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Growing trend of China's contribution to tissue engineering

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Abstract This study examines China's performance on tissue engineering using scientometrics measures such as China's global publication share, rank, growth rate and citation impact, its publications in various sub-fields, top journals in terms of national share based on last 5 years (2008–2012) publications data obtained from ISI Science citation index expanded database. We have also determined Chinese share with international collaborative papers at the national level, as well as h-core papers and high-cited papers, etc.

Keywords Tissue engineering · Regenerative medicine · China · Contribution · Scientometrics

Introduction

Human tissue damage or defect will lead to dysfunction. The traditional repair way is to transplant autologous tissues. Despite of relatively satisfactory effect, it needs autologous healthy tissues and causes a lot of complication and additional damage. As for human organ dysfunction syndrome, drug therapy or temporary replacement therapy may save some patients' life, but the source of donor organs is limited and the complications afterwards are fatal because of immunologic rejection, which needs immunosuppressive agents for a long time after operation.

Since American scientists firstly put forward the concept of "tissue engineering" in 1980s, a new revolutionary treatment is coming out for tissue damage or organ dysfunction patients.

The term "regenerative medicine" is often used synonymously with "tissue engineering", although those involved in "regenerative medicine" place more emphasis on the use of stem cells to produce tissues. The commonly applied definition of tissue engineering, as

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stated by Langer and Vacanti, is "an interdisciplinary field that applies the principles of engineering and life sciences toward the development of biological substitutes that restore, maintain, or improve tissue function or a whole organ" (Langer and Vacanti 1993). It is the use of a combination of cells, engineering and materials methods, and suitable biochemical and physio-chemical factors to improve or replace biological functions. Tissue engineering covers a broad range of applications, in practice the term is closely associated with applications that repair or replace portions of or whole tissues (i.e., bone, cartilage, blood vessels, bladder, skin, muscle, etc.). (http://en.wikipedia.org/wiki/Tissue_engineering).

Tissue engineering covers a broad range of disciplines, such as materials, engineering, life science, medicine, etc. In the field of medicine, genetics, tissue embryology, cell biology, molecular biology, etc., are involved; while in the field of clinical medicine, orthopaedic, thoracic surgery, neurosurgery, dental surgery, rehabilitation medicine, etc., are involved. Materials normally used in tissue engineering are polymer materials or ceramics.

Scientometrics is a tool by which the state of science and technology can be observed, through the overall production of scientific literature, at a given level of specialization. It provides an approach for situating a country in relation to the world, an institution in relation to a country, or assessment of scientific disciplines internationally (Pouris and Pouris 2011; Pouris 2007), etc. Scientometrics indicators provide a reliable evidence of scientific activity, and have been used in various research topics such as dental science (Kaur and Gupta 2010), psychology (Barrios et al. 2013; Guilera et al. 2013), HIV/AIDS (Pouris and Pouris 2011), sociology (Cronin et al. 1997), materials science (Garfield and Pudovkina 2003), hydrogeology (Schwartz and Fang 2007), and biochemistry, genetics and molecular biology (Bala and Gupta 2010).

China is one of the most attractive countries in terms of scientific performance today. It has experienced a sustained and remarkable increase in scientific productions. Various studies have been conducted in the past analyzing China's contribution in different subject fields and diseases. Zhang et al. analyzed China's contribution to the field of plastic and reconstructive surgery from 2000 to 2009 (Zhang et al. 2012). Liu et al. conducted ten-year survey on oncology publications in China from 2001 to 2010 (Liu et al. 2011). Makris et al. performed a bibliometric analysis through the ISI Web of Knowledge in modern biomedical (Makris et al. 2009).

The current study is aimed to measure the Chinese stand on tissue engineering research. We believe China plays a vital role in tissue engineering in the world and Chinese scientists have given their indelible contributions to human health.

Methodology and source data

The study focused on China's performance based on its publications related to tissue engineering during the past 5 years (2008–2012).

This study was done based on the publication data from China as well as other countries in tissue engineering retrieved from ISI-Thomson Reuters Scientific-databases (Science citation index expanded, SCIE). Science citation index (SCI) is a famous citation index originally produced by the institute for scientific information (ISI) and created by Eugene Garfield in 1960, which is now owned by Thomson Reuters. The larger version (SCIE) covers more than 6,500 notable and significant journals, across 150 disciplines, from 1900 to the present and updates weekly. These are alternately described as the world's leading journals of science and technology, because of a rigorous selection process (http://en.

wikipedia.org/wiki/Science_Citation_Index). In this paper, "Tissue engineering" and "regenerative medicine" were used as exact "Topic" terms to search papers in SCIE database from 2008 to 2012. 16,602 papers from four document types such as article, review, meeting abstract and proceedings paper were collected in this study.

The total number of papers was searched for the whole 5 years as well as for every single year. Citations were obtained according to "create citation report" in SCIE which updated weekly. For analyzing research topic, the separate search strategies for generating research area and source title outputs were developed to indicate the desired output. For retrieving and calculating the total international collaborative papers, a search strategy which combined China's collaboration with other countries was prepared to reveal China's total international collaborative output. H-index was involved to find out the core papers on tissue engineering in China. The top 10 high cited papers were listed to show the high quality and impact papers in China.

Results and discussion

Global publication share and ranking

The publication shares of the top 10 most productive countries in tissue engineering research range from 32.92 to 2.95 % of 16,602 total papers during 2008–2012. The USA tops the list with 5,466 papers (32.92 %), and China ranks second by 13.67 % for 2,269 papers, followed by Germany, Japan and England, whose global publication shares are 8.41, 7.70 and 6.85 %, respectively. Italy, South Korea, Canada, France and Netherlands rank at 6–10th positions with publication shares ranging from 5.84 to 2.95 % (Table 1).

Among these top 10 countries, USA and South Korea remained almost the same shares of their publications in every single year of the past 5 years, while Japan, England and Netherlands showed decline in their publication shares from 8.99, 8.22 and 3.44 to 6.54, 6.52 and 2.77 % respectively. Germany and Canada increased from 2008 to 2010 but declined in the next 2 years. Only China, Italy and France showed increase in their

Table 1 Publication output, share and growth rate of top 10 countries in tissue engineering research, 2008–2012

Country	Number of papers (Share of papers, %)						Growth rate for 5 years
	2008	2009	2010	2011	2012	Total	
USA	902 (34.49)	943 (33.32)	1,198 (34.42)	1,197 (33.31)	1,226 (30.03)	5,466 (32.92)	35.92
P R China	278 (10.63)	393 (13.89)	455 (13.07)	493 (13.72)	650 (15.92)	2,269 (13.67)	133.81
Germany	222 (8.48)	254 (8.97)	327 (9.39)	283 (7.87)	311 (7.62)	1,397 (8.41)	40.09
Japan	235 (8.99)	222 (7.84)	283 (8.13)	271 (7.54)	267 (6.54)	1,278 (7.70)	13.62
England	215 (8.22)	207 (7.31)	236 (6.78)	213 (5.93)	266 (6.52)	1,137 (6.85)	23.72
Italy	150 (5.74)	148 (5.23)	199 (5.72)	219 (6.09)	254 (6.22)	970 (5.84)	69.33
South Korea	137 (5.24)	146 (5.16)	174 (5.00)	191 (5.31)	228 (5.59)	876 (5.28)	66.42
Canada	88 (3.37)	118 (4.17)	147 (4.22)	141 (3.92)	130 (3.18)	624 (3.76)	47.73
France	75 (2.87)	82 (2.90)	97 (2.79)	118 (3.28)	130 (3.18)	502 (3.02)	73.33
Netherlands	90 (3.44)	86 (3.04)	116 (3.33)	84 (2.34)	113 (2.77)	489 (2.95)	25.26
Global	2,615	2,830	3,481	3,594	4,082	16,602	

publication shares, which were from 10.63, 5.74 and 2.87 to 15.92, 6.22 and 3.18 % respectively. And China's growth rate in publications was tremendous with 133.81 % from 2008 to 2012, while Italy and France were 69.33 and 73.33 %, respectively.

