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ORIGINAL ARTICLE

Research in orthopaedics from China has thrived over the last decade: A bibliometric analysis of publication activity

T. Cheng*

Department of Orthopaedic Surgery, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University School of Medicine, 600, Yisan Road, Shanghai 200233, People's Republic of China

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KEYWORDS

Orthopaedics;
China;
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Summary

Introduction: Over the past decades, there have been great advances in orthopaedics in China. The purpose of this study was to investigate the orthopaedic research output in the three Chinese-speaking regions – the Mainland (ML), Hong Kong (HK), and Taiwan (TW).

Hypothesis: We hypothesized that there was a positive trend in China orthopaedic research during the past decade and this regardless of the Chinese-speaking regions of origin.

Materials and methods: Forty-nine orthopaedic journals were retrieved from the PubMed database and Science Citation Index Expanded. Articles from ML, TW, and HK in 2000 to 2009 were identified. The total number of articles, clinical trials, randomized controlled trials (RCTs), impact factors (IF), citations, and articles published in the top 10 orthopaedic journals were analyzed.

Results: A total of 1878 published articles in 2000 to 2009 were broken down as follows: ML (607), TW (865), and HK (406). There was a significant increase in published articles for ML and TW from 2000 to 2009. The number of published articles from ML exceeded the total sum of articles from TW and HK in 2009. The accumulated IF of articles from TW (1751.91) was higher than that from ML (1054.67) and HK (708.25). TW had the highest average IF (2.025), followed by ML (1.902) and HK (1.862). The total citations of published articles in 2000 to 2009 from TW (4759) were higher than those for HK (2276) and ML (1751). The highest average citation of each article was from HK (5.784), followed by TW (5.720) and ML (3.051). TW published 339 articles in 10 high-impact journals, whereas ML and HK published 267 and 154 articles, respectively.

Discussion: Chinese researchers in the field of orthopaedics have been more and more active in the global orthopaedic community during the past 10 years. ML seems to have caught up to HK and TW in respect to research output.

Level of evidence: Level III. Systematic review of level II and level III studies.

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* Tel.: +86 21 64369181; fax: +86 21 64368031.

E-mail address: dr_tao.cheng@hotmail.com

Introduction

The introduction of Western medicine has dramatically promoted the development of modern Chinese orthopaedics. The Hong Kong Orthopaedic Association, the Chinese Medical Association Orthopaedic Society, and the Taiwan Association of Orthopaedics were established in 1965, 1977, and 1980, respectively [1–3]. Orthopaedics in China is developing rapidly and has achieved great advances in the past decades, including replantation of severed limbs or fingers [4–6], toe transplantation for thumb and finger reconstruction [7,8], nerve transfer for brachial plexus injury [9–11], flap for the reconstruction of serious leg soft tissue defects [12,13], diagnosis and treatment of idiopathic scoliosis and degenerative spine diseases [14–18], and arthroscopic surgical reconstruction of the injured ligament [19–23]. Recently, many specialties have identified and analyzed scientific publications from China [24–28]. However, the profile of research papers by Chinese authors in the world leading orthopaedic journals has not been reported. This study was conducted to quantify the contributions of China to the orthopaedic field during the last decade by analyzing data obtained from the Science Citation Index (SCI) journals. The hypothesis was that there was a positive trend in China during the period of 2000 to 2009.

Materials and methods

Search strategy

A total of 49 journals related to orthopaedics were selected from the "Orthopaedics" category of SCI Expanded (SCIE) subject categories in the Journal Citation Reports (JCR) 2008, established by the Institute for Scientific Information (ISI). A comprehensive search of ISI Web of Knowledge and PubMed database was conducted to identify articles published in 2000 to 2009 originating from three Chinese-speaking regions, the Mainland (ML), Taiwan (TW), and Hong Kong (HK). The last search was conducted in March 2010. Journal title abbreviations were used to perform searches in ISI Web of Knowledge and PubMed. The search terms were listed in Appendix 1. First author's affiliation was used to accurately distinguish research output from the three regions. The number of clinical trials and randomized controlled trials (RCTs) among the total articles was identified according to publication types. The search strategy, screening of articles, and data extraction were conducted independently by two reviewers. Discrepancies were resolved through discussions. If consensus was not reached, a third reviewer made the final decision. Bibliometric analysis was then performed to compare quantitative aspects among the three regions based on the following parameters:

