% of PACG patients progress to blindness[3]. Asia accounts for approximately 77% of all PACG cases worldwide. The prevalence of PACG is highest in Asia (1.09%), followed by Latin America and the Caribbean (0.85%), Africa (0.60%), and Europe (0.42%). The PACG prevalence in Oceania (0.35%) and North America (0.26%) are the lowest[2].

While POAG is defined as acquired optic neuropathy associated with characteristic optic nerve structural damage and visual field loss in an eye that has no angle closure nor identifiable secondary cause[4], PACG is a completely different type with a distinct diagnosis. The International Society of Geographic and Epidemiologic Ophthalmology classified three categories. Primary angle-closure suspect (PACS) is an eye with narrow angles (>180° of the posterior pigmented trabecular meshwork not visible), without elevated IOP nor peripheral anterior synechiae (PAS). Primary angle-closure (PAC) is diagnosed in eyes with narrow angles, with elevated

IOP and/or PAS, without glaucomatous damage of the optic nerve. PACG is PAC together with evidence of glaucomatous optic neuropathy[5]. These continuum forms are generally referred to as primary angle-closure disease (PACD). The risk factors associated with PACD include ethnicity, older age, female gender, small cornea, shallow anterior chamber, thick lens, anterior lens position, and short axial length (AL)[6]. To assess the presence of angle closure, gonioscopy is the most important method[7]. However, the findings are subjective and vary with the light and mechanical compression of the eye during examination. Therefore, quantitative methods such as ultrasound biomicroscopy (UBM) and optical coherence tomography (OCT) have gradually become widely used in the last decades[8]. OCT technology has developed rapidly recently, especially the swept-source OCT (SS-OCT), which largely improved image acquisition speed, resolution, scan depth and width[9]. And additional improvements in OCT methods, such as OCT angiography (OCTA), made it possible to observe the retinal and choroidal vessels through OCT[10]. These imaging devices help to find more anatomical features in the pathogenesis of PACD.

The clinical management of PACD includes medical treatment, laser therapy, and surgical approach[11]. In addition to IOP lowering approaches such as trabeculectomy, protection of the configuration and function of anterior chamber angle (ACA) is unique and important in PACD management[12]. Therefore, laser peripheral iridotomy (LPI), as well as lens extraction, have proven to be effective[13-14]. Phacoemulsification and combined phacoemulsification, aiming to treat angle-closure disease with cataract procedures, have shown great efficiency in the reduction of postoperative IOP and medication use in recent years[15]. And among the combined phacoemulsification procedures, combining phacoemulsification with goniosynechialysis (GSL) or with trabeculectomy have been discussed the most[16-17].

Bibliometrics analysis is a scientific and quantitative approach to tracking the publication trends in a specific research field over time[18-19]. Such analysis can be used to compare contributions between countries, institutions, journals, and authors. It also includes co-word analysis and cluster analysis to summarize the progress and reveal the current hotspots or future trends. Bibliometrics research has expanded markedly in recent years due to its contributions to clinical guidelines and policy-making[20]. However, few bibliometric studies have been performed on research related to glaucoma[21-23], and to date, no bibliometric studies have been conducted regarding PACD.

The purpose of this study was to present a comprehensive and visualized bibliometrics analysis of the trend and focus of global PACD research by analyzing publications from 1991 to 2022 obtained from the Web of Science Core Collection (WoSCC) database. This study would help researchers and specialists to understand the range and new topics in the field of PACD in general and guide them in future endeavors.

MATERIALS AND METHODS

Ethical Approval Data from bibliographic information were searched and downloaded from WoSCC. These were publicly available data. The extraction of this data did not involve interaction with human subjects or animals. Thus, there were no ethical issues involving the use of these data, no approval from an Ethics Committee or written informed consent to participate was required.

Data Sources and Search Strategies All searches were conducted on a single day (Jan 15, 2023) to avoid biases introduced by the renewal of database. The WoSCC was considered to be the most suitable database for bibliometric analysis. Therefore, we comprehensively searched the WOSCC database from 1991 to 2022. The integration of search strategies was as follows: TS=("primary angle-closure") AND Language=English. Only the original articles and reviews in the database were included. Various types of manuscripts, such as editorial materials, letters, corrections, news items, book reviews, and proceeding papers were excluded. Detailed enrolment and selection procedures are shown in Figure 1.

Data Collection Two reviewers independently conducted a preliminary search, WoSCC data including titles, keywords, publication dates, countries and regions, institutions, authors, publishing journals, and sums of citations were extracted and imported into Microsoft Excel 2010 (Redmond, Washington, USA) and VOSviewer 1.6.17 (Leiden University, Leiden, the Netherlands) for bibliometric analysis.

Bibliometric Analysis WoSCC was used to describe and examine the characteristics of all included publications. Microsoft Excel 2010 was applied to assess and rank the number of publications among different countries, journals, institutions, and authors. It was also applied to predict the growth trends of publications in the PACD field. The prediction model $f(x)=ax^3+bx^2+cx+d$ was generated according to the cumulative publications to analyze time trends and future publication patterns. In this formula, x represents time (year) and f(x) denotes the cumulative volume of publications in a certain year[24-25]. VOSviewer, an application used to analyze correlations between literature, was used to map and visualize the network of related countries, authors, and keywords[26]. Co-occurrence analysis uses the frequency of multiple words in the same article to identify how close they are, thereby demonstrating hot topics and trends in the discipline[27-28]. The high-frequency keywords were classified into disparate clusters according to co-occurrence analysis and simultaneously color-coded by time course. The average publishing year (APY) was used to quantitatively evaluate how recent of the published

articles from a country or author, as well as the novelty of a keyword[29-30].

RESULTS

Number of Global Publications and Citation During the 32 years from 1991 to 2022, a total of 1721 PACD-related articles met the search criteria in the WoSCC database. The distribution of articles was analyzed by year of publication (Figure 2). The results showed that the number of publications has increased overall from 4 in 1991 to 155 in 2022. Based on the citation report retrieved from the WoSCC database, all publications related to PACD have been cited 34 591 times since 1991, with an average citation frequency of 20.23 times for each paper. The distribution of citations also showed a significant increase from 1991 to 2022, with 4760 times cited in 2021 and 3980 times in 2022.

Countries' Contributions to Global Publication and the Growth Trends Prediction The distribution of articles was further analyzed by country/region. China produced the most publications (554, 32.19%), followed by the United States (362, 21.03%), Singapore (288, 16.73%), India (224, 13.02%), and England (181, 10.52%; Table 1). Furthermore, in the past 32 years, the United States and Singapore published the most papers from 1991 to 2008, while China had published more papers than these two countries since 2009. Japan (120, 6.97%) and Australia (107, 6.22%) also published more than 100 articles over the past three decades. More than 50 articles had been published in the Taiwan Region and South Korea. Time series analysis showed that the trend of publications from England, Japan and Singapore is earlier (APY of 2011-2012), followed by the United States, India, Australia and South Korea (APY of 2014-2015). The literature published in China was the latest (APY of 2016.63). The citation frequency per publication is high in England (42.98), Singapore (37.19) and USA (34.02), while the citation/publication rate in other countries range from 12.42 (Iran) to 21.63 (Australia).

