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RESEARCH TREND ANALYSIS OF MOLECULAR IMAGING FROM THE PERSPECTIVE OF LITERATURE DATA

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Abstract —The purpose of this paper is to study molecular imaging from the perspective of bibliometric. Through data analysis and comparison analysis, study results can provide researchers help and advices, such as research trends, research frontier. This paper quantitatively analysis 18732 related molecular imaging literature from 2006 to 2015 by analysing Published literature quantity, countries and regions, research institutions and source journals using Scopus database based on SCIVAL data analysis platform and Excel software. Result shows that the molecular imaging research is still in the development stage in the last ten years, and the annual publication of the academic literature show the overall growth trend. The ACS Nano and the Journal of the American Chemical Society have the highest reputation in the field of molecular imaging. This study also give some helpful suggestions to domestic researchers in building research team, broadening cooperation channels,and tracking national science and technology policy.

Keywords—Medical Imaging, Molecular Imaging, Research Trend, Bibliometric

I. INTRODUCTION

Traditional medical image diagnosis (X-ray, CT, MR, ultrasound, etc.) mainly shows the final effect of molecular changes and the image of diseases with anatomical changes. Molecular Imaging can detect the abnormality of cell and Molecular level in the process of disease, and detect the abnormality before the disease with no anatomical changes, it plays a bridge between molecular biology and clinical medicine in exploring the occurrence, development and regression of diseases and evaluating the curative effect of drugs, and it is a new subject that integrates medical imaging technology and molecular biology, chemistry, physics, radiation medicine, nuclear medicine and computer science[1,2].In 1999, Weissleder of Harvard University in the United States first proposed the concept of molecular imaging[3].It represents the development trend of medical imaging in the future, and its revolutionary impact on modern and future medical models.

Bibliometric is a science that studies the laws and scientific management of the working system of literature, as well as the dynamic characteristics of science and technology[4]. Since the 1990s, bibliometric has gradually become an important method to study the current situation and development trend of a certain scientific field[5,6].

In this study, the Scopus database was taken as the source.Data collection, mining and analysis of all relevant molecular imaging literature from 2006 to 2015 are conducted in a multi-dimensional and multi-level manner, in order to grasp the overall development trend of molecular imaging at home and abroad, and to reveal the hotspots of frontier research.

II. DATA AND METHODS

A. Data source

The research literature data is derived from the Scopus database of the secondary literature database. It has many journals, non-English literature, and complete disciplines.

B. Analysis methods

This study uses the subject words and combined with the domain classification method, selecting the field of "molecular imaging", setting the type as the number of research papers and reviews , setting the time range from 2006 to 2015, setting the retrieval formula as: TITLE-ABS-KEY("molecular imaging") AND(LIMIT-TO (DOCTYPE ,"ar ") OR LIMIT-TO(DOCTYPE ,"re")) AND (LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR,2014) OR LIMIT-TO (PUBYEAR,2013) OR LIMIT-TO (PUBYEAR,2012) OR LIMIT-TO (PUBYEAR,2011) OR IMIT-TO (PUBYEAR ,2010) OR LIMIT-TO (PUBYEAR ,2009)OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR ,2007) OR LIMIT-TO (PUBYEAR ,2006). Finally, 18,732 articles related

to "molecular imaging" were obtained (the search deadline is March 30, 2017, due to the lag of data update, the 2016 data is not in the statistical range). Then, data mining and analysis are carried out using the professional data analysis tool SCIVAL platform and Excel software.

III.RESULTS AND ANALYSIS

A. Annual changes in the literature of molecular imaging studies

The annual changes published in the paper can reflect the development process of the research in this field and the research level of a certain period of time.

From 2006 to 2015, the annual published number of “molecular imaging" documents in Scopus is shown in Table1.

TABLE.1 THE AGE DISTRIBUTION OF MOLECULAR IMAGING RESEARCH LITERATURE FROM 2006 TO 2015

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number	599	826	995	1304	1766	2221	2561	2964	2908	2588

According to D.S. Price's scientific literature growth theory[7], compared the number of annual publications since the rise of molecular imaging research worldwide, it indicates that the field was in the first stage of discipline development before 2006; It was in the second stage of discipline development from 2006 to 2015, and the literature showed a continuous growth trend and maintained a period of growth. This indicates that the study of molecular imaging has experienced the initial slow development and entered the second stage of uniform development[8].

B. Quality changes in the molecular imaging studies literature

A high citation rate of 1% refers to the papers that have been cited in the top 1% of the world in a discipline in the last 10 years. By analyzing the performance of molecular imaging literature in the highly cited literature, the quality change trend of the literature in this field can be seen.

TABLE.2 PERFORMANCE OF GLOBAL MOLECULAR IMAGING LITERATURE IN HIGHLY CITED PAPERS FROM 2006 TO 2015

	Five years total(2006-2010)	Five years total(2011-2015)
High cited 1% literature	263	440
Accounted for High cited 1% literature (%)	4.8	3.3
High cited 10% literature	1,633	3,483
Accounted for High cited 10% literature (%) (%)	29.8	26.3

It can be seen from the comparative analysis of the above two five-year data that the number of literature with 1% high citation rate in molecular imaging increased by 67% in 2011-2015 compared with 2006-2010, but the proportion with 1% high citation rate decreased by 31%; The number of highly cited references in molecular imaging increased by 113% in 2011-2015 compared with 2006-2010. This indicates that, compared with 2006-2010, the number of publications of molecular imaging research literature has increased significantly in the past five years, but the output of globally influential literature has not increased synchronously.

C. The main research and analysis of Molecular imaging

In this study, the analysis of molecular imaging includes the analysis of the countries and regions where the literature was produced, the analysis of research institutions.

1) Analysis of major countries and regions

The geographical distribution of literature output can help researchers to identify the leading countries and regions in a certain research field, help researchers to understand the position of their own research level in this field in the world.

a) Analysis on the number of publications in major countries and regions

From 2006 to 2015, the top 10 countries in terms of molecular imaging literature were the United States, Germany, China, the United Kingdom, Japan, the Netherlands, France, Italy, Canada and South Korea, as shown in Table 3. These 10 countries have published 78.39 percent of the world's total publications in this field.

TABLE.3 THE TOP 10 COUNTRIES HAVE PUBLISHED THE LITERATURE ON MOLECULAR IMAGING STUDIES FROM 2006 TO 2015

Sort by numbers	Country/Region	2006-2015
1	United States	8036
2	Germany	2089
3	China	2011
4	United Kingdom	1294
5	Japan	1245
6	Netherlands	927
7	France	872
8	Italy	731
9	Canada	730
10	South Korea	631

Table 4 provides the chronological distribution of molecular imaging research literature in China, the United States and Germany over the last 10 years. Compared with the United States and other developed countries, the research on molecular imaging in China started relatively late. With the development of this

subject, more and more attention has been paid to molecular imaging studies in China. From 2011 to 2015, the number increased by 415% compared with the previous five years, surpassing Germany and ranking second in the world, meanwhile, the volume of relevant literature published in the United States and Germany increased by 104% and 155% respectively compared with the previous five years. Even Though, China's total output in 10 years is still less than one third of that of the United States, this indicates that there is a big gap between China and the United States in the research strength, experience and methods of molecular imaging.

TABLE.4 AGE DISTRIBUTION OF MOLECULAR IMAGING LITERATURE IN CHINA, UNITED STATES AND GERMANY FROM 2006 TO 2015

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China	22	31	48	92	134	236	282	361	408	397
United States	321	401	511	604	808	983	1127	1176	1173	932
Germany	57	92	117	127	195	227	293	340	322	319

b) Analysis of citation frequency of major countries and regions

Table 5 shows the comparison between the number of published documents and citation count, citations per publication in the top 20 countries and regions in the field of molecular imaging from 2011 to 2015. According to the data in the table, South Korea, Britain, Australia, the United States, Switzerland, Belgium, Germany, Sweden, the Netherlands and Spain have the highest citations per publication frequency.

