

A Bibliometric Analysis and Visualisation of Research Trends in Surface Modification of Implant

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Abstract

Innovations and advances in material engineering and surface engineering play a key role in developing modern, safe, durable, and biocompatible implants. The bibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of “surface modification of implants”. All published articles related to “surface modification of implants” from “Scopus”, were the Clinical Oral Implants Research, Biomaterials, and Journal of Bio-medical Materials Research. The most active countries were China, Germany, and the USA. The leading organization engaged in the research regarding surface modification of implants was the Dental Materials Research Centre, Isfahan University of Medical Sciences, Iran. The most active authors who had made valuable contributions related to surface modification of implants were Wang X. and De Wild M.

Keywords: Surface modification, Implants, Material engineering, Bibliometric analysis, VOS viewer,

INTRODUCTION

The 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 [1]. Innovations and advances in material engineering [2]–[4] and surface engineering play a key role in developing modern implants [5]. Surface modification by using surface texturing, surface coating, bioactive glass/ bioglass coating, surface texturing, additive manufacturing, and many more technologies are available to enhance the performance [6], [7] of implants by ensuring safety, durability, and corrosion resistance. Moreover, surface conditioning offers better chemical stability and mechanical behavior than the base material based implants [8]. There are various types of implant surfaces and surface treatments like physical surface treatment, chemical surface treatment, biological surface treatment, and combined surface treatment. There are a wide variety of surface alteration techniques for each type of surface treatment mentioned above [9].

The major remedial measures against corrosion of implants are chemical treatments and bioceramic coating [10]; Laser treatment against corrosion of implants by Surface melting [11][12][13][14][15] Boride coating on the Ti-6Al-4V alloy against corrosion of bio-implants

[16];calcium coating of bio-implants [17]; using integrated anodization and thermal oxidation for improving bio-implants [18] using Friction Stir Processing (FSP) for developing corrosion-resistant surfaces [19].

Implant infections are a global problem and surface modification of implants is an optimum solution for this issue. There are numerous surface modification measures to improve performance, life, and safety of implants [20][21], Cicada and catkin based surface modification of implant material can inhibit bacterial activity by retaining its biocompatibility [22]. Dipping and spraying techniques can also be used for surface modification of implants and thereby ensuring the creation of anti-adhesive, antibacterial, and anti-inflammatory implants. The more over-spraying method on implants had a comparative advantage over the dipping method, as the spraying method offers optimal density and homogenous distribution of particles in the coated surface [23]. Similarly, surface modifications of bone implants will improve the performance, safety, and biocompatibility [24]–[27]

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 surface modification of implants
- b) To find out the trends related to research in surface modification of implants

1.2 Research Questions

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

RESEARCH METHODOLOGY

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE (surface modification implants) on 20/01/2021. 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 [28]–[34].

RESULTS AND DISCUSSION

1.1 Results

This first round of search produced an outcome of 332 documents, in nine languages, out of which 332 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 226 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 1982 had been shown in Figure 2.

Documents by type

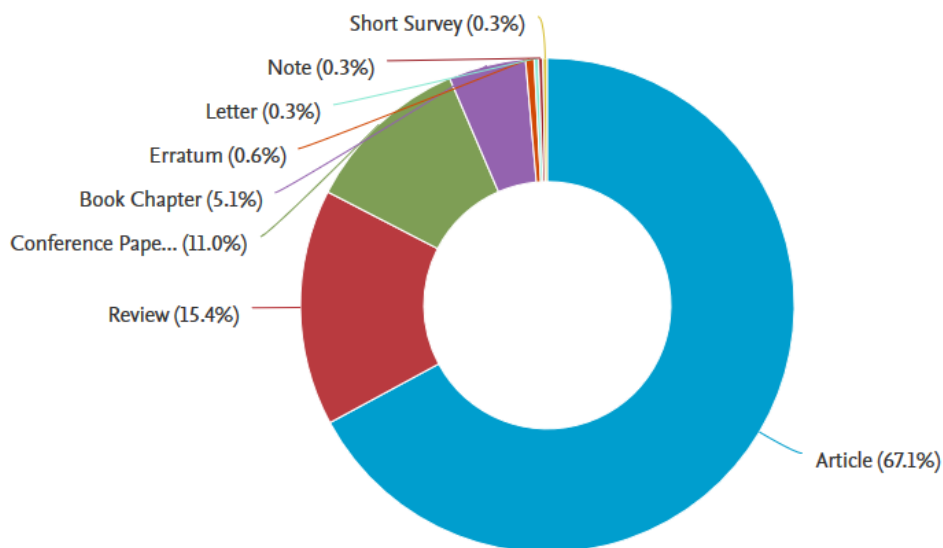


Figure 1: Classification of the documents on “surface modification of implants”, Source: www.scopus.com

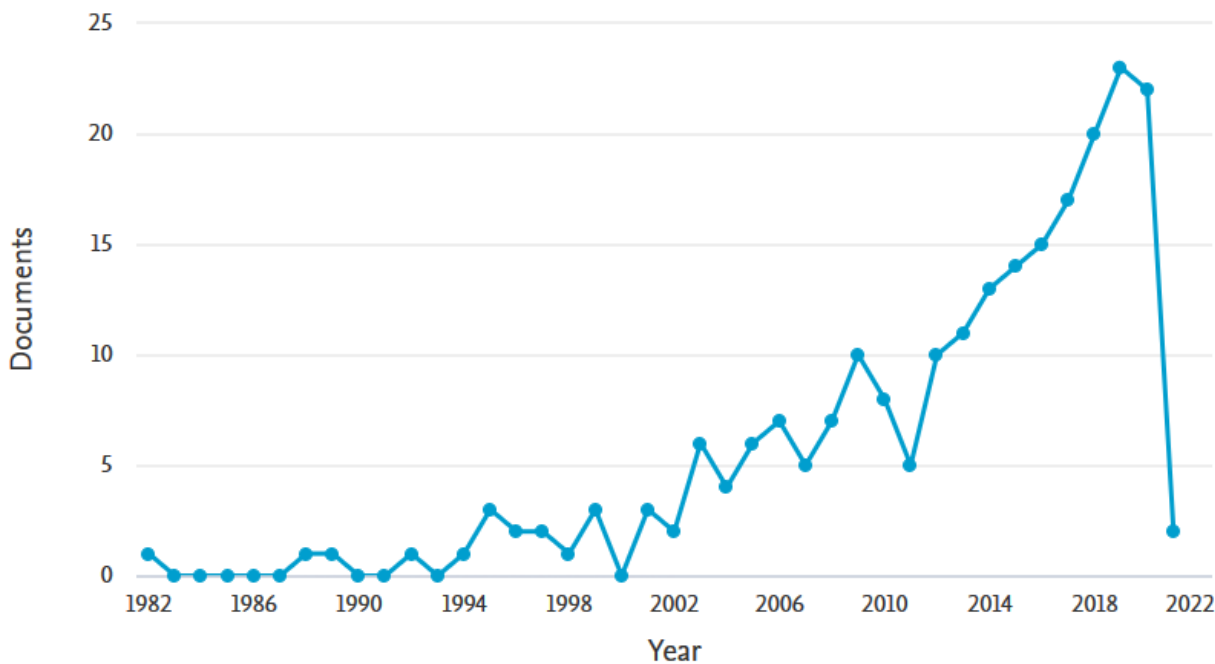


Figure 2: Period wise publication of articles, Source: WWW.scopus.com

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 three and the minimum number of citations of authors as one. This combination plotted the map of 33 authors, in 12 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.

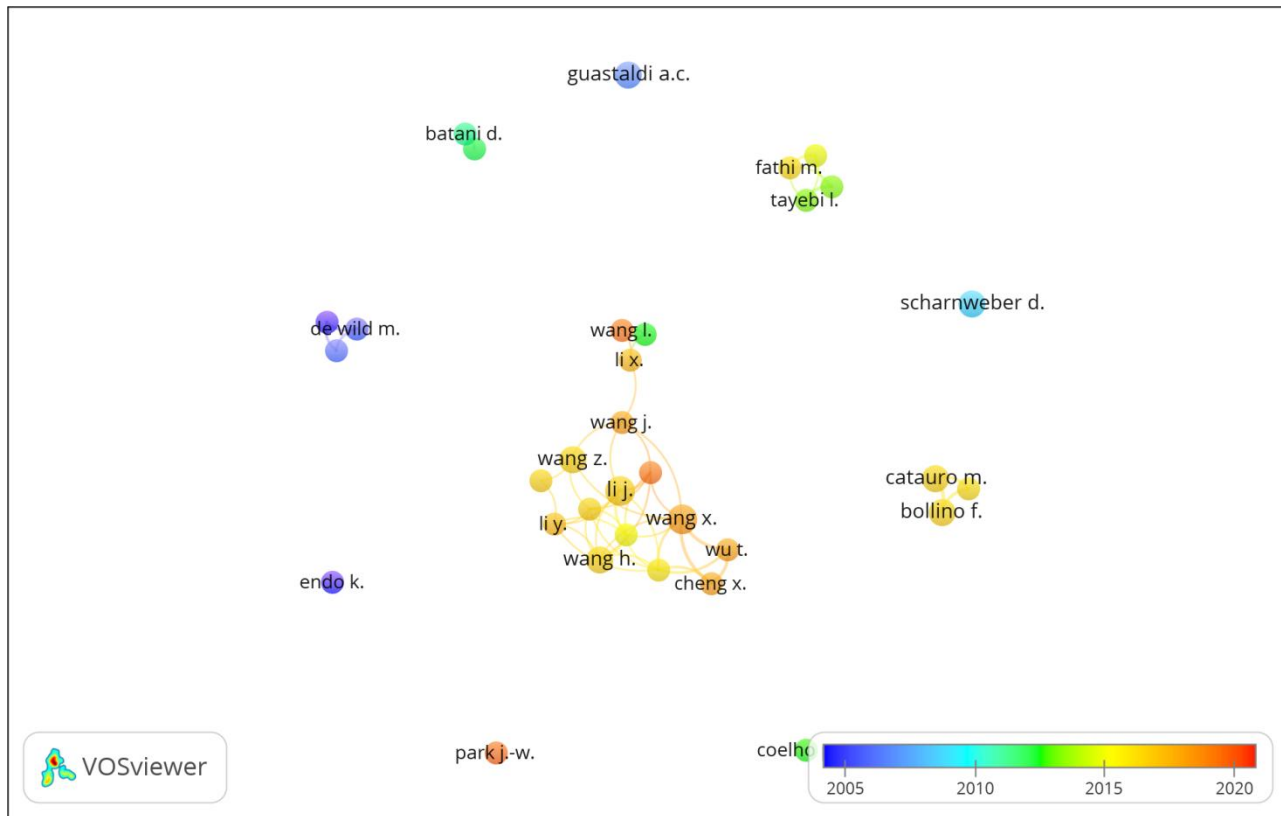


Figure 3: Co-authorship analysis on basis of authors

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 and co-authorship links	Wang X.	5	58	11.6	41
Authors with the highest citations	De Wild M.	3	642	214	16

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as 30. This combination plotted the map of 26 thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

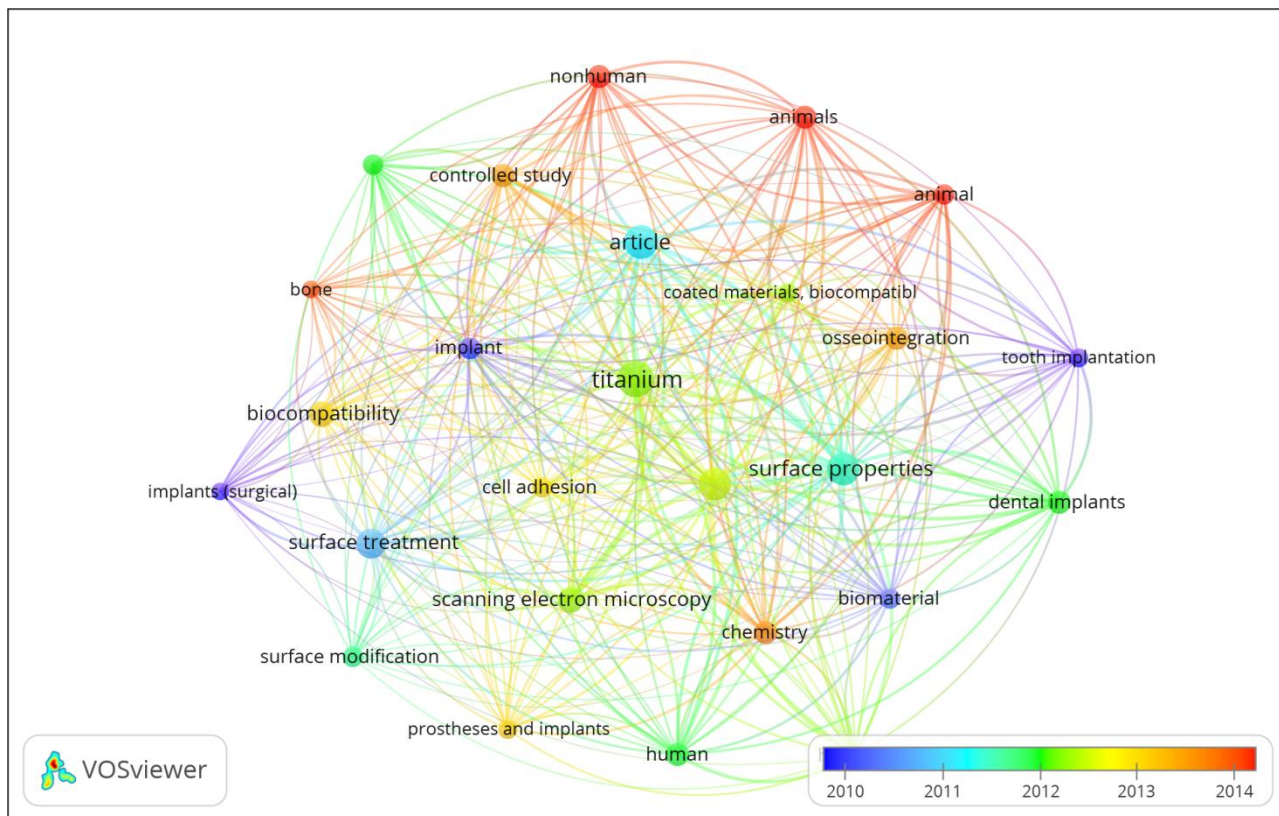


Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on “surface modification of 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 “surface modification of implants”, with the highest number of publications and citations, was the Dental Materials Research Centre, