

## A Bibliometric Analysis and Visualisation of Research Trends in Titanium-Based Orthopaedic Implants

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**Abstract:** Titanium is one of the widely used metal for orthopaedic implants. The bibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of “Titanium-based orthopaedic implants”. All published articles related to “Titanium-based orthopaedic implants” from “Scopus”, were analyzed using the VOS viewer to develop analysis tables and visualization maps. This article had set the objective to consolidate the scientific literature regarding “Titanium-based orthopaedic implants” and also to find out the trends related to the same. The most active journal related to this research domain was Biomaterials. The most active country was the United States of America. The leading organization engaged in research regarding Titanium Based orthopaedic implants was the Brown University of the United States of America and the Chinese Academy of Sciences of China. The most active authors who had made valuable contributions related to orthopaedic implants were Webster T.J.

**Keywords:** Orthopaedic-implants, Titanium, Material engineering, Bibliometric analysis, VOS viewer,

### 1. Introduction

An engineered medical device to replace a missing or damaged joint or bone is known as an orthopaedic implant. Various types of orthopaedic implants and practices are widely used in the medical world. Wear and corrosion of orthopaedic implants ultimately lead to poor performance, pain, and wastage of money. Similarly, various types of surface treatments and surface coatings can be conducted on orthopaedic implants to improve their competency to be used as a material for orthopaedic-implants. Patient-specific orthopaedic implants are the trends of the day and can improve the performance and reduce the cost of implant (Haglin et al., 2016). Infections of biomaterials are common and are highly dangerous (Nuswantoro et al., 2020).

Titanium is one of the widely used metal for orthopaedic implants. Moreover, Nanostructured titanium is an ideal material for improving orthopaedic implants (Durmus and Webster, 2012). Titanium is ideal for the growth of bioactive surfaces on orthopaedic implants (Gil et al., 2002). There are various developments in material engineering and surface engineering, which can play a significant role in the development of new types of orthopaedic implants; and in enhancing the performance of orthopaedic implants. Bioactive coats on titanium implants can improve biocompatibility of titanium compounds for orthopaedic implants (Karlova et al., 1998); similarly Ceramic coatings on the high-strength titanium as a prospective material for orthopaedic implants (Karlova et al., 2001); the anti-biofilm activity of a new bioactive glass coating on titanium implants (Marques et al., 2020); Electrophoretic deposition performance of hydroxyapatite coating on titanium alloys for orthopaedic implant application (Nuswantoro et al., 2020). Some latest researches had come up with wear-resistant titanium-ceramic composites for orthopaedic implant devices (Abkowitz et al., 2005)(Abkowitz et al., 2004); Electrospun fabrication and direct coating of bio-degradable fibrous composite on orthopaedic Titanium implant (Al Aboody, 2021); Activating titanium oxide coatings for orthopaedic implants (Cao and Liu, 2013); Hydroxyapatite-coated titanium for orthopaedic implant applications (Cook et al., 1988); Keratin proteins extracted from human hair are employed for developing coatings on titanium (Jun et al., 2007);

This bibliometric analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding Titanium-based orthopaedic implants. This article is arranged into four sections. The first section is the introduction, followed by the discussion of the methodology by which the research was conducted. The third section deals with results and discussion. The fourth section deals with the conclusion. The following research objectives and research questions were framed for conducting bibliometric analysis systematically.

#### 1.1 Research Objectives

- a) To consolidate the literature regarding Titanium-based orthopaedic implants
- b) To find out the trends related to research in Titanium-based orthopaedic implants

#### 1.2 Research Questions

- a) Who are the active researchers working on Titanium-based orthopaedic implants?
- b) Which are the main organizations and countries working on Titanium-based orthopaedic implants?

c) Which are the main journals related to Titanium-based orthopaedic implants?

## 2. Research Methodology

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE-ABS (Titanium “orthopaedic implants”) on 12/03/2021. All the tables in this paper were created by using Microsoft Excel and VOS Viewer. Grammarly was used for spelling and grammar checks. Mendeley was used for article review and citation. This paper had been inspired by bibliometric analysis in its presentation style, analysis, and methodology from the works (Farhat et al., 2013; Liao et al., 2016; Kolkailah et al., 2019; Rodríguez-Padial et al., 2019; Tran et al., 2019; Ullah et al., 2019; Shahid et al., 2020).

## 3. Results and discussion

### 3.1 Results

This first round of search produced an outcome of 1282 documents, in 8 languages, out of which 1242 documents were in English. The classification of document categories is shown in Figure 1. For improving the quality of the analysis, we had selected only the peer-reviewed articles and all other documents had not been considered. Thus after using filters “Article” and “English” the second round search produced an outcome of 932 English articles (both open access and others). This paper had used all English articles to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 1970 had been shown in Figure 2.

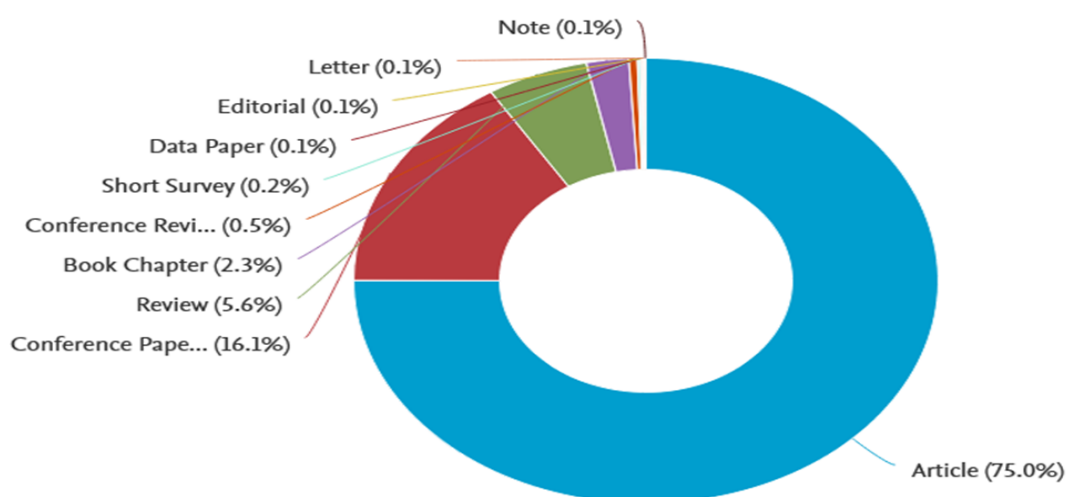


Figure 1: Classification of the documents on “Titanium-based orthopaedic implants”, Source: [www.scopus.com](http://www.scopus.com)

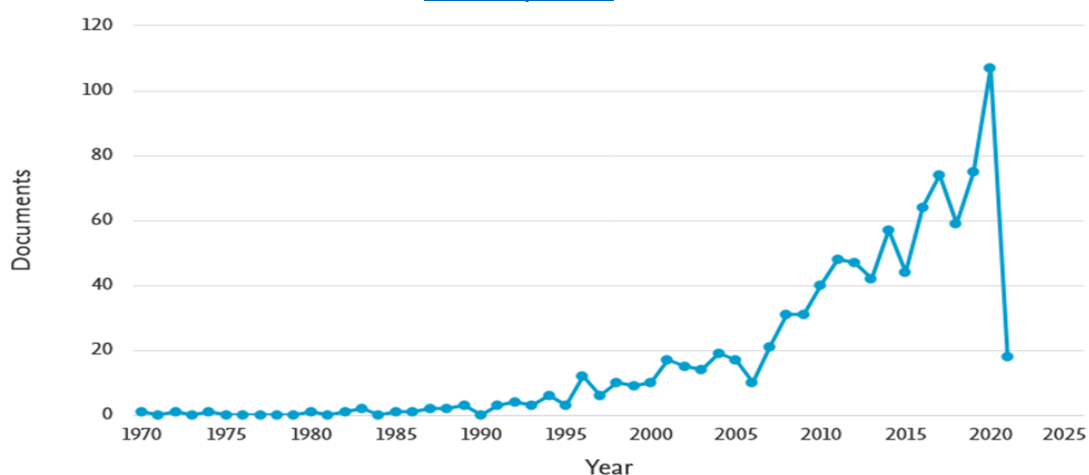


Figure 2: Period wise publication of articles, Source: WWW.scopus.com

Co-authorship analysis of top authors had been shown in figure 3. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as eight and the minimum number of citations of authors as one. This combination plotted the map of 32 authors, in five clusters. The overlay visualization map of co-authorship analysis plotted in Figure 3, points out the major researchers with their strong co-authorship linkages and clusters involved.