Citations-based indicators are valuable and reveal measures of the impact and internationalization of the scientific work (Moed 2005; Garfield and Welljams-Dorof 1992). Citation analysis is more formal, open, scholarly founded, supplemented in the evaluation of groups (Moed 2005). So by comparing citation impact per paper among the top 10 countries, it was observed that Netherlands and USA were on top 2 of the list with citation impact per paper of 15.35 and 15.00, followed by Canada (12.90), England (12.75), Japan (10.61), Italy (10.52), Germany (10.44), France (9.83), South Korea (9.08) and China (7.96) (Table 2).

From Tables 1 and 2, it shows that China developed very well and played an important role in tissue engineering in the past 5 years, but the impact and internationalization of publications were still barely satisfactory.

Research area of tissue engineering in China

China's publication output on tissue engineering during 2008–2012 has been involved in the following top 10 research areas according to data analysis of SCIE: of the 2,269 China papers, the highest publication output coming from material science (994 papers and 43.81 % publication share), followed by engineering (670 papers, 29.53 %), cell biology (331 papers, 14.59 %), chemistry (323 papers, 14.24 %), polymer science (315 papers, 13.88 %), biotechnology applied microbiology (275 papers, 10.69 %) and so on (Table 3).

On analyzing the quality and impact of tissue engineering research output under different subjects, it was found that engineering, chemistry and material science had scored high impacts (10.19, 10.18, and 9.25 citations per item respectively), followed by cell biology (8.08 citations per item), biochemistry molecular biology and science technology other topics (8.03 citations per item) and so on (Table 3). The quality and impact of research output in engineering, chemistry and material science in China were more remarkable than that of the other research areas.

As comparison to China, the global research areas in tissue engineering during 2008–2012 had been involved in the following: of the 16,602 global papers, the highest publication output coming from material science (5,200 papers), and then engineering (5,054 papers), cell biology (3,610 papers), biotechnology applied microbiology (2,761 papers), and so on (Table 4), which showed slightly different from China (Table 3).

Table 2 Citation impact of top 10 countries in tissue engineering, 2008–2012

Country	Total papers	STC	ACPI
USA	5,466	81,992	15.00
P R China	2,269	18,068	7.96
Germany	1,397	14,580	10.44
Japan	1,278	13,562	10.61
England	1,137	14,499	12.75
Italy	970	10,202	10.52
South Korea	876	7,956	9.08
Canada	624	8,050	12.90
France	502	4,935	9.83
Netherlands	489	7,504	15.35

Weekly updated data from "create citation report" in SCIE

STC sum of the times cited, *ACPI* average citations per item

Table 3 Contribution and impact of Chinese papers on different research areas of tissue engineering, 2008–2012

Research area	Total papers	Share (%)	STC	ACPI
Material science	994	43.81	9,193	9.25
Engineering	670	29.53	6,826	10.19
Cell biology	331	14.59	2,675	8.08
Chemistry	323	14.24	3,288	10.18
Polymer science	315	13.88	2,504	7.95
Biotechnology applied microbiology	275	10.69	1,795	7.91
Biochemistry molecular biology	174	7.67	1,398	8.03
Science technology other topics	151	6.65	1,254	8.03
Physics	128	5.64	985	7.70
Research experimental medicine	128	5.64	880	6.88
Total of China	2,269		15,319	5.95

Weekly updated data from "create citation report" in SCIE

STC sum of the times cited, *ACPI* average citations per item

China's contribution to the global research areas output can be also seen from Table 4. Polymer science, material science and chemistry scored high shares which were 21.97, 19.12 and 19.12 % respective contributions to the corresponding global research areas in tissue engineering, indicating that China had made strong performance in chemistry area of tissue engineering, especially in polymer and material science.

Most productive journals publishing Chinese research papers

The 10 most productive journals publishing Chinese research papers together contributed 633 papers in tissue engineering, which accounted for 27.90 % of the total output of China during 2008–2012 (Table 5).