- total number of articles;
- number of clinical trials and randomized controlled trials;
- accumulated impact factors (IF) and average IF generated according to JCR 2008;
- accumulated citation reports and average citation of each article;

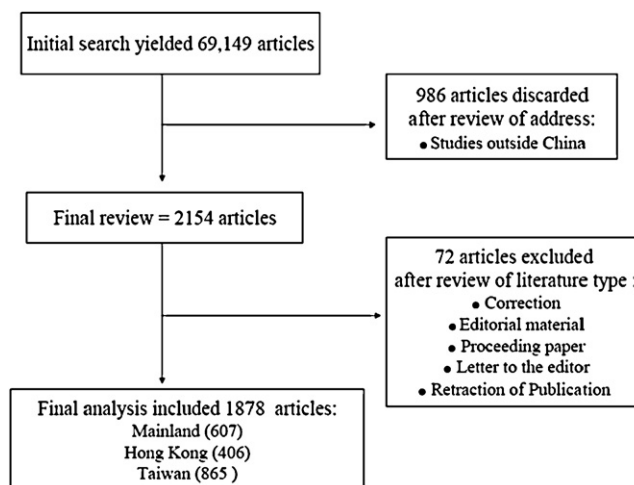


Figure 1 Flow chart of the selection process.

- number of articles published in the top 10 high-impact journals (IF > 2).

Statistical analysis

The SPSS 13.0 (SPSS, Chicago, IL) was used to analyze all data. Curvilinear regression was used to explore the trend of publications over time in years. Kruskal-Wallis and rank-sum tests were used for detecting differences among the three regions. Statistical significance was determined at the value $P < 0.05$.

Results

Total number of articles

A total of 69,149 articles were published in 49 journals related to orthopaedics from 2000 to 2009 worldwide. There were 1878 articles (2.72%) from ML, TW, and HK. TW contributed more articles (865, 46.06%) than ML (607, 32.32%) and HK (406, 21.62%) (Fig. 1). The annual total number of articles from the three regions increased gradually from 2000 to 2009 (69 to 390, $P = 0.000$). The numbers increased significantly from 2000 to 2009 in TW and ML (43 to 138, $P = 0.000$; 8 to 225, $P = 0.002$, respectively). However, the increase in HK was not significant (18 to 27, $P = 0.186$). Since 2006, the number of articles published from ML exceeded that from HK; from 2008 onwards, it exceeded that from TW as well. The number was bigger than the sum total of articles from TW and HK in 2009 (Fig. 2).

Clinical trial and randomized controlled trials

Of all articles from the three regions, 175 were clinical trials and 83 were RCTs. In the last decade, TW contributed the most clinical trials (91) and RCTs (43). ML contributed 48 clinical trials and 24 RCTs and HK contributed 36 clinical trials and 16 RCTs. Although the number of clinical trials and RCTs from ML was not as many as that from TW during the past 10 years, it did show an increase in the last 2 years (32 clinical trials and 19 RCTs). These numbers are more

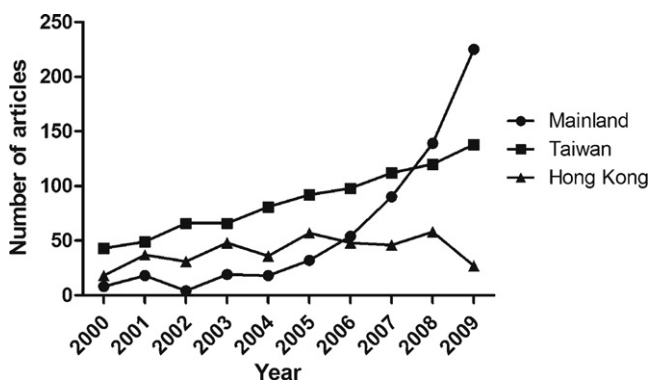


Figure 2 Time trend of the number of articles from the Mainland, Hong Kong and Taiwan during 2000 to 2009.

