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Scientometric Evaluation of Research on Biomedical Ti Alloys†

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Recently, the interest in biomedical Ti alloys has been increased. In this paper, to understand biomedical Ti alloys research trends, we investigated total 3,168 papers published from 2004 to 2013. These papers were published by 2,220 institutes in 70 countries. The research of biomedical Ti alloys had steadily increased yearly. University Hong Kong (2.98) and Ohio State University (3.23) had the highest Q_1 (index level of paper quality) and Q_2 (strength of international collaboration) value, respectively. Main research topics had been changing Ti alloys, biomaterials, Ti-6Al-4V alloys and β-type Ti alloys to mechanical and corrosion properties of Ti alloys for the last 10 years.

Keywords: Ti alloys, Biomaterials, Biomedical, Scientometric analysis.

INTRODUCTION

The rapid growth of the global population is leading to an increased demand for implants for bone dysfunction caused by diseases such as arthritis and cancer[1]. Such implants are necessary to repair or alter natural body tissues[2]. However, given the unique structures and mechanical properties of natural tissues such as bone tissue, repairing or changing them is challenging. Since the introduction of bioceramics as medical implants in the 1960s, metal implants such as titanium alloy, stainless steel and cobalt-chromium alloys have been extensively used in medical applications[3]. In the early period of medical implant development, the only criteria for implant material suitability were appropriate physical properties and non-toxicity[4]. Today, the criteria include the physical properties of the bone implant material and its ability to promote the growth of the body tissue[5].

Titanium and its alloys are well established as suitable implant materials in the field of osteosynthesis, oral implantology and in certain joint prosthetics applications. The attractiveness of Ti alloys for implantation is applications determined by a combination of favorable characteristics including corrosion resistance, biocompatibility, low elastic modulus, density and the capacity of titanium to bond with bone and other tissues[6,7]. Recently, the application of Ti alloys has been made widely and diversely in the biomedicine. Therefore, it's really important to understand development trends in this area in order to pre-study for the research plan.

In this study, research trends of biomedical Ti alloys were reviewed using papers published in the literatures during 10 years from 2004 to 2013.

METHODOLOGIES

The documents used in this study were taken from the database of the SCI. Table-1 shows search query keywords used for the extraction of papers in the field of biomedical Ti alloys during 10 years. The scientomatric analysis of papers was performed using the COMPAS (competitive analysis service), KM (Knowledge Matrix), NetMiner and VOS viewer. COMPAS and KM were developed by KISTI (Korea Institute of Science and Technology Information)[7].

RESULTS AND DISCUSSION

During 2004-2013, a total of 3,168 papers were published in the field of biomedical Ti alloys. Fig. 1 shows the distribution of papers by year. We find that the research of biomedical Ti alloys has steadily increased every year.

2,220 Institutes published 3,168 papers in the field of biomedical Ti alloys from 2004 to 2013. Fig. 2 shows major institutes in this field. The most publishing institute was Tohoku Univ. with 129 papers and followed Chinese Acad. Sci. (116), Harbin Inst. Technol. (66), City Univ. Hong Kong (54) and Chosun Univ. (52).

Fig. 3 shows the index level of papers and the strength of international collaboration of major institutes in biomedical

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TABLE-1
QUERY FOR SEARCHING PAPERS
IN BIOMEDICAL TI ALLOYS

No.	Search query
1	TITLE: (titanium or Ti) Indexes=SCI-EXPANDED Timespan=2004-2013
2	TITLE: (alloy*) Indexes=SCI-EXPANDED Timespan=2004-2013
3	#1 AND #2 Indexes=SCI-EXPANDED Timespan=2004-2013
4	TOPIC: ("titanium alloy" or "titanium alloys" or "Ti alloys" or "Ti alloy") Indexes=SCI-EXPANDED Timespan=2004-2013
5	#3 OR #4 Indexes=SCI-EXPANDED Timespan=2004-2013
6	TOPIC: (bone* or biocompat* or implant* or biodegrad* or biomed* or human* or biomaterial* or coronary or orthoped* or biometal* or medic*) Indexes=SCI-EXPANDED Timespan=2004-2013
7	TITLE: (bio*) Indexes=SCI-EXPANDED Timespan=2004-2013
8	#6 OR #7 Indexes=SCI-EXPANDED Timespan=2004-2013
9	#5 AND #8 Indexes=SCI-EXPANDED Timespan=2004-2013

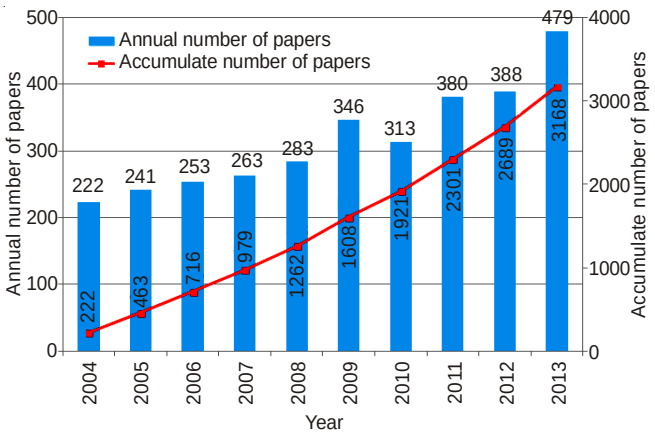

Fig. 1. Number of papers on biomedical Ti alloys in the years 2004-2013

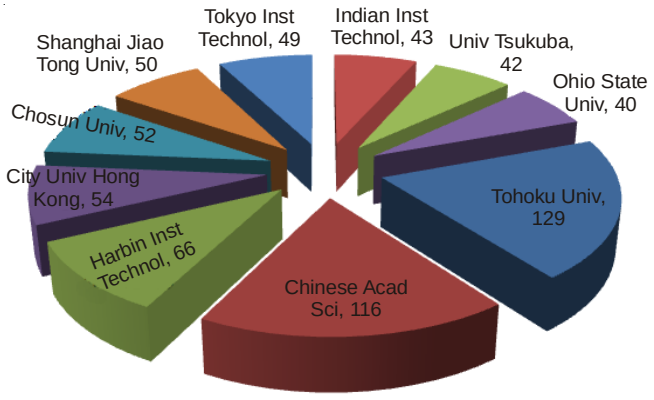

Fig. 2. Number of papers in the field of biomedical Ti alloys by major institutes

Ti alloys. Equations of index level and strength of international collaboration are as follows, respectively.

$$Q_1 = N_1/M_1 \quad (1)$$

$$Q_2 = N_2/M_2 \quad (2)$$

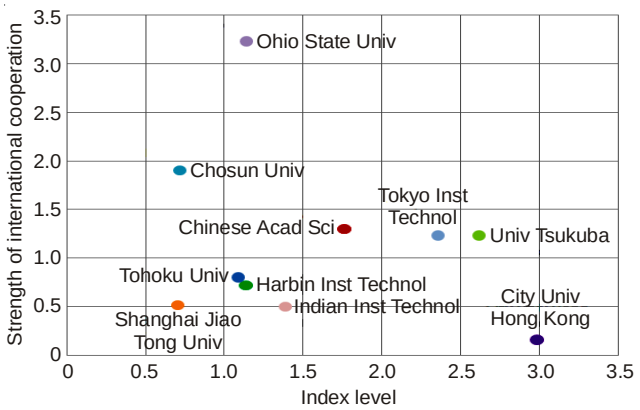

Fig. 3. Index level of papers and the strength of international collaboration in the field of biomedical Ti alloys by major institutes

Q_1 means index level. M_1 indicates average cited number of papers in a certain technical area, in this case it means biomedical Ti alloys; N_1 means the average cited number of papers of a certain institute. It shows that City Univ. Hong Kong (2.98) has the highest value of index level, followed by Univ. Tsukuba (2.61), Tokyo Inst. Technol. (2.36), Chinese Acad. Sci. (1.76) and Indian Inst. Technol. (1.39).