TABLE.5 CITATION COUNT AND CITATIONS PER PUBLICATION IN MAJOR COUNTRIES FROM 2006 TO 2015

Sort by numbers	Country	Scholarly Output	Citation Count	Citations per Publication
1	United States	3132	39485	12.61
2	China	831	8742	10.52
3	Germany	820	10077	12.29
4	Netherlands	475	5556	11.7
5	United Kingdom	463	6426	13.88
6	Japan	414	3089	7.46
7	Italy	352	3209	9.12
8	France	288	3043	10.57
9	Canada	274	2810	10.26
10	South Korea	273	4134	15.14

Note: the data from the above table is extracted from the SciVal platform and is not fully synchronized with Scopus data

c) Analysis on cooperative relations between major countries and regions

International cooperation between countries and regions can reflect the degree of activity and international reputation of a country and region in a certain academic field[9].The University-Enterprise cooperation paper is a reflection of the ability of university scientific research institutions to serve the society[10], and also an effective means to promote the technological innovation of national enterprises and technological breakthrough. Analysis result shows the cooperation of all countries and regions in 2011-2015.In the United States, 32.1 percent had international partners and 3.3 percent had been completed by research institutions and enterprises. International cooperation accounted for 33.4 percent of China's 1,864 published documents, but only 1 percent were published by University-enterprise cooperation. Of the 1,714 published papers in Germany, 51.8% had international partners and 5.2% had been jointly completed by research institutions and enterprises. It can be seen that in the field of molecular imaging, Germany is the most active in international cooperation and University-enterprise cooperation.

2) Analysis of major research institutions

a) Analysis on the publications volume of major research institutions

The top 10 research institutions of molecular imaging in the world are: Harvard University, Stanford University, National Institutes of Health, Johns Hopkins University, Centre National DE la recherche scientifique, Washington University St. Louis, University of Pennsylvania, Technische Universitat Munchen, University of California at Los Angeles, Memorial Sloan-Kettering Cancer Center. Eight of these institutions belong to the United States, indicating that the United States has an dominant position in the research level in this field. None of China's institutions made on the list.

b) Analysis of citation frequency of the main research institutions

Table 6 shows the number of output, total cited frequency, number of authors, and the influence index of the Citations per publication and field-weighted Citation Impact of the above research institutions in 2011-2015. From the analysis of the influence of the literature of the research institution, Memorial sloan-kettering Cancer Center and University of Texas m. d. Anderson Cancer Center in the United States were cited more than 30 times, 33.8 times and 31.3 times respectively. Meanwhile, their region-weighted index of citation impact was also the highest, 3.46 and 3.47 times respectively.

Peking University is also added in the table. From 2011 to 2015, 133 articles were published, the total cited frequency was 2,793 times, and the influence index of regional weighted citation was 1.98, the same as that of the 20th national institute of health and medical research of France. In terms of citations per publication frequency, Peking University has certain

research ability and influence in this field, but it is still a big gap with international high-level universities.

TABLE.6 CORRELATION INDEX OF MAJOR RESEARCH INSTITUTIONS OF MOLECULAR IMAGING IN THE WORLD FROM 2011 TO 2015

Institution	Country	Out put	Citations	Authors	Citations per Publication	Field-Weighted Citation Impact
Harvard University	United States	528	13966	1054	26.5	2.75
Stanford University	United States	401	11788	800	29.4	3.05
National Institutes of Health	United States	363	9817	601	27	2.77
Johns Hopkins University	United States	281	6647	531	23.7	2.73
CNRS	France	222	3779	604	17	2.11
Washington University St. Louis	United States	221	6286	424	28.4	3.03
University of Pennsylvania	United States	202	3211	367	15.9	2.2
Technische Universitat Munchen	Germany	196	3936	343	20.1	2.89
University of California at Los Angeles	United States	181	4110	455	22.7	2.86
Memorial Sloan-Kettering Cancer Center	United States	178	6008	355	33.8	3.46
Peking University	China	133	2793	383	21	1.98

Note: the data from the above table is extracted from the SciVal platform and is not fully synchronized with Scopus data

IV. Analysis of the sources on molecular imaging research literature

SJR (SCImago Journal Rank) and SNIP (Source Normalized Impact per Paper) are new indicators for journal evaluation based on Scopus database and different from JCR Impact Factor.