From Table 5, *Biomaterials* published the most Chinese papers in tissue engineering with 153 papers in the past 5 years sharing 6.74 % of the total output. The IF-5 of this journal is 8.415 and ranks Q1/Q1 in the corresponding categories. Then comes *Journal of*

Table 4 Contribution of global papers to different research areas in tissue engineering, 2008–2012

Research area	Global papers	China papers	China share (%)
Material science	5,200	994	19.12
Engineering	5,054	670	13.26
Cell biology	3,610	331	9.17
Biotechnology applied microbiology	2,761	275	9.96
Chemistry	1,689	323	19.12
Polymer science	1,434	315	21.97
Biochemistry molecular biology	1,336	174	13.02
Science technology other topics	1,144	151	13.20
Research experimental medicine	920	128	13.91
Physics	691	128	18.52

Biomedical Materials Research Part A, 109 papers shared 4.80 % of the total output and IF-5 is 3.105 ranked Q1/Q2 in the corresponding categories. *Journal of Materials Science—Materials in Medicine* and *Acta Biomaterialia*, which published 3.13 and 2.64 % Chinese papers, are also remarkable for their high IF-5 with 2.480 and 5.076, ranking Q2/Q2 and Q1/Q1 respectively in the corresponding categories. From Table 5, it shows that the quality of Chinese papers in tissue engineering was noticeable.

The journal *Biomaterials,* for example, was analyzed to compare China's contribution with that of the other countries published in the journal from 2008 to 2012 (Table 6). *Biomaterials* is an international journal covering the science and clinical application of biomaterials. The scope of this journal covers the wide range of physical, biological and chemical sciences that underpin the design of biomaterials and the clinical disciplines in which they are used. *Biomaterials* is relevant to areas such as cancer diagnosis and therapy, implantable devices, drug delivery systems, gene vectors, bionanotechnology and tissue engineering (http://www.journals.elsevier.com/biomaterials/). IF-5 of *Biomaterials* is 8.415, ranking No.1 in the categories of "Engineering, Biomedical" and "Materials Science, Biomaterials".

From Table 6, 1,021 papers were published on tissue engineering in *Biomaterials* from 2008 to 2012, 15 % of which were from China and contributed 13.8 % citations to the

Table 5 Chinese research output and impact of top 10 most productive journals contributing to tissue engineering, 2008–2012

Journal name	Total papers	Share (%)	IF-5[a]	Quartile in category[b]
Biomaterials	153	6.74	8.415	Q1/Q1 (Engineering, Biomedical/Materials Science, Biomaterials)
Journal of Biomedical Materials Research Part A	109	4.80	3.105	Q1/Q2 (Engineering, Biomedical/Materials Science, Biomaterials)
Journal of Materials Science—Materials in Medicine	71	3.13	2.480	Q2/Q2 (Engineering, Biomedical/Materials Science, Biomaterials)
Acta Biomaterialia	60	2.64	5.076	Q1/Q1 (Engineering, Biomedical/Materials Science, Biomaterials)
Tissue Engineering Part A	50	2.20	–	–
Biomedical Materials	44	1.94	2.675	Q2/Q3 (Engineering, Biomedical/Materials Science, Biomaterials)
Journal of Biomedical Materials Research Part B—Applied Biomaterials	40	1.76	2.305	Q2/Q3 (Engineering, Biomedical/Materials Science, Biomaterials)
Journal of Biomaterials Science-Polymer Edition	37	1.63	2.215	Q3/Q3/Q2 (Engineering, Biomedical/Materials Science, Biomaterials/Polymer Science)
Applied Surface Science	35	1.54	2.032	Q2/Q1/Q2/Q2 (Chemistry, Physical/Materials Science, Coating & Films/Physics, Applied/Physics, Condensed Matter)
Journal of Bioactive and Compatible Polymers	34	1.50	2.460	Q2/Q2/Q1 (Biotechnology & Applied Microbiology/Materials Science, Biomaterials/Polymer Science)
Total of China	2,269	100		

[a] Data from JCR 5-year journal impact factor from 2006 to 2010

[b] Data from JCR journal ranking of quartile in different categories

Table 6 Publication output, share and citations on tissue engineering in *Biomaterials,* 2008–2012

No.	Country	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	Total (%)	STC (%)
1	USA	67 (45.9)	89 (42.6)	112 (43.8)	106 (49.5)	81 (41.3)	455 (44.6)	10,519 (48.5)
2	P R China	20 (13.7)	25 (12.0)	30 (11.7)	35 (16.4)	43 (21.9)	153 (15.0)	3,001 (13.8)
3	Germany	10 (6.9)	18 (8.6)	17 (6.6)	16 (7.5)	13 (6.6)	74 (7.3)	1,516 (7.0)
4	Japan	6 (4.1)	13 (6.2)	21 (8.2)	17 (7.9)	14 (7.1)	71 (7.0)	1,107 (5.1)
5	England	16 (11.0)	17 (8.1)	12 (4.7)	9 (4.2)	6 (3.1)	60 (5.9)	1,758 (8.1)
6	Singapore	11 (7.50)	14 (6.7)	19 (7.4)	4 (1.9)	9 (4.6)	57 (5.6)	1,722 (7.9)
7	Australia	3 (2.1)	11 (5.3)	19 (7.4)	12 (5.6)	6 (3.1)	51 (5.0)	1,227 (5.7)
8	Canada	6 (4.1)	7 (3.4)	10 (3.9)	15 (7.0)	10 (5.1)	48 (4.7)	758 (3.5)
9	South Korea	4 (2.7)	5 (2.4)	15 (5.9)	9 (4.2)	13 (6.6)	46 (4.5)	882 (4.1)
10	Italy	6 (4.1)	5 (2.4)	16 (6.3)	10 (4.7)	8 (4.1)	45 (4.4)	674 (3.1)
11	Switzerland	4 (2.7)	6 (2.9)	12 (4.7)	12 (5.6)	7 (3.6)	41 (4.0)	859 (4.0)
12	Netherlands	6 (4.1)	9 (4.3)	11 (4.3)	4 (1.9)	9 (4.6)	39 (3.8)	900 (4.2)
	Total	146	209	256	214	196	1,021	21,685

STC Sum of the times cited, data from "create citation report" in SCIE

journal, only next to USA (44.6, 48.5 %). China was the only country which showed a steady growth trend in the number of papers published in the journal, while the other countries showed jumping trends during the past 5 years. It demonstrates that China is an important actor in tissue engineering in the world.

International collaboration

During the period under study, 640 papers out of total 2,269 papers on tissue engineering published from China involved international collaboration which is 28.21 % of the total. The international collaborative publication percentages didn't increase during the past 5 years (Table 7), compared to the growth of total China papers from 10.63 % of global output in 2008 to 15.92 % in 2012 (see Table 1).

Among the top 10 international collaborative partners, USA was the major collaborating partner of China during 2008–2012 by contributing 41.72 % publication share of China's total international collaborative output on tissue engineering, and showed a significant growth each year, from 26 papers in 2008 to 87 papers in 2012. Then followed by Singapore (with 9.22 %), Japan (8.91 %), England (7.66 %), Australia (7.34 %), Germany (6.09 %), Netherlands (4.53 %), Canada (4.06 %), South Korea (3.13 %), and France (2.03 %) (Table 7).

Chinese high cited papers on tissue engineering, 2008–2012

The H-index is an index that attempts to measure both the productivity and impact of the published work of a scientist or scholar. The index is based on the set of the scientist's most cited papers and the number of citations that they have received in other publications. The index was suggested by Jorge E. Hirsch, a physicist at UCSD (University of California, San Diego), as a tool for determining theoretical physicists' relative quality and is sometimes called the Hirsch index or Hirsch number (http://en.wikipedia.org/wiki/H-

Table 7 Top 10 international collaborative partners in tissue engineering, 2008–2012

Collaborative partners	2008	2009	2010	2011	2012	Total	Share (%)
USA	26	35	55	64	87	267	41.72
Singapore	5	10	23	5	16	59	9.22
Japan	7	10	15	10	15	57	8.91
England	4	10	12	6	17	49	7.66
Australia	1	8	9	16	13	47	7.34
Germany	5	5	8	12	9	39	6.09
Netherlands	4	5	8	5	7	29	4.53
Canada	5	8	4	7	2	26	4.06
South Korea	3	5	5	4	3	20	3.13
France	6	2	3	0	2	13	2.03
International collaborative papers	110	94	135	128	173	640	–
Total China papers	278	393	455	493	650	2,269	–
Share (%)	39.57	23.92	29.67	25.96	26.62	28.21	–

