A Bibliometric Analysis and Visualisation of Research Trends in Toxicity of Steel-implants

Gurmeet Singh[a]
[a]
Department of Mechanical Engineering, Chandigarh University, Gharuan,
Punjab,India. 140413

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Abstract: Steel is one of the most used metals for implants and toxicity is an important issue associated with steel implants. The bibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of "Toxicity of steel-implants". All published articles related to "Toxicity of steel-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 "Toxicity of steel-implants" and also to find out the trends related to the same. The most active journals in this research domain were the Journal of Biomedical Materials Research and Bio-materials. The most active country was the United States of America, and the leading organization engaged in the research regarding the toxicity of steel-implants was the Tulane University of United States of America. The most active authors were Sousa J. P and Niinomi M.

Keywords: Toxicity, Steel-implants, Material engineering, Bibliometric analysis, VOS viewer,

1. Introduction

An engineered medical device to replace a missing or damaged biological structure is known as an implant. Different types of metals and materials are used to create implants and the most popularly used metals and alloys for bio-implants are stainless steel, cobalt-chromium alloy, and Titanium(Priyanka et al., 2014). Various types of implants had been used in modern medicine and include sensory implants, neurological implants, cardiovascular implants, orthopedic implants, contraceptive implants, and cosmetic implants. Stainless steel is used for diversified implanting devices. Toxicity and corrosion are serious challenges associated with stainless steel implants. Material engineering and surface engineering can play a significant role in improving safety and reducing toxicity associated with steel implants.

Stainless steel is often considered a safe metal for hip implants in comparison with Nickel (Fisher, 1993). The most commonly used other metals are Nickel, chromium, Cobalt, Titanium, and Zirconium. Safety of material used is an important determinant while choosing implants and Stainless steel is a comparatively s safe metal used for implants. Similarly, the blood nickel content can be reduced and serious complications like hypernickelemia can be avoided (Linden et al., 1985). Stainless steel is not having high-class anticorrosive properties (Balestriere et al., 2020) and there are cases of implant failure due to corrosion of stainless steel (Pugh, Jaffe, and Jaffe, 1975). Bacterial infection of implants can be a cause for allergy and failure of steel implants. Bacterial infection of steel implants can be mitigated by silver coating on the implants (Devasconcellos et al., 2012). The future research can be on various research niches like surface coating, anti-bacterial properties, and corrosion-resistant technologies associated with stainless steel implants. The reduced level of corrosion can help in less wear and less amount metal content in the blood.

This bibliometric analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding bio-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 the toxicity of steel-implants
b) To find out the trends related to research in toxicity of steel-implants

1.2 Research Questions

a) Who are the active researchers working on the toxicity of steel-implants?
b) Which are the main organizations and countries working on the toxicity of steel-implants?
c) Which are the main journals related to the toxicity of steel-implants?

2. Research Methodology

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE –ABS-KEY(Toxicity Steel-implants) on 01/03/2021. 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 142 documents, in eight languages, out of which 132 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 92 English articles (both open access and others) and had been used to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 1968 had been shown in Figure 2.

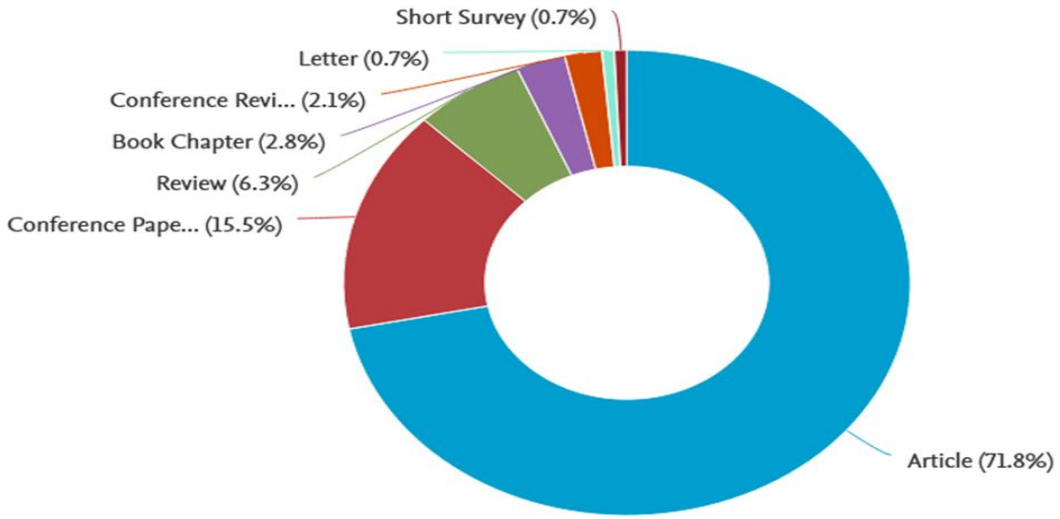

Figure 1: Classification of the documents on "Toxicity of steel-implants", Source: www.scopus.com

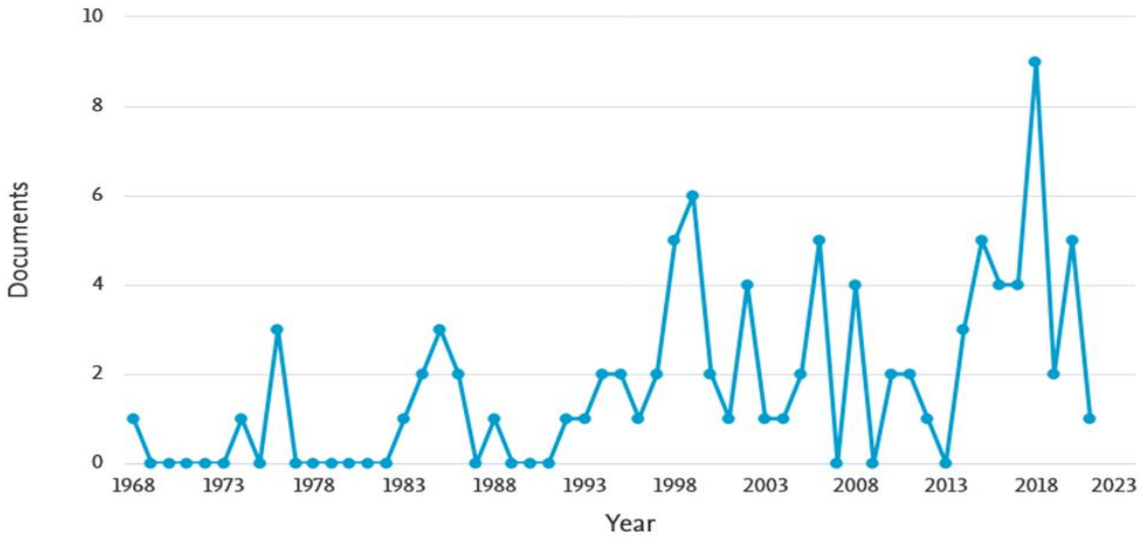

Figure 2: Period wise publication of articles, Source: WWW.scopus.com

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 two and the minimum number of citations of authors as one. This combination plotted the map of 19 authors, in 11 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.

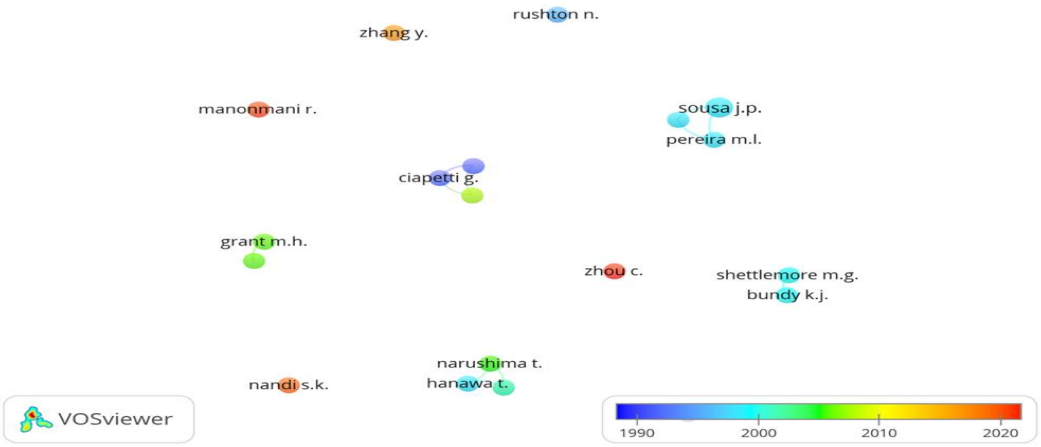

Figure 3: Co-authorship analysis on basis of authors

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 two 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 and co-authorship links	Sousa J.P	3	113	38	8
Authors with the highest citations	Niinomi M	2	204	102	2

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as 20. This combination plotted the map of 25 thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

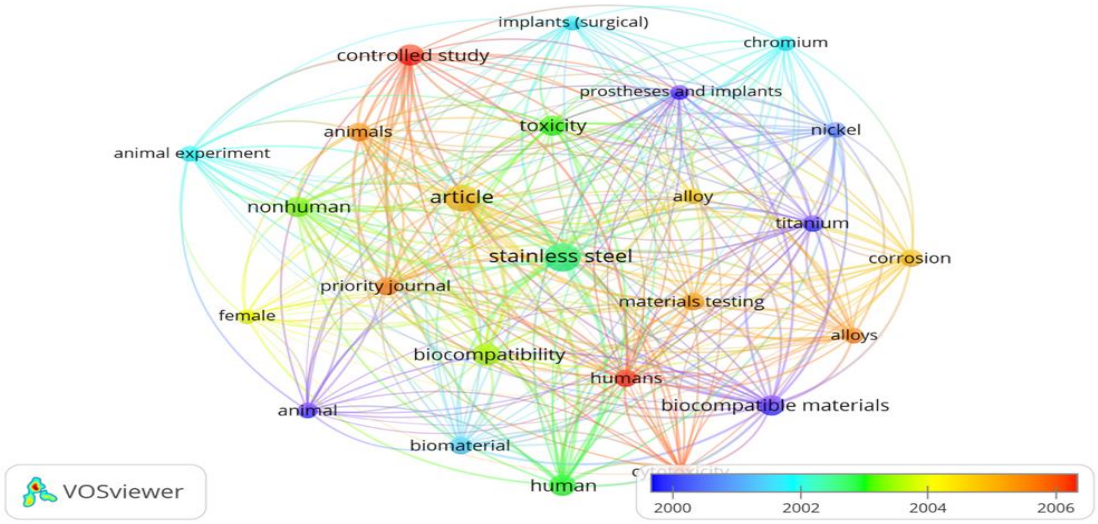

Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on "Toxicity of steel-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 "Toxicity of steel-implants", with the highest number of publications and citations, was the Tulane University of United States of America (Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Tulane University	United States of America	4	168	42

Co-authorship analysis of the countries engaged in the research on "Toxicity of steel-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.

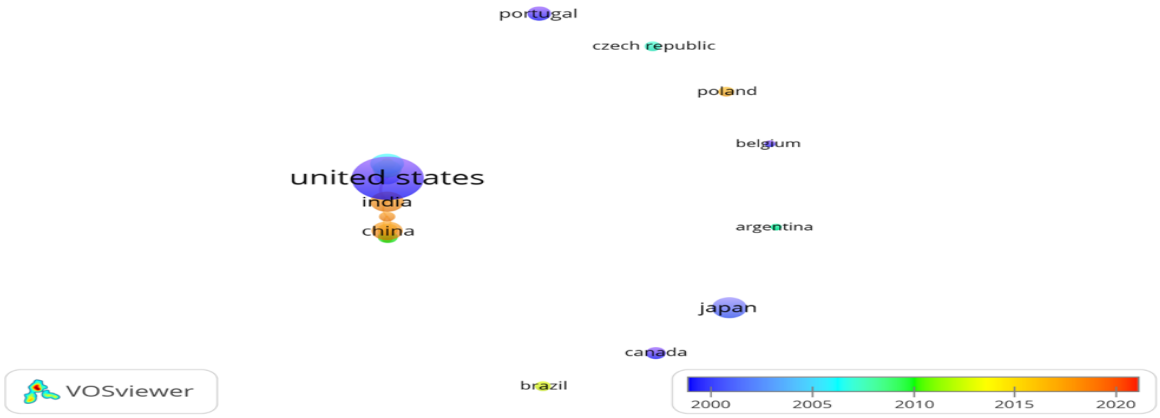

Figure 5: Co-authorship analysis on basis of countries

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, citations, and co-authorship links	United States of America	38	2441	10

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

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 "Toxicity of steel-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
Journal with the highest publications and co-authorship links	Journal of Biomedical Materials Research	16	613	6
Journal with the highest citations	Biomaterials	9	1202	5

From the above discussion regarding the bibliometric patterns in the research regarding the toxicity of steel-implants, this research had observed a gradual increase in research interest regarding the toxicity of steel-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 authors in this research domain were Sousa J. P and Niinomi .M. with the highest publication and co-authorship links; and citations respectively (Refer to table 1). The overlay analysis of top countries researching the toxicity of steel implants indicates that the United States of America was the leading country relating to the highest number of publications, citations, and co-authorship links (Refer to figure 5). The top journals of this research domain were identified as the Journal of Biomedical Materials Research and Bio-materials. From these wide sources of information, researchers can focus

on top journals where they can identify the most relevant and highly cited articles regarding the toxicity of steel-implants.

4. Conclusion

Toxicity of steel-implant was an interesting research domain and the most active journals related to this research domain were the Journal of Biomedical Materials Research and Bio-materials. The most active country was the United States of America, and the leading organization engaged in the research regarding the toxicity of steel-implants was the Tulane University of United States of America. The most active authors who had made valuable contributions related to steel implants were Sousa J. P and Niinomi M. This research domain offers a new avenue for researchers and future research can be on innovations in reducing the toxicity of steel-implants.

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