In 2007, Spain's SCImago project research group proposed a new journal evaluation index SCImago Journal Rank (SJR) based on the Scopus database[11]. In 2008, Nature reported a new journal evaluation index SJR based on the Scopus database. [12]. The journal reputation indicator SJR gives higher weights to high-reputation journals, the more a journal is cited by a high-review journal, the higher its reputation[13]. SNIP was formally proposed by Professor Henk F. Moed of the University of Leiden in the Netherlands as a supplementary indicator of SJR in 2010[14]. SNIP refers to the influence of single article source standardization. The purpose of calculating the influence of single article source standardization is to directly compare the influence of journals in different disciplines and eliminate the variation of influence factors in different fields

Analysis result show the top 10 source journals published in the field of molecular imaging in 2006-2015. The 18,732 molecular imaging documents included in 160 journals from all over the world, the top 10 source journals accounted for 35.32% of the total number of publications on this topic.The top three journals with the most literature in 2011-2015 are: Journal of Nuclear Medicine, PLoS One, Molecular Imaging and Biology. The Journal of Nuclear Medicine ranks first with 1,068 articles, accounting for 22% of the total. Through the numerical analysis of SJR and SNIP of the source journals, ACS Nano and Journal of the American Chemical Society, with SNIP, SJR, Citation Count and Citations per Publication among the top 2 journals. The ACS Nano and the Journal of the American Chemical Society are high-profile journals in the field of molecular imaging, with high citation quality, strong disciplinary influence, and world-leading level. Result also shows the research directions of source journals, mainly in nuclear medicine, medicine, cytology, imaging diagnostics, radiology, molecular biology, bioengineering, biomedical technology, biomaterials, nanotechnology, optics and photons. Science, material chemistry, organic chemistry, etc.

V.Conclusion and recommendations

A. Conclusion

From the literature point of view, the annual changes in the literature on molecular imaging related research in 2006-2015 are steadily increasing, indicating that the field is still in the development stage in the past 10 years. The number of relevant documents in the United States, Germany, and China ranks among the top three in the world. If the impact analysis is carried out from the citation frequency of the literature, the literature in Korea, the United Kingdom, the United States, and Germany is significantly more influential than other countries and regions.

From the perspective of research institutions, the United States has an absolute dominant position in the number of research institutions and the number of publications in the literature. The type of research institution is mainly university, and the literature is generally cited as high frequency, indicating that the United States has strong research strength and innovation ability in the field of molecular imaging. Although there are more and more scholars working on this field, there is still a gap between the actual research results and the rapid development of international molecular imaging.

From the source journals, the ACS Nano and Journal of the American Chemical Society have the highest reputation index of journals in the field of molecular imaging, which can provide more substantial help to

researchers in terms of research frontiers and significance disclosure.

B. Recommendations

- Build a multidisciplinary research team, moving from basic research to clinical application. As an interdisciplinary subject, molecular imaging requires the cooperation of interdisciplinary talents such as pharmacy, clinical medicine, physics, basic medicine, chemistry, computer science and radiology.
- Broaden international cooperation channels and improve the performance of scientific research cooperation.
- Overcome the monotonous research means and seize the opportunity to develop innovative technologies. Molecular imaging is directly related to basic research and clinical application, and is the most typical carrier in the field of translational research medicine[15].From basic research to clinical research, it is possible to move to clinical research and clinical applications step by step, ultimately achieving sustainable, high-quality transformation.

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