Table 8 List of top 10 high cited papers on tissue engineering in China, 2008–2012

No	Authors	Title	Source	Citations
1	Williams, David F.	On the mechanisms of biocompatibility	Biomaterials	293
2	Yu, Lin; Ding, Jiandong	Injectable hydrogels as unique biomedical materials	Chemical Society Reviews	278
3	Parolini, Ornella; Alviano, Francesco; Bagnara, Gian Paolo; et al.	Concise review: Isolation and characterization of cells from human term placenta: Outcome of the first international workshop on placenta derived stem cells	Stem Cells	198
4	Lu, Xiaofeng; Wang, Ce; Wei, Yen	One-Dimensional Composite Nanomaterials: Synthesis by Electrospinning and Their Applications	Small	153
5	Williams, David F.	On the nature of biomaterials	Biomaterials	126
6	Liu, Ruixue; Fraylich, Michael; Saunders, Brian R.	Thermoresponsive copolymers: from fundamental studies to applications	Colloid and Polymer Science	113
7	Smart, Nicola; Bollini, Sveva; Dube, Karina N.;et al.	De novo cardiomyocytes from within the activated adult heart after injury	Nature	108
8	Lin, Guiting; Garcia, Maurice; Ning, Hongxiu;et al.	Defining Stem and Progenitor Cells within Adipose Tissue	Stem Cells	104
9	Huang, Pengyu; He, Zhiying; Ji, Shuyi; et al.	Induction of functional hepatocyte-like cells from mouse fibroblasts by defined factors	Chemical Society Reviews	94
10	Chen, Fa-Ming; Zhang, Min; Wu, Zhi-Fen	Toward delivery of multiple growth factors in tissue engineering	Biomaterials	89

index). "A scientist has index h if h of his/her Np papers have at least h citations each, and the other (Np–h) papers have no more than h citations each" (Hirsch 2005; Ball 2005).

With the developments related to the Hirsch Index, Ronald Rousseau introduced the notion of a Hirsch core, which means the paper collection of the top h papers (Rousseau 2006). Figure 1 is the citation distribution for Chinese tissue engineering papers. From Fig. 1, H-index is 43, that is to say the top 43 citation papers were the core papers on tissue engineering in China.The top 10 high cited papers are listed in Table 8.

Of the top 10 high cited papers, eight were international collaborative, one involved national collaboration and one was non-collaborative. Of the 10 high cited papers, two papers fell in the citation range of 270–300, two papers fell in the citation range of 150–200, four papers fell in 100–130, another two papers fell in 80–100. These 10 high cited papers have received 1,556 citations, with an average of 155.6 citations per paper.

These 10 high cited papers have appeared in 6 journals. They were *Biomaterials* (3 papers, IF-5 = 8.415), *Chemical Society Reviews* (2 papers, IF-5 = 28.09), *Small* (1 paper, IF-5 = 8.262), *Nature* (1 paper, IF-5 = 36.235), *Stem Cells* (2 papers, IF-5 = 8.612), *Colloid and Polymer Science* (1 paper, IF-5 = 2.077).

Summary and conclusion

Chinese authors have contributed 2,269 papers in tissue engineering during 2008–2012, which is 13.67 % share of the global publications only next to USA. China's publication share showed increase from 10.63 to 15.92 % during the past 5 years. China papers in tissue engineering were growing tremendously by 133.81 % from 2008 to 2012. But the citation impact per paper was only 7.96. It shows that China developed very well and