The growth of PACD publications predicted by the model fitting curves demonstrated a significant correlation between time and the cumulative number of publications (Figure 3). In addition, based on the cumulative number of publications in the past 32y, the trends in the next 5y were estimated. The number of global publications was growing steadily and rapidly, which is consistent with the situation in several major countries, such as China and the United States. China has manifested faster growth, while Singapore and England increased slowly.

Journals Publishing Research on PACD More than half of the publications in this field were published in 10 journals (885, 51.42%). The *Investigative Ophthalmology Visual Science* published the most articles (259, 15.05%). The *Journal of Glaucoma* and *Ophthalmology* ranked second and third with 172 and 95 publications, while the *British Journal of*
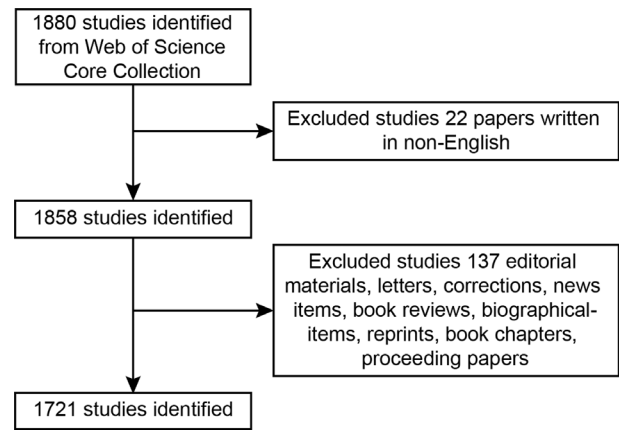

Figure 1 Flow diagram of the PACD research inclusion process PACD: Primary angle-closure disease.
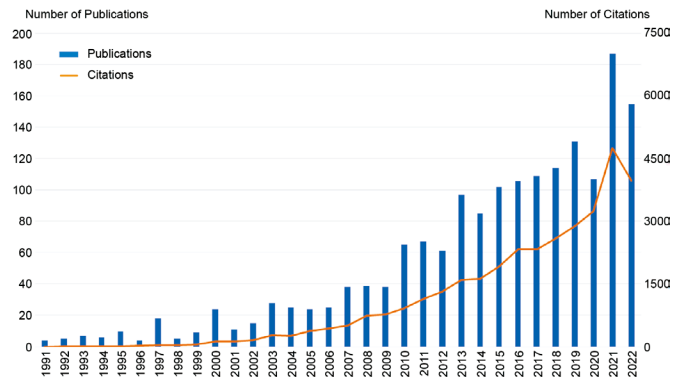

Figure 2 The number of publications and citations related to PACD worldwide per year PACD: Primary angle-closure disease.

Table 1 Top 10 countries/regions with the most publications in PACD research

Country/region	Publications	Citations	Citation/publication ratio	Average publishing year
China	554	8220	14.84	2016.63
U.S.A.	362	12315	34.02	2015.34
Singapore	288	10710	37.19	2012.64
India	224	4360	19.46	2014.68
England	181	7779	42.98	2011.29
Japan	120	2147	17.89	2012.57
Australia	107	2314	21.63	2015.21
Taiwan Region	69	1026	14.87	2009.56
South Korea	69	971	14.07	2014.68
Iran	43	534	12.42	2016.17

PACD: Primary angle-closure disease.

Ophthalmology, the *American Journal of Ophthalmology*, and *Clinical and Experimental of Ophthalmology* published more than 50 articles ranked fourth to sixth. The top 10 journals with the most publications are all specialized journals of ophthalmology (Figure 4). The analysis of highly cited articles showed that specialized journals have an incredible scientific impact on all scholars, and 8 of the top 10 highly cited articles were published in these specialized journals (Table 2), including 4 articles on *Ophthalmology*, 2 articles on the *Archives of Ophthalmology,* 1 article on the *British Journal of*
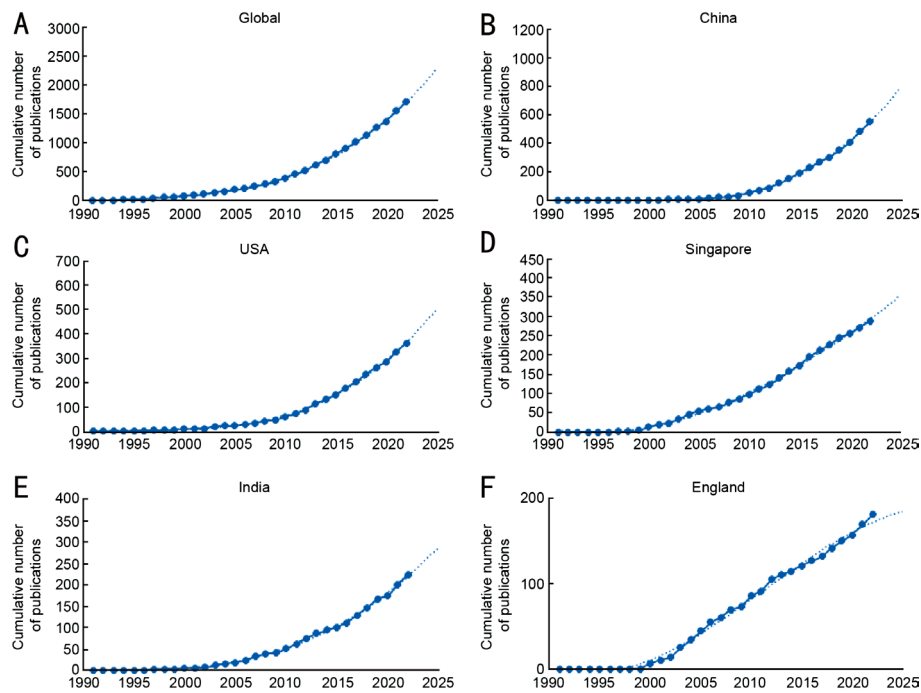
Figure 3 Fitting curves of publication growth trends in the global and top 5 countries/regions with the most publications.
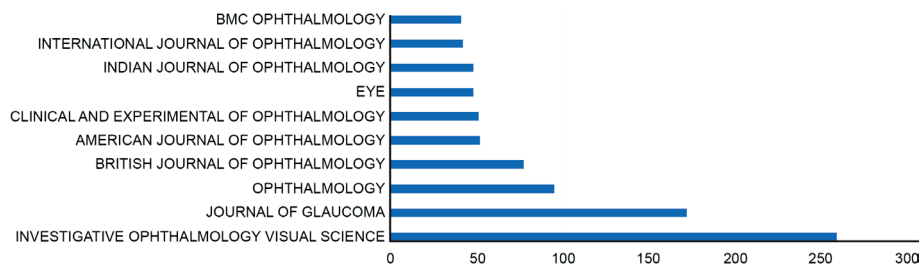

Figure 4 Top 10 journals with the most publications in the PACD field PACD: Primary angle-closure disease.
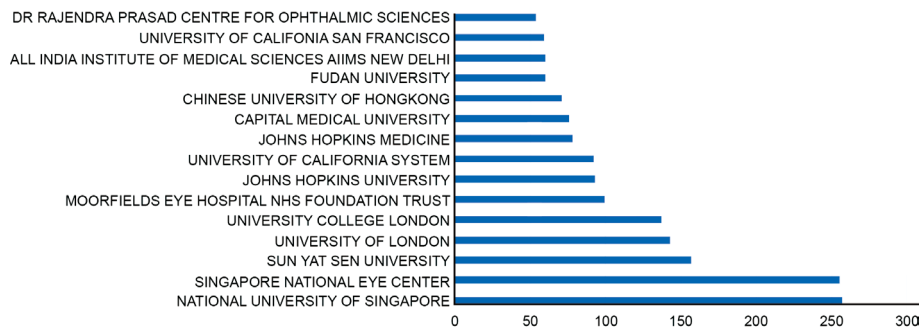

Figure 5 Top 15 institutions with the most publications in the PACD field PACD: Primary angle-closure disease.

Ophthalmology, and 1 article on the *Survey of Ophthalmology*. Other comprehensive high-impact journals, such as the *Lancet* published one high-quality article in 2017.

Institutions and Authors Publishing Research on PACD In terms of institutions, the publications from the top 15 institutes accounted for 95.18% of all literature on PACD. The National University of Singapore and the Singapore National Eye Center had the highest number of publications (257, 14.93% and 255, 14.82%), followed by the Sun Yat-sen University (157, 9.12%), the University of London (143, 8.31%), the University College London (137, 7.96%) and Moorfields Eye Hospital NHS Foundation Trust (100, 5.81%; Figure 5).

Among the top 15 institutions identified in this field, all are from the top 5 countries with the most publications, including 4 institutions from the United States and China, 3 from England, and 2 from Singapore and India.

The top 11 authors published a total of 784 articles, accounting for 45.55% of all publications in the PACD field. Aung Tin from Singapore published 221 articles related to PACD with a total of 8187 citations, ranked first in both the number of publications and citations. Foster PJ from England, Nongpiur ME from Singapore, He Mingguang from China, and Friedman DS from the United States ranked second to fifth with 60 to 88 publications. However, according to the

Table 2 Top 10 publications with the most citations in PACD research

Title	Corresponding author	Journal	Publication year	Total citations
Global prevalence of glaucoma and projections of glaucoma burden through 2040 A systematic review and Meta-analysis	Cheng Ching-Yu	Ophthalmology	2014	2614
Glaucoma	Panda-Jonas S	Lancet	2017	551
The prevalence of glaucoma in Chinese residents of Singapore—A cross-sectional population survey of the Tanjong Pagar District	Seah SKL	Archives of Ophthalmology	2000	463
Glaucoma in China: how big is the problem?	Johnson GJ	British Journal of Ophthalmology	2001	420
Glaucoma in Mongolia—A population-based survey in Hovsgol Province, Northern Mongolia	Johnson GJ	Archives of Ophthalmology	1996	351
Prevalence of glaucoma and intraocular pressure distribution in a defined population—The Egna-Neumarkt study	Tenna V	Ophthalmology	1998	309
Prevalence and clinical characteristics of glaucoma in adult Chinese: A population-based study in Liwan District, Guangzhou	He Mingguang	Invest Ophthalmol Vis Sci	2006	287
The prevalence of glaucoma in the Melbourne Visual Impairment Project	Taylor HR	Ophthalmology	1998	273
Angle-closure glaucoma in an urban population in southern India—The Andhra Pradesh Eye Disease Study	Rao GN	Ophthalmology	2000	257
Issues in the epidemiology and population-based screening of primary angle-closure glaucoma	Tielsch JM	Survey of Ophthalmology	1992	251

PACD: Primary angle-closure disease.

citations, Foster PJ and Friedman DS ranked second and third with 5184 and 3719 citations, respectively. Among the top 11 authors, 5 authors are from Singapore and 4 from China. The other two are from the United States and England (Table 3). Time series analysis showed that the trends of publications by authors from the United States and England are earlier (APY of 2012-2013), followed by authors from Singapore (APY of 2014-2016). Chinese authors published the latest publications (APY of 2015-2018), especially Professor Sun Xinghuai (APY of 2018.26).

Analysis of Keywords and Hotspots in PACD The keywords that occurred in the titles and abstracts of all 1721 publications were analyzed by VOSviewer. The 87 keywords that appeared more than 30 times were included and classified into 3 clusters on the map (Figure 6A). Circles of larger size represent the keywords that appeared at higher frequencies. The hotspots of PACD research based on the map in the past decade were mainly: epidemiology, glaucoma-related pathogenesis research, OCT and other imaging examinations, and glaucoma surgical management. Within cluster 1 (red), the primary keywords included prevalence (419 times), IOP (202 times), progression (86 times), risk (80 times), genome-wide association (GWA, 51 times), expression (37 times), and aqueous-humor (34 times). In cluster 2 (green), glaucoma (681 times), OCT (190 times), UBM (151 times) and parameters (70 times) occurred frequently. In cluster 3 (blue), the main keywords were eyes (235 times), phacoemulsification (145 times), trabeculectomy (118 times), cataract (79 times), and cataract-surgery (66 times).

All keywords were colored according to the average publication time by VOSviewer. Keywords that appeared relatively earlier were colored blue, and keywords with a

Table 3 Top 11 authors with the most publications in PACD research

Author	Country/region	Publications	Citations	Average publishing year
Aung Tin	Singapore	221	8187	2015.14
Foster PJ	England	88	5184	2012.74
Nongpiur ME	Singapore	70	1201	2016.13
He Mingguang	China	62	1917	2015.05
Friedman DS	USA	60	3719	2013.3
Chew PTK	Singapore	55	2285	2011.62
Baskaran M	Singapore	47	1220	2014.44
Zhang Xiulan	China	46	492	2016.66
Perera SA	Singapore	45	751	2015.51
Sun Xinghuai	China	45	545	2018.26
Wang Ningli	China	45	435	2015.11

PACD: Primary angle-closure disease.

more recent appearance were colored yellow (Figure 6B). Keywords shown in blue, such as cluster 3 appeared earlier. Keywords shown in yellow such as GWA (APY of 2018.29), susceptibility loci (APY of 2018.50), lens extraction (APY of 2018.81), combined phacoemulsification (APY of 2016.89) and OCT (APY of 2016.33) appeared recently. Genetic studies may be a new research trend in the PACD field, OCT and phacoemulsification have also attracted wide attention in the past five years.

DISCUSSION

In this study, we analyzed the global publication trends of PACD-related research from 1991 to 2022 through bibliometrics. PACD is the general reference of a continuum form from PACS, PAC to PACG. Therefore, using "primary angle-closure" as the search topic can accurately target all relevant publications regarding to PACD. Previous bibliometric analysis have focused on glaucoma[21-23], POAG[31], application of stem cells in glaucoma[32]. As far as we know, this is the
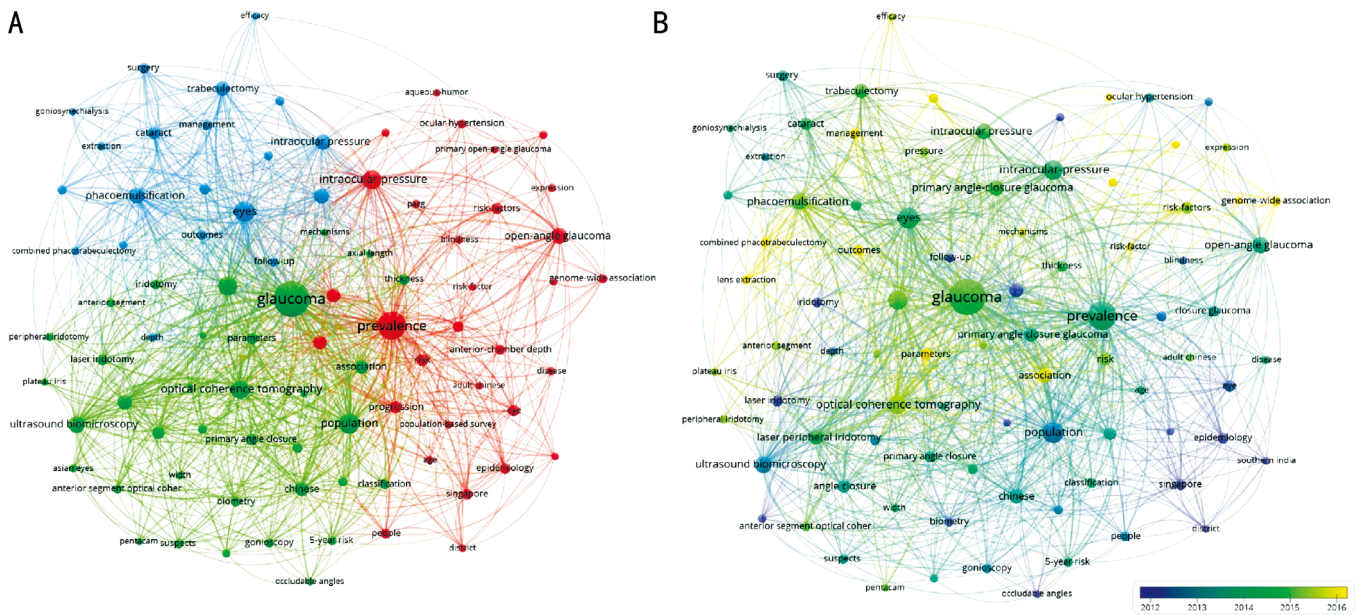
Figure 6 The analysis of keywords in PACD field A: Mapping of keywords. All keywords were divided into 3 clusters and given different colors. The circle with a larger size represented a higher frequency. B: Distribution of keywords based on the average publication time. Yellow indicates a recent appearance and blue indicates an early appearance. PACD: Primary angle-closure disease.

first bibliometric analysis regarding to PACD. We observed a steady growth in the global cumulative number of publications and citations over time. After 2010, the number of publications exceeded 50 per year, and the increase has been faster and faster each year. This indicated that PACD gradually came into focus and remained an important field in ophthalmology. Funding availability is also an important contributor to this growth. The increase in general academic funding, and PACD-specific funding from governments and corporations, led to a growing number of academic institutions, and further increased publications.

The United States ranked first in the total number of citations and second in the total number of publications. Singapore ranked second in the sum of citations and third in the sum of publications. The two countries started PACD research very early, and still make great contributions to the field of PACD. China ranked first in the total number of publications. Rapid growth has been observed in the time curve since 2013, more than half of the total publications were published after 2015 in China, based on the APY of 2016.63. Significantly, China accounted for one-third of the global number of publications in 2019-2022, indicating the gradually indispensable position of China in the field. China has given growing attention to PACD, which may be attributed to the increased scientific prowess of this country and the heavy disease burden of approximately 7 million people affected in this country[33]. Ethnicity is an important risk factor for PACD, and Asia has the highest PACG prevalence of 0.96% throughout the world[34]. In fact, among the top ten countries with the most publications, six were located in Asia, suggesting that the heavy disease burden

is a strong motivation for academic research. Notably, there is a disproportionality between the number of publications and the number of citations from England, Singapore, and the USA. This is likely due to a combination of factors. First, the citation frequency in other countries including China may be lower due to differences in language and cultural norms, while the language used in the US, England, and Singapore are English, leading to greater recognition and citation of their research. Plus, fewer publications in these countries are indexed in international databases. Second, there may be differences in research quality. England, Singapore, and the US are broadly considered to be world-leading nations in research quality and output. The researchers in these countries may also come from more prestigious institutions and have greater access to resources for conducting high-quality research, which may also contribute to the higher citation rates. At last, China has a much larger population and a number of educational institutions, which leads to more publications, as well as larger academic standards differences between institutions.

All the top 15 institutions in research on PACD were from the top 5 countries with the most publications and citations. Among them, four institutions were from the United States and four were from China. Remarkably, Singapore occupied the two most productive institutions in the world. We also noticed that more than 95% of all the literature on PACD was from the top 15 institutes. This suggests that good institutions that offer superior conditions for research including advanced equipment, standardized systems, adequate funding, and professional researchers, could bring significant contributions to an academic field.

Journals of ophthalmology such as *Investigative Ophthalmology and Visual Science*, *Journal of Glaucoma*, and *Ophthalmology* were the top 3 journals with the most publications of research on PACD. Thus, they are the primary journals involved in the field of PACD, future developments are more likely to be published in these journals as well. Among the top 11 authors with the most publications, five came from Singapore and four came from China. Aung Tin from Singapore Eye Res Institution has published most papers, he followed up on the long-term progress of the disease, especially on the treatment and outcome of acute primary angle-closure. Foster PJ investigated the prevalence of PACG in a wide range of regions around the world. Nongpiur ME is dedicated to finding novel anatomical risk factors for PACG and identifying novel genetic variants associated with PACG. The works of He Mingguang guided the use of LPI in PACG treatment. Collaborations between these leading researchers are worth attention. Many highly cited publications came from the cooperation between the authors, which is not limited to institutions or countries. This indicates the close connection of researchers in the PACD field, this model may contribute a lot to the development of this area.

Through keywords analysis, three clusters of PACD research hotspots have been categorized: epidemiology and glaucoma-related pathogenesis research, OCT and other imaging examinations, glaucoma surgical management. Epidemiology-based studies topped the citations over other clinical and investigative-based studies. In fact, among the top 10 publications with the highest number of citations, six were epidemiology studies. The reason may be that epidemiology research benefit from large data sets with a long-term follow-up period, they are generally prospective, which make them easier to establish reliable connections in comparison to retrospective studies that use data collected after the fact. Researchers often refer to epidemiology studies in the introduction section of a publication, this is because epidemiology studies provide valuable insight into the prevalence, causes, and risk factors of diseases, through which researchers found public health concerns, made hypotheses, and designed protocols to determine the relationship between certain exposure or interventions with health outcome. However, with respect to the latest focus, the other clusters have attracted more attention. Gonioscopy remains the most important diagnostic method and the gold standard for assessing the presence and degree of angle-closure[7]. However, it is highly subjective and its findings vary with the amount of light and mechanical compression in the eye during examination[35]. More objective and quantitative imaging devices were developed, such as UBM and anterior segment OCT (AS-OCT). Imaging of structures posterior to the iris is possible only with UBM,

plateau iris and anterior positioning of the ciliary body were discovered by UBM in PACG eyes and determined to be part of the non-pupillary block mechanism of PACG[36-37]. AS-OCT utilizes optical signals to obtain high-resolution images, compared to gonioscopy and UBM, the technique is quick, non-contact, and depends less on the technicians' skills[11]. AS-OCT also has the advantage of a longer scan depth, which allows the visualization of the lens. Thicker lenses with greater lens vaults were found to be important anatomical features in angle-closure eyes by AS-OCT, revealing the crucial role of the lens in the pathogenesis of angle-closure disease[38-39]. Other factors associated with narrow ACA found by UBM and AS-OCT include increased iris thickness, greater iris curvature, larger iris area, and iris volume[40-42]. Anterior segment dimension parameters such as small anterior chamber depth (ACD), width, area, and volume are also associated with PACG[7,43]. In recent years, the development of OCT technology, especially the application of SS-OCT in anterior segment imaging, has greatly improved image acquisition speed, resolution, and scan depth and width[9]. Superior to the older forms of OCT, SS-OCT enables observation of the entire 360° circumference of the ACA, quantitative measurement of the extent of angle closure by measuring the irido-trabecular contact index, as well as the amount of PAS[44-45]. Another advantage of SS-OCT is that it could provide the three-dimensional reconstruction of the entire ACA[46]. SS-OCT could also capture the anterior and posterior lens surfaces simultaneously, it helps researchers find that steeper anterior curvature, greater tilt and decentration of the lens may be novel anatomic characteristics of PACG[47-48]. One of the weaknesses of OCT is that it requires manual localization of the scleral spur by users to produce results. This could be overcome by advances in artificial intelligence, where new deep-learning algorithms have been developed to help automatically localize the scleral spur, detect angle-closure, and even classify the PACG mechanism[49-51]. A novel extension of OCT technology is OCTA, which provides high-resolution images of retinal and choroidal functional vessels[10]. Studies using OCTA found a decrease in the retinal vessel density in PACG eyes, especially the peripapillary vessel density[52]. Peripapillary vessel density was positively correlated with retinal nerve fiber layer and ganglion cell complex thickness, its diagnostic ability in PACG was comparable to that of retinal nerve fiber layer[53-54]. The results illustrated the role of retinal microvascular in the pathogenesis of PACD. Future studies will continue to focus on the performance of these parameters in the prediction, diagnosis, and postoperative evaluation of PACD.

Surgical management of PACD includes filtration procedures and angle-widening procedures. Filtration procedure is usually applied in PACG eyes when medical and laser therapy

fails to control IOP, the most common filtration surgery is trabeculectomy[12]. Multiple studies have demonstrated the efficiency of trabeculectomy on IOP reduction in PACG eyes, along with the comparability between trabeculectomy and other non-penetrating filtration procedures[55-58]. The angle-widening procedure mainly refers to lens extraction surgery. A series of randomized controlled trials highlighted the effectiveness of lens extraction in angle-closure population[14-15,59]. Lens extraction is beneficial in lowering IOP and reducing the requirement for glaucoma drugs. Compared to LPI, lens extraction showed greater efficacy and was more cost-effective[60]. UBM and AS-OCT found that lens extraction contributed to the postoperative widening of ACA and increase of ACD not only by completely diminishing the impact of lens volume and pupillary block, but also by attenuating anterior positioning of the ciliary processes[61]. Recently, combined phacoemulsification has received wide attention. It mainly refers to combined phacoemulsification with GSL or with trabeculectomy. Compared to phacoemulsification alone, there is not yet sufficient evidence to show that phaco-GSL adds additional lowering of IOP and reduction of postoperative medication use[62-63]. However, it has been widely proved that phaco-GSL is superior in terms of reducing PAS extension, widening the anterior angle, and increasing the aqueous outflow facility[17,64]. Meanwhile, compared to phacoemulsification alone, phaco-trabeculectomy was more effective but was associated with more postoperative complications[65-66]. Future studies could continue to focus on the efficiency of combined phacoemulsification, as well as its application indications.

Family history is an important risk factor for PACD. A study showed that the siblings of PAC or PACG probands have an angle-closure prevalence of 36.7%, and in another study, the heritability of narrow-angle was calculated at 58.8%[67-68]. However, the genetic cause of PACD has not yet been fully elucidated. Previous research chose candidate genes primarily based on biological plausibility or association with similar phenotypes. For example, tissue modeling genes have been found to participate in AL regulation, and the genetic variation of relevant genes including matrix metalloproteinase-9, frizzled-related protein, and heat shock protein 70 (which regulates the expression of matrix metalloproteinases) was gradually found to be associated with an increased risk of PACG[69-71]. Other genetic risk factors for PACG include variants on endothelial nitric oxidase synthase, hepatocyte growth factor, and ATP binding cassette subfamily C member 5[72-73]. Owing to GWA studies (GWAS), the susceptibility loci associated with PACG could be widely screened and identified[74]. Eight loci were found according to GWAS, they are PLEKHA7 rs11024102, COL11A1 rs3753841, PCMTD1-ST18 rs1015213, EPDR1 rs3816415, CHAT rs1258267, GLIS3 rs736893, FERMT2 rs7494379, and DPM2-FAM102A rs3739821[75-76]. These genes were further verified in different populations to be associated with PACG, however, the results varied across regions, this may be due to the selection bias of the original GWAS[77-80]. Meanwhile, the role of these genes in the pathology of PACG is still unclear. The findings that all eight susceptibility loci were not relevant to AL nor ACD cast a veil over the pathogenesis of these variations[81-82]. Another study showed a controversial result that only PCMTD1-ST18 rs1015213 was associated with ACD[83]. In addition, the inclusion of these alleles in ACD only results in a 0.5% improvement in discriminating PACG, indicating the complexity of the genetic features in PACG[84].

The present study has the following limitations. First, we only enroll publications written in English from WoSCC database, because it can be difficult to find these non-English articles without knowing the language. The citations of non-English articles are easily low even if the research is valuable, making it difficult to draw a fair statistical conclusion. Most non-English journals are also not included in the WoSCC database, making them harder to track. This search strategy could lead to some valuable publications written in other languages being omitted. Another limitation is that the publication may discuss PACD as part of a larger research topic, so the authors may not have included PACD in their title, abstract nor keywords. To solve it, we can consider using broader search terms to capture all publications discussing PACD to increase searching thoroughness, but the accuracy of this targeted topic wouldn't be ensured. Moreover, the latest publications lack time to be tested and accumulate citations, therefore, they are not emphatically analyzed in our study. Lastly, the writing form of the name of the authors was different in some articles, therefore, when counting for a total publication, some publications written by the same author were not assigned together.