Table 1 Accumulated and averaged impact factors (IF) of articles from the Mainland (ML), Taiwan (TW), and Hong Kong (HK).

Year	Accumulated IF			Average IF		
	ML	TW	HK	ML	TW	HK
2000	13.53	78.54	34.68	1.69	1.82	1.92
2001	29.53	90.07	69.87	1.64	1.83	1.88
2002	8.54	139.53	54.13	2.13	2.11	1.74
2003	35.06	134.77	91.65	1.84	2.04	1.90
2004	35.34	170.35	63.27	1.96	2.10	1.75
2005	65.15	195.57	106.56	2.03	2.12	1.87
2006	11.09	225.01	92.02	2.05	2.29	2.00
2007	182.23	224.45	97.04	2.23	2.00	1.73
2008	279.90	224.65	113.11	2.01	1.87	1.48
2009	394.26	268.96	47.57	1.75	1.94	1.76
Total	1054.67	1751.91	769.93	1.90	2.02	1.86

than those from TW (26 clinical trials and 15 RCTs) and HK (9 clinical trials and four RCTs).

Impact factor

According to the JCR 2008, all 49 journals in the category of orthopaedics showed IF (mean = 1.46, range 0.178 to 4.08) in 2008. The accumulated IF of articles from TW (1751.91) was higher than that from ML (1054.67) and HK (708.25) ($P=0.006$). As shown in Table 1, TW had the highest average IF (2.02), followed by ML (1.90) and HK (1.86).

Citation report

The total citations of published articles from 2000 to 2009 in TW (4759) were higher than in HK (2276) and ML (1751) ($P=0.000$). HK had the highest average citation of each article (5.78), followed by TW (5.72) and ML (3.05) (Table 2).

High-impact orthopaedic journals

In the JCR 2008, 10 high-impact journals showed IF greater than 2. A total of 760 articles from ML, TW, and HK were published in the 10 journals in the past 10 years. TW published

Table 2 The total and average citations of articles from the Mainland (ML), Taiwan (TW), and Hong Kong (HK).

Year	Total citations			Average citations		
	ML	TW	HK	ML	TW	HK
2000	66	382	201	8.25	9.09	11.16
2001	210	597	285	11.66	13.26	8.90
2002	56	699	208	14	12.05	8.32
2003	248	618	410	13.05	9.50	8.54
2004	134	679	220	7.44	8.38	6.28
2005	260	760	398	8.38	8.26	6.98
2006	289	480	315	5.45	5	6.70
2007	285	346	134	3.23	3.08	2.39
2008	163	162	86	1.21	1.40	1.48
2009	40	36	19	0.19	0.28	0.70
Total	1751	4759	2276	3.05	5.72	5.78

Table 3 Articles published (2000–2009) in the high-impact journals from the Mainland (ML), Taiwan (TW), and Hong Kong (HK).

Rank	Journal	2008 IF	ML	TW	HK
1	<i>Osteoarthr Cartilage</i>	4.08	12	20	3
2	<i>Am J Sports Med</i>	3.64	4	16	6
3	<i>J Bone Joint Surg Am</i>	3.31	10	37	9
4	<i>J Orthop Res</i>	2.96	20	64	14
5	<i>Spine</i>	2.79	127	91	65
6	<i>Gait Posture</i>	2.74	2	25	9
7	<i>Arthroscopy</i>	2.50	20	48	28
8	<i>Eur Spin J</i>	2.39	54	19	10
9	<i>J Am Acad Orthop Surg</i>	2.25	0	0	0
10	<i>J Bone Joint Surg Br</i>	2.19	18	19	10
Total			267	339	154

IF: impact factors.

339 (44.60%) articles in the high-impact journals, whereas ML and HK published 267 (35.13%) and 154 (20.26%) articles, respectively (Table 3). Of these, 37.24% (283/760) were published in *Spine*, 12.90% (98/760) in *Journal of Orthopaedic Research*, and 12.63% (96/760) in *Arthroscopy*.

Discussion

The geographical distribution of publications as an indicator of scientific research has become a topic of interest in medical areas [29–31]. To some degree, the number of publications could reflect clinical and fundamental research activity within a country. In this study, we found that a rapid increase in the number of scientific publications from China over the period 2000 to 2009, especially from ML and TW. Since 2008, the number of articles published from ML exceeded those from TW. In addition, the number is greater than the combined totals from TW and HK in 2009. In the early 2000s, the number of scientific publications from HK and TW was more than those from ML. The gap, however, in terms of quality and quantity among ML, HK and TW, has been diminishing since the late 2000s.

The 49 journals listed by the JCR in the category "Orthopaedics" originate from eight different countries. Several journals offer researchers the alternative of publishing in German or French, but English is the predominant language of publication in orthopaedics indexed in the PubMed and SCI database. Although *Orthopaedic Surgery*, *The Journal of Orthopaedic Surgery* (Hong Kong), *Chinese Journal of Traumatology* (English Edition), and *Journal of Orthopaedic Surgery and Research* from China published research articles in English, none of them has been indexed in SCI. HK and TW have the advantage of a strong foundation in written English. In contrast, in ML, English is not commonly used in professional practice. Thus, the publication of numerous high-quality articles testifies to extraordinary endeavors so that important scientific findings can be shared and publicized. In fact, a substantial number of articles from ML were published in domestic journals in Chinese. We believe that along with the advances of the country in terms of global communication and economic development, authors from China will give a higher contributing in terms of scientific articles related to orthopaedics.

The study demonstrated that TW had the highest average IF, followed by ML and HK. HK had the highest average citation of each article, followed by TW and ML. The difference is partly explained by inconsistency between the IF of journals and citation of articles. The IF has been widely used as a measure for evaluating the comparative quality of research published in scientific journals [32,33]. However, even high-IF journals may publish poor-quality articles at times. The number of citations that one article receives is not necessarily a measure of the quality of the research or even its influence on the practice of the author's or authors' peers.

According to the data of the current study, the average IF of the three regions of China is relatively higher compared to the average IF (1.463) of all orthopaedic journals. It should be noted that the quantity of articles from Chinese authors from ML was extensive but they were seldom cited by others. Therefore, Chinese authors must endeavor to increase international academic exchanges and expand friendly contacts and cooperation with scientific circles in other countries.

Although the number of clinical trials and RCTs from ML during the past 10 years was not as many as that from TW, the number of trials from ML increased in the last 2 years, at a higher level than those of TW and HK. There are several reasons for this. First, China is the largest developing country in the world, with a population accounting for about 20% (1.3 billion) of the global population. Moreover, orthopaedic-related injuries and diseases were common in Chinese hospitals. This may be easy to enroll plenty of eligible patients. Second, during the last 30 years, ML has opened its doors to international trade and switched to a market-orientated economy, which encouraged rapid economic growth. As a result, China has increased the financial resources invested in research activities in order to share knowledge and advance the field of medicine in recent years. Third, ML has the largest number of orthopaedic surgeons. In addition, orthopaedic units have been established as independent departments in large and middle general hospitals, which may facilitate to perform large-scale multiple-centre studies. Fourth, proficiency in the English language and Internet access is available. These have

helped orthopaedic surgeons to move geographical boundaries, allowing for global sharing of knowledge and research cooperation.

The present study has several strengths. First, 49 journals, as well as the 10 top journals listed in the "Orthopaedics" category by JCR, were analyzed and summarized. Note that IFs can only be directly compared when the journals belong to the same area of investigation. Second, the 10 years between publication of the articles and the search of the databases allowed time for the articles to develop an established citation history in a variety of sources. Third, two trained reviewers, who have experience in systematic literature searching, conducted the study. Data collection was comprehensive and careful, including independent abstraction of data at all stages. The bibliometric analysis has proposed a compact picture of the development of orthopaedics in China. However, the study has several limitations. First, although we defined subgroups, such as clinical trials and RCTs, a more rigorous form of analysis of these studies may be useful to further define the quality of these studies, as well as help inform the reader of another aspect of the impact. For example, there is a need for a classification of Chinese orthopaedic papers using different topics (hip, knee, trauma, arthroplasty, research, arthroscopy, etc.) and using levels of evidence (I–IV) in each category to distinguish the articles from three regions of China. The findings from clinical trial and RCT usually are the strongest form of medical evidence. However, there are genuine challenges to conducting surgical trials [34]. In order to analyze the development of orthopaedics in China, we focus on the number of clinical trials and RCTs. Second, there is a lack of basic data regarding number of hospitals, orthopaedic surgeons per capita, etc. Further study is warranted to elicit the relationship between them and research output adjusted for population size and gross national product over the period 2000 to 2009. Third, quantity of publications may not accurately reflect the true impact. Comparisons of publications are not necessarily valid measures of scientific contributions. China remains the world's largest developing country and its economic output per capita is less than that of Western developed countries. China has to undergo a process: the accumulation of small "quantitative" changes eventually lead to a change in "quality".

Conclusions

In conclusion, the number of published articles from China dramatically increased during the 2000–2009 period. Chinese researchers in the field of orthopaedics have been more and more active in the global orthopaedic community during the past 10 years. ML seems to have caught up to HK and TW regarding research output.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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Appendix 1.

("Acta Orthop" [Journal] OR "Acta Orthop Scand" [Journal] OR "Am J Sports Med" [Journal] OR "Arch Orthop Trauma Surg" [Journal] OR "Arthroscopy" [Journal] OR "BMC Musculoskelet Disord" [Journal] OR "Clin Biomech" [Journal] OR "Clin J Sport Med" [Journal] OR "Clin Orthop Relat Res" [Journal] OR "Connect Tissue Res" [Journal] OR "Curr Orthop" [Journal] OR "Eur Spine J" [Journal] OR "Foot Ankle Int" [Journal] OR "Gait Posture" [Journal] OR "Hand Clin" [Journal] OR "Hip Int" [Journal] OR "Injury" [Journal] OR "Int Orthop" [Journal] OR "Isokinet Exerc Sci" [Journal] OR "J Am Acad Orthop Surg" [Journal] OR "J Am Podiatr Med Assoc" [Journal] OR "J Arthroplasty" [Journal] OR "J Back Musculoskelet" [Journal] OR "J Bone Joint Surg Am" [Journal] OR "J Bone Joint Surg Br" [Journal] OR "J Hand Surg Am" [Journal] OR "J Hand Surg Eur Vol" [Journal] OR "J Hand Ther" [Journal] OR "J Orthop Res" [Journal] OR "J Orthop Sci" [Journal] OR "J Orthop Sports Phys Ther" [Journal] OR "J Orthop Trauma" [Journal] OR "J Pediatr Orthop B" [Journal] OR "J Pediatr Orthop" [Journal] OR "J Shoulder Elbow Surg" [Journal] OR "J Spinal Disord Tech" [Journal] OR "Knee" [Journal] OR "Knee Surg Sports Traumatol Arthrosc" [Journal] OR "Orthop Clin North Am" [Journal] OR "Orthop Nurs" [Journal] OR "Orthopade" [Journal] OR "Orthopedics" [Journal] OR "Osteoarthritis Cartilage" [Journal] OR "Phys Ther" [Journal] OR "Prosthet Orthot Int" [Journal] OR "Rev Chir Orthop Reparatrice Appar Mot" [Journal] OR "Orthop Traumatol Surg Res" [Journal] OR "Spine (Phila Pa 1976)" [Journal] OR "Sportverletz Sportschaden" [Journal] OR "Z Orthop Ihre Grenzgeb" [Journal] OR "Z Orthop Unfall" [Journal]).

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