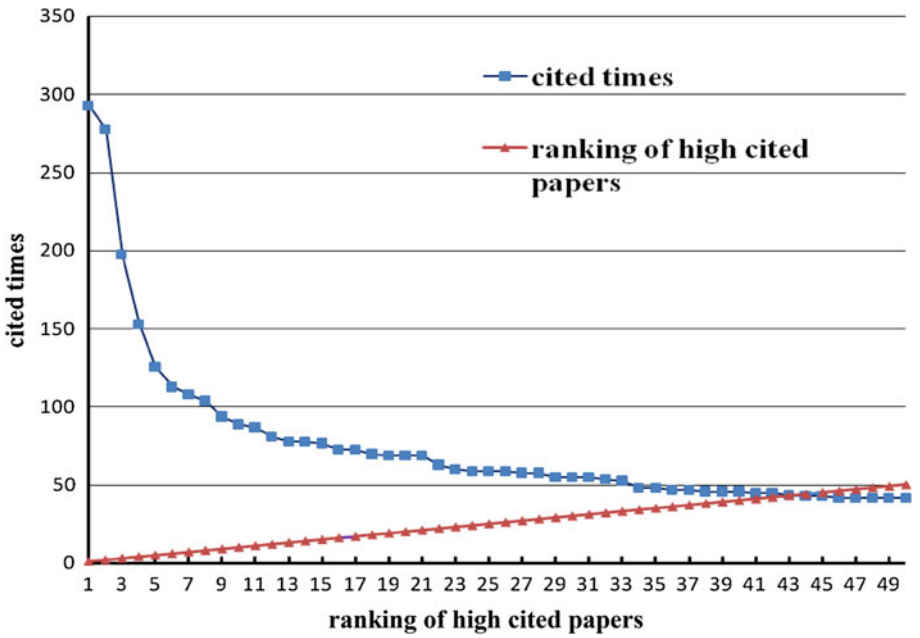

Fig. 1 Cited times distribution for tissue engineering papers

played an important role in tissue engineering in the past 5 years, but the impact and internationalization of the publications were far to satisfactory.

In terms of research area distribution of Chinese papers on tissue engineering during 2008–2012, the largest share (43.81 %) came from material science, followed by engineering (29.53 %), cell biology (14.59 %), chemistry (14.24 %), polymer science (13.88 %), biotechnology applied microbiology (10.69 %) and so on. Among them, engineering, chemistry and material science had scored the highest impacts (10.19, 10.18 and 9.25 citations per paper respectively), followed by cell biology (8.08 citations per paper), biochemistry molecular biology and science technology other topics (8.03 citations per paper) and so on. The quality and impact of research output in engineering, chemistry and material science in China were more remarkable than the other research areas. The global research areas in tissue engineering during 2008–2012 showed slightly different from China, but China had made strong performance in chemistry areas of tissue engineering, especially in polymer and material science.

The 10 most productive journals publishing Chinese research papers together contributed 633 papers in tissue engineering during the past 5 years. They were *Biomaterials* (IF-5 = 8.415), *Journal of Biomedical Materials Research Part A* (IF-5 = 3.105), *Journal of Materials Science—Materials in Medicine* (IF-5 = 2.480), *Acta Biomaterialia* (IF-5 = 5.076) and so on. *Biomaterials* as example was analyzed to compare China's contribution with that of the other countries published in the journal from 2008 to 2012. 15 % of the papers were from China and contributed 13.8 % citations to the journal, only next to USA (44.6, 48.5 %). China was the only country which showed a steady growth trend in the number of papers published in the journal. China is an important actor in tissue engineering in the world.

28.21 % of total 2,269 papers on tissue engineering published from China involved international collaboration. But the international collaborative publication percentages didn't increase during the past 5 years compared to that of total China papers from 2008 to 2012. USA was the major collaborating partner of China, then followed by Singapore, Japan, England, Australia, Germany, Netherlands, Canada, South Korea, and France.

The top 43 citation papers were the h-core papers on tissue engineering in China in the past 5 years. But of the top 10 high cited papers, eight were international collaborative. These 10 high cited papers have appeared in 6 journals with high impact factors, they are *Biomaterials* (IF-5 = 8.415), *Chemical Society Reviews* (IF-5 = 28.09), *Small* (IF-5 = 8.262), *Nature* (IF-5 = 36.235), *Stem Cells* (IF-5 = 8.612), *Colloid and Polymer Science* (IF-5 = 2.077).

According to SCIE database a significant increase occurred in both the quantity and quality of the Chinese publications on tissue engineering. This was indicated by the major rise in the amount of published papers, the average citations per paper and the constantly increasing presence of Chinese researchers and institutions in top journals and research groups. The extent of this contribution may not be proportional to the total research activity performed in China, but it is this part of knowledge that interacts with the rest of the international research activity, promoting research potential in tissue engineering and regenerative medicine.

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