In conclusion, the current study demonstrated the global trends and focus of PACD research over the past three decades through bibliometric analysis. China, the United States, and Singapore made outstanding contributions to the field of PACD research. The *Investigative Ophthalmology Visual Science* and *Journal of Glaucoma* are qualified journals for finding new progress regarding PACD. GWA, OCT, and combined phacoemulsification were considered the latest hotspots for future research. These findings would help researchers identify emerging themes and frontiers in the field of PACD and guide them in future endeavors.

REFERENCES

1 GBD 2019 Blindness and Vision Impairment Collaborators; Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. *Lancet Glob Health* 2021;9(2):e144-e160.

2 Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis. *Ophthalmology* 2014;121(11):2081-2090.

3 George R, Panda S, Vijaya L. Blindness in glaucoma: primary open-angle glaucoma versus primary angle-closure glaucoma—a meta-analysis. *Eye(Lond)* 2022;36(11):2099-2105.

4 Aspberg J, Heijl A, Bengtsson B. Screening for open-angle glaucoma and its effect on blindness. *Am J Ophthalmol* 2021;228:106-116.

5 Foster PJ. The definition and classification of glaucoma in prevalence surveys. *Br J Ophthalmol* 2002;86(2):238-242.

6 Jonas JB, Aung T, Bourne RR, Bron AM, Ritch R, Panda-Jonas S. Glaucoma. *Lancet* 2017;390(10108):2183-2193.

7 Liang YB, Shen RY, Zhou WH, Fan SJ, Chan PP, Tham CCY, Congdon N, Friedman DS, Wang NL. Prevalence and ocular biometric characteristics of myopia in primary angle closure disease in rural China: the Handan eye study. *Invest Ophthalmol Vis Sci* 2022;63(12):19.

8 Nolan W. Anterior segment imaging: ultrasound biomicroscopy and anterior segment optical coherence tomography. *Curr Opin Ophthalmol* 2008;19(2):115-121.

9 Wang SB, Cornish EE, Grigg JR, McCluskey PJ. Anterior segment optical coherence tomography and its clinical applications. *Clin Exp Optom* 2019;102(3):195-207.

10 Kashani AH, Chen CL, Gahm JK, Zheng F, Richter GM, Rosenfeld PJ, Shi YG, Wang RK. Optical coherence tomography angiography: a comprehensive review of current methods and clinical applications. *Prog Retin Eye Res* 2017;60:66-100.

11 Wright C, Tawfik MA, Waisbourd M, Katz LJ. Primary angle-closure glaucoma: an update. *Acta Ophthalmol* 2016;94(3):217-225.

12 Sun XH, Dai Y, Chen YH, Yu DY, Cringle SJ, Chen JY, Kong XM, Wang XL, Jiang CH. Primary angle closure glaucoma: what we know and what we don't know. *Prog Retin Eye Res* 2017;57:26-45.

13 Nolan WP, Foster PJ, Devereux JG, Uranchimeg D, Johnson GJ, Baasanhu J. YAG laser iridotomy treatment for primary angle closure in east Asian eyes. *Br J Ophthalmol* 2000;84(11):1255-1259.

14 Azuara-Blanco A, Burr J, Ramsay C, Cooper D, Foster PJ, Friedman DS, Scotland G, Javanbakht M, Cochrane C, Norrie J. Effectiveness of early lens extraction for the treatment of primary angle-closure glaucoma (EAGLE): a randomised controlled trial. *Lancet* 2016;388(10052):1389-1397.

15 Chen PP, Lin SC, Junk AK, Radhakrishnan S, Singh K, Chen TC. The effect of phacoemulsification on intraocular pressure in glaucoma patients: a report by the American academy of ophthalmology. *Ophthalmology* 2015;122(7):1294-1307.

16 Shao TT, Hong JX, Xu JJ, Le QH, Wang JJ, Qian SH. Anterior chamber angle assessment by anterior-segment optical coherence tomography after phacoemulsification with or without goniosynechialysis in patients with primary angle closure glaucoma. *J Glaucoma* 2015;24(9):647-655.

17 Tsai HY, Liu CJ, Cheng CY. Combined trabeculectomy and cataract extraction versus trabeculectomy alone in primary angle-closure glaucoma. *Br J Ophthalmol* 2009;93(7):943-948.

18 Agarwal A, Durairajanayagam D, Tatagari S, *et al*. Bibliometrics: tracking research impact by selecting the appropriate metrics. *Asian J Androl* 2016;18(2):296-309.

19 Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: an overview and guidelines. *J Bus Res* 2021;133:285-296.

20 Mukherjee D, Lim WM, Kumar S, Donthu N. Guidelines for advancing theory and practice through bibliometric research. *J Bus Res* 2022;148:101-115.

21 Sun YX, Liu YN, Han Y, Kong FQ, Zhang Y, Labisi SA, Cao K. Bibliometric analysis of glaucoma-related literature based on SCIE database: a 10-year literature analysis from 2009 to 2018. *Int J Ophthalmol* 2020;13(12):1998-2006.

22 Chien JL, Sabharwal J, Namoglu EC, *et al*. The 100 most mentioned glaucoma articles online with highest altmetric attention scores. *J Glaucoma* 2021;31(1):8-14.

23 Ramin S, Pakravan M, Habibi G, Ghazavi R. Scientometric analysis and mapping of 20 years of glaucoma research. *Int J Ophthalmol* 2016;9(9):1329-1335.

24 Wang YR, Zhai X, Liu C, Wang N, Wang YJ. Trends of triple negative breast cancer research (2007-2015): a bibliometric study. *Medicine (Baltimore)* 2016;95(46):e5427.

25 Gu X, Xie MY, Jia RB, Ge SF. Publication trends of research on retinoblastoma during 2001-2021: a 20-year bibliometric analysis. *Front Med* (*Lausanne*) 2021;8:675703.

26 Arruda H, Silva ER, Lessa M, Proença D Jr, Bartholo R. VOSviewer and bibliometrix. *J Med Libr Assoc* 2022;110(3):392-395.

27 Romero L, Portillo-Salido E. Trends in sigma-1 receptor research: a 25-year bibliometric analysis. *Front Pharmacol* 2019;10:564.

28 Peng C, Kuang LJ, Zhao JY, Ross AE, Wang ZQ, Ciolino JB. Bibliometric and visualized analysis of ocular drug delivery from 2001 to 2020. *J Control Release* 2022;345:625-645.

29 Zhao J, Yu GY, Cai MX, Lei X, Yang YY, Wang QJ, Zhai X. Bibliometric analysis of global scientific activity on umbilical cord

mesenchymal stem cells: a swiftly expanding and shifting focus. *Stem Cell Res Ther* 2018;9(1):32.