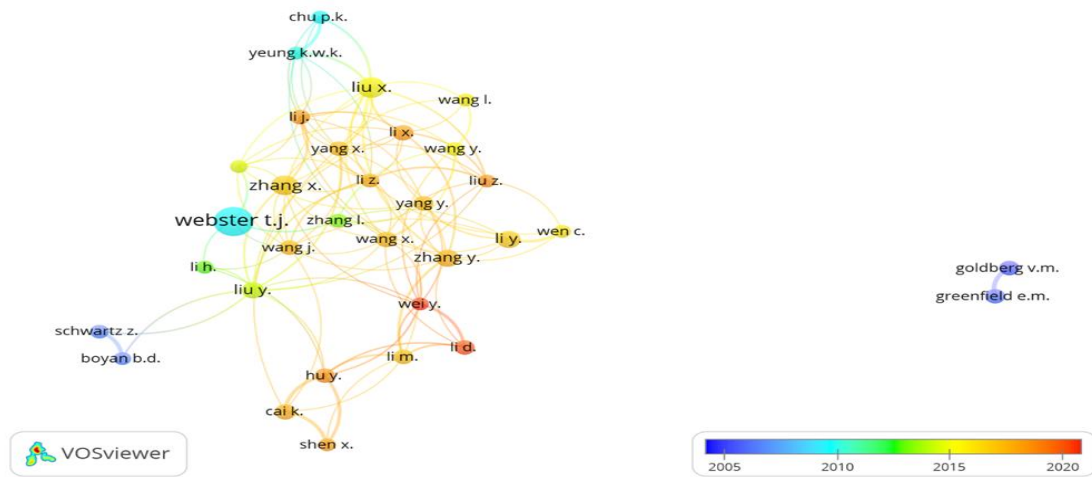


Figure 3: Co-authorship analysis on basis of authors

The citation analysis of top authors had been shown in table 1, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of an author as one and the minimum citations of an author as one.

Table 1: Highlights of most active authors

Description	Authors	Documents	Citations	Average citations per documents	Link strength
Authors with the highest publication, co-authorship links and citations	Webster T.J	42	3107	74	133

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as 100. This combination plotted the map of 41 thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

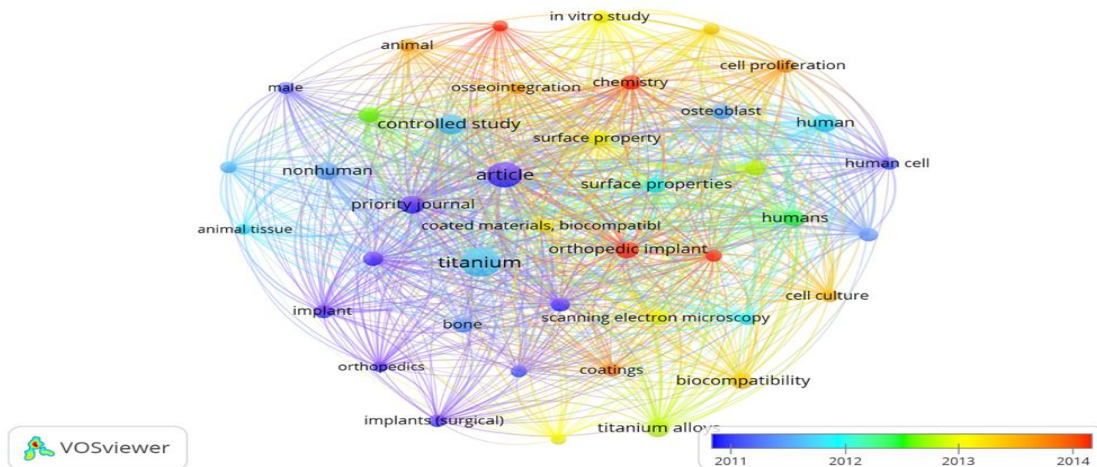


Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on “Titanium-based orthopaedic implants” had been found out by the volume of publications and citation analysis, the parameters used are the minimum number of documents of an organization as one and the minimum number of citations of organizations as one. The leading organization in the research regarding “Titanium-based orthopaedic implants”, with the highest number of publications and citations, was the Brown University of United States of America and the Chinese Academy of Sciences of China(Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Brown University	United States of America	32	2400	75
Chinese Academy of Sciences	China	32	570	17.8

Co-authorship analysis of the countries engaged in the research on “Titanium-based orthopaedic implants” had been shown in Figure 5. The overlay visualization map of co-authorship analysis plotted in Figure 5, points out the main countries with their strong co-authorship linkages and clusters involved.