Q_2 means strength of international collaboration. M_2 is the average proportion of foreign institutions in collaboration institutes of an institute in a certain technical area, in this case it means biomedical Ti alloys; N_2 is the proportion of foreign institutions in collaboration institutes of a certain institute. It is observed that following Ohio State Univ. (3.23) on the list were Chosun Univ. (1.91), Chinese Acad. Sci. (1.30), Univ. Tsukuba (1.23) and Tokyo Inst. Technol. (1.23).

Fig. 4 shows the network with institutes and technologies in the field of biomedical Ti alloys. It shows that major institutes (Tohoku Univ., City Univ. Hong Kong, Harbin Inst. Technol., Chinese Acad. Sci. and Chosun Univ.) and core technologies in the field of biomedical Ti alloys. Tohoku Univ. had published a lot of papers in research fields of Ti alloy, biomaterials, microstructure, young's modulus, mechanical properties, biocompatibility and β-type Ti alloy. City Univ. Hong Kong had published a lot of papers in research fields of corrosion resistance, nickel-Ti alloy, surface modification and plasma immersion ion implantation. Harbin Inst. Technol. had published a lot of papers in research fields of plasma immersion ion implantation, micro arc oxidation, coating and Ti alloy. Chinese Acad. Sci. had published a lot of papers in research fields of Ti alloy, plasma spraying and bioactivity. Chosun Univ. had published a lot of papers in research fields of Ti alloy, biomaterials, corrosion and nanotube.

In order to investigate the changing trend of main topics in the biomedical Ti alloys research field, we analyzed main topics in this field in the years 2004-2008 and 2009-2013, respectively as shown in Fig. 5. It shows that the main topic was Ti alloys, biomaterials, Ti-6Al-4V alloys and beta type Ti alloys in 2004-2008, while mechanical properties and corrosion were added to main topics in 2009-2013. In other words, the research trend in this field had expanded to mechanical and corrosion properties of Ti alloys for the last 10 years.

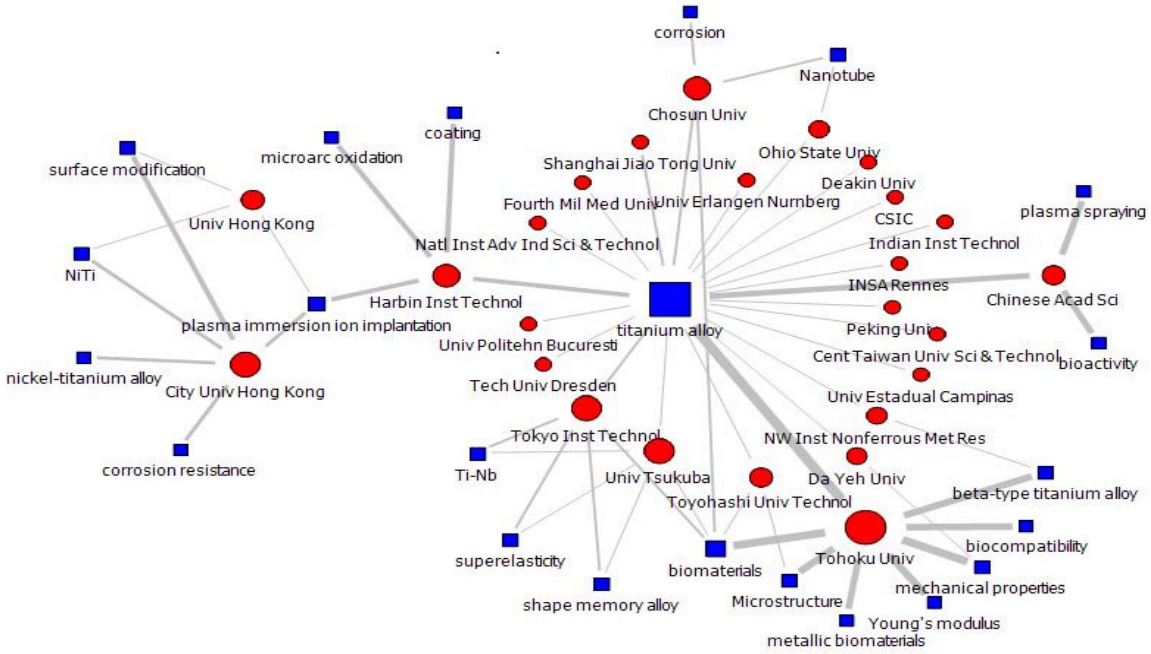

Fig. 4. Network with institutes and technologies about 3,168 papers published in the field of biomedical Ti alloys, 2004-2013. The node ■ is an institute. The node ● is a technology. The thinnest link means 10 frequencies and the thickness of link is proportional to the frequency

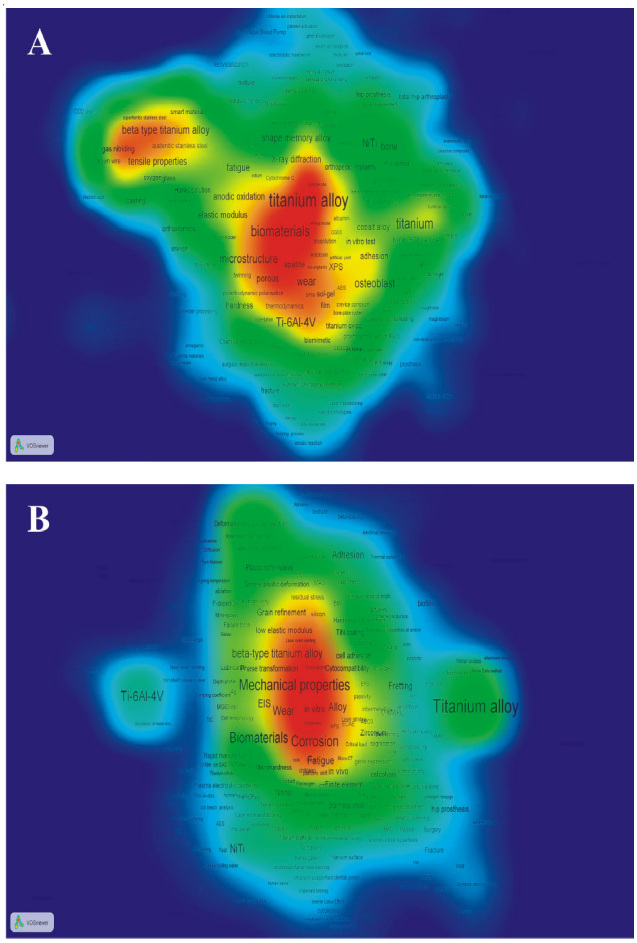

Fig. 5. Main topics in biomedical Ti alloys research field in the years 2004-2008 (A) and 2009-2013 (B), respectively

Conclusion

In this study, the method of scientometric analysis was used to investigate the biomedical Ti alloys research trends. 3,168 Papers were published by 2,220 institutes of 70 countries from 2004 to 2013. The research of biomedical Ti alloys has steadily increased yearly. Top 10 institutes were Tohoku Univ. (129 papers), Chinese Acad. Sci.(116 papers), Harbin Inst. Technol. (66 papers), City Univ. Hong Kong (54 papers), Chosun Univ. (52 papers), Shanghai Jiao Tong Univ. (50 papers), Tokyo Inst. Technol. (49 papers), Indian Inst. Technol. (43 papers), Univ. Tsukuba (42 papers) and Ohio State Univ. (40 papers). Univ. Hong Kong (2.98) and Ohio State Univ. (3.23) had the highest Q_1 and Q_2 value, respectively. Tohoku Univ. is major institute in technologies of Ti alloy, biomaterials, microstructure, young's modulus, mechanical properties, biocompatibility and β-type Ti alloy. Main research topics had been changing Ti alloys, biomaterials, Ti-6Al-4V alloys and beta type Ti alloys to mechanical and corrosion properties of Ti alloys for the last ten years.

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