30 Xie MY, Wu QR, Wang YF, Ge SF, Fan XQ. Publication trends of research on uveal melanoma during 2000-2020: a 20-year bibliometric study. *Ann Transl Med* 2020;8(21):1463.

31 Zhao LT, Li JF, Feng LM, Zhang C, Zhang WL, Wang C, He Y, Wen D, Song WT. Depicting developing trend and core knowledge of primary open-angle glaucoma: a bibliometric and visualized analysis. *Front Med* (*Lausanne*) 2022;9:922527.

32 Tao YY, Zhang Q, Meng M, Huang JF. A bibliometric analysis of the application of stem cells in glaucoma research from 1999 to 2022. *Front Cell Dev Biol* 2023;11:1081898.

33 Song PG, Wang JW, Bucan K, Theodoratou E, Rudan I, Chan KY. National and subnational prevalence and burden of glaucoma in China: a systematic analysis. *J Glob Health* 2017;7(2):020705.

34 Cho HK, Kee C. Population-based glaucoma prevalence studies in Asians. *Surv Ophthalmol* 2014;59(4):434-47.

35 Porporato N, Baskaran M, Husain R, Aung T. Recent advances in anterior chamber angle imaging. *Eye* (*Lond*) 2020;34(1):51-59.

36 Warjri GB, Senthil S. Imaging of the ciliary body: a major review. *Semin Ophthalmol* 2022;37(6):711-723.

37 Nongpiur ME, Verma S, Tun TA, Wong TT, Perera SA, Aung T. Plateau iris and severity of primary angle closure glaucoma. *Am J Ophthalmol* 2020;220:1-8.

38 Chakrabarti K, Samant S, Mohapatra R, Mishra S, Das S, Chakrabarti M. A comparison of lens parameters in patients with various subtypes of primary angle-closure disease and the normal population: a prospective study. *Indian J Ophthalmol* 2022;70(8):2889-2894.

39 Tarongoy P, Ho CL, Walton DS. Angle-closure glaucoma: the role of the lens in the pathogenesis, prevention, and treatment. *Surv Ophthalmol* 2009;54(2):211-225.

40 Loo Y, Tun TA, Vithana EN, Perera SA, Husain R, Wong TT, Aung T, Nongpiur ME. Association of peripheral anterior synechiae with anterior segment parameters in eyes with primary angle closure glaucoma. *Sci Rep* 2021;11(1):13906.

41 Huang WB, Li XY, Gao XB, Zhang XL. The anterior and posterior biometric characteristics in primary angle-closure disease: data based on anterior segment optical coherence tomography and swept-source optical coherence tomography. *Indian J Ophthalmol* 2021;69(4):865-870.

42 Sun JH, Sung KR, Yun SC, Cheon MH, Tchah HW, Kim MJ, Kim JY. Factors associated with anterior chamber narrowing with age: an optical coherence tomography study. *Invest Ophthalmol Vis Sci* 2012;53(6):2607-2610.

43 Chou CC, Shih PJ, Wang CY, Jou TS, Chen JP, Wang IJ. Corvis biomechanical factor facilitates the detection of primary angle closure glaucoma. *Transl Vis Sci Technol* 2022;11(10):7.

44 Baskaran M, Ho SW, Tun TA, How AC, Perera SA, Friedman DS, Aung T. Assessment of circumferential angle-closure by the iris-trabecular contact index with swept-source optical coherence tomography. *Ophthalmology* 2013;120(11):2226-2231.

45 Lai I, Mak H, Lai G, Yu M, Lam DS, Leung CK. Anterior chamber angle imaging with swept-source optical coherence tomography: measuring peripheral anterior synechia in glaucoma. *Ophthalmology* 2013;120(6):1144-1149.

46 Fukuda S, Kawana K, Yasuno Y, Oshika T. Repeatability and reproducibility of anterior chamber volume measurements using 3-dimensional corneal and anterior segment optical coherence tomography. *J Cataract Refract Surg* 2011;37(3):461-468.

47 Wang XL, Chen XX, Tang YZ, Wang JJ, Chen YH, Sun XH. Morphologic features of crystalline lens in patients with primary angle closure disease observed by CASIA 2 optical coherence tomography. *Invest Ophthalmol Vis Sci* 2020;61(5):40.

48 Kimura S, Morizane Y, Shiode Y, Hirano M, Doi S, Toshima S, Fujiwara A, Shiraga F. Assessment of tilt and decentration of crystalline lens and intraocular lens relative to the corneal topographic axis using anterior segment optical coherence tomography. *PLoS One* 2017;12(9):e0184066.

49 Fu HZ, Li F, Sun X, *et al*, for iChallenge-PACG study group. AGE challenge: angle closure glaucoma evaluation in anterior segment optical coherence tomography. *Med Image Anal* 2020;66:101798.

50 Xu BY, Chiang M, Chaudhary S, Kulkarni S, Pardeshi AA, Varma R. Deep learning classifiers for automated detection of gonioscopic angle closure based on anterior segment OCT images. *Am J Ophthalmol* 2019;208:273-280.

51 Niwas SI, Lin WS, Bai XL, Kwoh CK, Sng CC, Aquino MC, Chew PT. Reliable feature selection for automated angle closure glaucoma mechanism detection. *J Med Syst* 2015;39(3):21.

52 Li Z, Xu ZK, Liu Q, Chen XL, Li LR. Comparisons of retinal vessel density and glaucomatous parameters in optical coherence tomography angiography. *PLoS One* 2020;15(6):e0234816.

53 Zhang S, Wu C, Liu L, Jia Y, Zhang Y, Zhang Y, Zhang H, Zhong Y, Huang D. Optical coherence tomography angiography of the peripapillary retina in primary angle-closure glaucoma. *Am J Ophthalmol* 2017;182:194-200.

54 Rao HL, Kadambi SV, Weinreb RN, *et al*. Diagnostic ability of peripapillary vessel density measurements of optical coherence tomography angiography in primary open-angle and angle-closure glaucoma. *Br J Ophthalmol* 2017;101(8):1066-1070.

55 Sihota R, Shakrawal J, Sidhu T, Sharma AK, Dada T, Pandey V. Does TRABECULECTOMY meet the 10-10-10 challenge in PACG, POAG, JOAG and Secondary glaucomas? *Int Ophthalmol* 2020;40(5):1233-1243.

56 Romero P, Hirunpatravong P, Alizadeh R, Kim EA, Nouri-Mahdavi K, Morales E, Law SK, Caprioli J. Trabeculectomy with mitomycin-C: outcomes and risk factors for failure in primary angle-closure glaucoma. *J Glaucoma* 2018;27(2):101-107.

57 Wilson MR, Mendis U, Paliwal A, Haynatzka V. Long-term follow-up of primary glaucoma surgery with Ahmed glaucoma valve implant versus trabeculectomy. *Am J Ophthalmol* 2003;136(3):464-470.

58 Vanner EA, Sun CQ, McSoley MJ, Persad PJ, Feuer WJ, Lum F, Kelly SP, Parrish RK, Chang TC, Gedde SJ. Tube versus trabeculectomy

IRIS ® registry 1-year composite outcome analysis with comparisons to the randomized controlled trial. *Am J Ophthalmol* 2021;227:87-99.

59 Zhuo YH, Wang M, Li Y, Hao YT, Lin MK, Fang M, Ge J. Phacoemulsification treatment of subjects with acute primary angle closure and chronic primary angle-closure glaucoma. *J Glaucoma* 2009;18(9):646-651.

60 Lam DS, Leung DY, Tham CC, Li FC, Kwong YY, Chiu TY, Fan DS. Randomized trial of early phacoemulsification versus peripheral iridotomy to prevent intraocular pressure rise after acute primary angle closure. *Ophthalmology* 2008;115(7):1134-1140.

61 Nonaka A, Kondo T, Kikuchi M, Yamashiro K, Fujihara M, Iwawaki T, Yamamoto K, Kurimoto Y. Angle widening and alteration of ciliary process configuration after cataract surgery for primary angle closure. *Ophthalmology* 2006;113(3):437-441.

62 Husain R, Do T, Lai J, Kitnarong N, Nongpiur ME, Perera SA, Ho CL, Lim SK, Aung T. Efficacy of phacoemulsification alone vs phacoemulsification with goniosynechialysis in patients with primary angle-closure disease: a randomized clinical trial. *JAMA Ophthalmol* 2019;137(10):1107-1113.

63 Wang N, Jia SB. Phacoemulsification with or without goniosynechialysis for angle-closure glaucoma: a global Meta-analysis based on randomized controlled trials. *Int J Ophthalmol* 2019;12(5):826-833.

64 Rodrigues IA, Alaghband P, Beltran Agullo L, Galvis E, Jones S, Husain R, Lim KS. Aqueous outflow facility after phacoemulsification with or without goniosynechialysis in primary angle closure: a randomised controlled study. *Br J Ophthalmol* 2017;101(7):879-885.

65 Hansapinyo L, Choy BNK, Lai JSM, Tham CC. Phacoemulsification versus phacotrabeculectomy in primary angle-closure glaucoma with cataract: long-term clinical outcomes. *J Glaucoma* 2020;29(1):15-23.

66 Wang F, Wu ZH. Phacoemulsification versus combined phacotrabeculectomy in the treatment of primary angle-closure glaucoma with cataract: a Meta-analysis. *Int J Ophthalmol* 2016;9(4):597-603.

67 Kong XM, Chen YH, Chen XL, Sun XH. Influence of family history as a risk factor on primary angle closure and primary open angle glaucoma in a Chinese population. *Ophthalmic Epidemiol* 2011;18(5):226-232.

68 Amerasinghe N, Zhang J, Thalamuthu A, He MG, Vithana EN, Viswanathan A, Wong TY, Foster PJ, Aung T. The heritability and sibling risk of angle closure in Asians. *Ophthalmology* 2011;118(3):480-485.

69 Shi HH, Zhu RR, Hu N, Shi J, Zhang JF, Jiang LJ, Jiang H, Guan HJ. Association of frizzled-related protein (MFRP) and heat shock protein 70 (HSP70) single nucleotide polymorphisms with primary angle closure in a Han Chinese population: Jiangsu Eye Study. *Mol Vis* 2013;19:128-134.

70 Cong YH, Guo XM, Liu X, Cao D, Jia XY, Xiao XS, Li SQ, Fang SH, Zhang QJ. Association of the single nucleotide polymorphisms in the extracellular matrix metalloprotease-9 gene with PACG in Southern China. *Mol Vis* 2009;15:1412-1417.

71 Awadalla MS, Burdon KP, Kuot A, Hewitt AW, Craig JE. Matrix metalloproteinase-9 genetic variation and primary angle closure glaucoma in a Caucasian population. *Mol Vis* 2011;17:1420-1424.

72 Awadalla MS, Thapa SS, Burdon KP, Hewitt AW, Craig JE. The association of hepatocyte growth factor (HGF) gene with primary angle closure glaucoma in the Nepalese population. *Mol Vis* 2011;17:2248-2254.

73 Awadalla MS, Thapa SS, Hewitt AW, Craig JE, Burdon KP. Association of eNOS polymorphisms with primary angle-closure glaucoma. *Invest Ophthalmol Vis Sci* 2013;54(3):2108-2114.

74 Visscher PM, Brown MA, McCarthy MI, Yang J. Five years of GWAS discovery. *Am J Hum Genet* 2012;90(1):7-24.

75 Vithana EN, Khor CC, Qiao CY, *et al*. Genome-wide association analyses identify three new susceptibility loci for primary angle closure glaucoma. *Nat Genet* 2012;44(10):1142-1146.

76 Khor CC, Do T, Jia HY, *et al*. Genome-wide association study identifies five new susceptibility loci for primary angle closure glaucoma. *Nat Genet* 2016;48(5):556-562.

77 Awadalla MS, Thapa SS, Hewitt AW, Burdon KP, Craig JE. Association of genetic variants with primary angle closure glaucoma in two different populations. *PLoS One* 2013;8(6):e67903.

78 Chen YH, Chen XL, Wang L, Hughes G, Qian SH, Sun XH. Extended association study of PLEKHA7 and COL11A1 with primary angle closure glaucoma in a Han Chinese population. *Invest Ophthalmol Vis Sci* 2014;55(6):3797-3802.

79 Duvesh R, Verma A, Venkatesh R, Kavitha S, Ramulu PY, Wojciechowski R, Sundaresan P. Association study in a South Indian population supports rs1015213 as a risk factor for primary angle closure. *Invest Ophthalmol Vis Sci* 2013;54(8):5624-5628.

80 Yousefian A, Shokoohi-Rad S, Abbaszadegan MR, Rad DM, Zargari S, Milanizadeh S, Morovatdar N, Daneshvar R. Primary angle closure glaucoma-associated genetic polymorphisms in northeast Iran. *J Ophthalmic Vis Res* 2020;15(1):45-52.

81 Nongpiur ME, Wei X, Xu L, *et al*. Lack of association between primary angle-closure glaucoma susceptibility loci and the ocular biometric parameters anterior chamber depth and axial length. *Invest Ophthalmol Vis Sci* 2013;54(8):5824-5828.

82 Zhuang WJ, Wang SL, Hao J, Xu MY, Chi H, Piao SY, Ma JQ, Zhang XL, Ha SP. Genotype-ocular biometry correlation analysis of eight primary angle closure glaucoma susceptibility loci in a cohort from Northern China. *PLoS One* 2018;13(11):e0206935.

83 Day AC, Luben R, Khawaja AP, Low S, Hayat S, Dalzell N, Wareham NJ, Khaw KT, Foster PJ. Genotype-phenotype analysis of SNPs associated with primary angle closure glaucoma (rs1015213, rs3753841 and rs11024102) and ocular biometry in the EPIC-Norfolk Eye Study. *Br J Ophthalmol* 2013;97(6):704-707.

84 Nongpiur ME, Khor CC, Cheng CY, *et al*. Integration of genetic and biometric risk factors for detection of primary angle closure glaucoma. *Am J Ophthalmol* 2019;208:160-165.