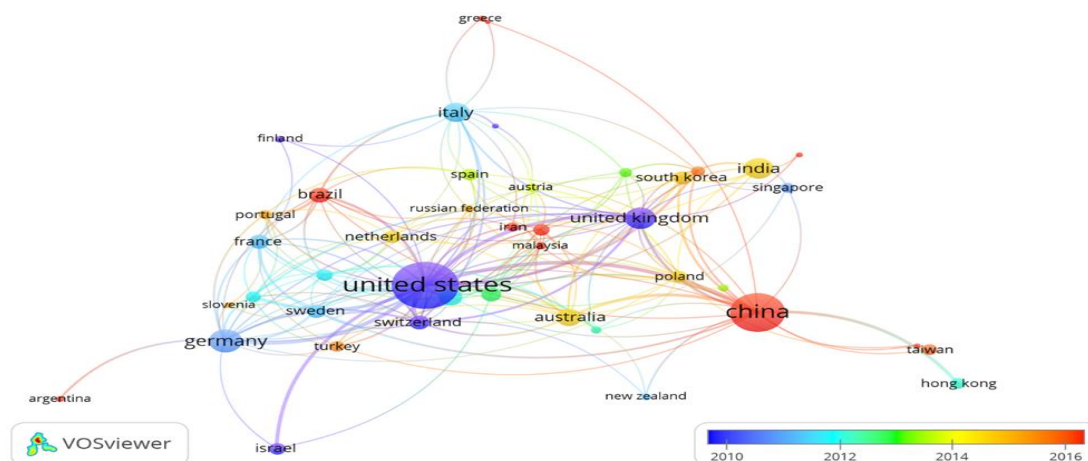


Figure 5: Co-authorship analysis on basis of countries

The citation analysis of top countries had been shown in table 3, along with co-authorship links. For the citation analysis, the parameters used were the minimum number of documents of a country as one and the minimum citations of the country as one.

Table 3: Highlights of Active Countries

Description	Country	Documents	Citations	Link strength
The country with the highest publication, links, and citations	United States of America	270	14825	120

The most active countries in this research domain were the United States of America with the highest number of publications, co-authorship links, and citations.

Link analysis and citation analysis were used to identify the most active journal in this research domain. We have taken the parameters of the minimum number of documents of a journal as one and the minimum number of citations of a journal as one for the link analysis and citation analysis. Highlights of the most active and relevant journals related to “Titanium-based orthopaedic implants” are shown in table 4. Table 4 shows the journal activity of this research domain through parameters of publication volume, citations, and co-authorship linkages.

Table 4: Analysis of journal activity

Description	Journal details	Documents	Citations	Average citations per documents	Links
Journal with the highest, publications, citations and co-authorship links	Biomaterials	52	7264	139.7	255

From the above discussion regarding the bibliometric patterns in the research regarding Titanium Based orthopaedic implants, this research had observed a gradual increase in research interest regarding Titanium Based orthopaedic implants from the starting of the millennium and the momentum is going on positively. This points out the relevance and potential of this research domain (Refer to Figure 2). The most active author in this research

domain was Webster T.J with the highest publication, co-authorship links, and citations (Refer to table 1). The overlay analysis of top countries researching Titanium Based orthopaedic implants indicates that the United States of America was the leading country relating to the highest number of publications citations, co-authorship links (Refer to figure 5). The top journal of this research domain was identified as Biomaterials. Researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding Titanium Based orthopaedic implants.

#### **4. Conclusion**

The Titanium Based orthopaedic implants was an interesting research domain and the most active journal related to this research domain was Biomaterials. The most active country was the United States of America. The leading organization engaged in research regarding Titanium Based orthopaedic implants was the Brown University of the United States of America and the Chinese Academy of Sciences of China. The most active authors who had made valuable contributions related to orthopaedic implants were Webster T.J. This research domain offers a new avenue for researchers and future research can be on Titanium-based implants.

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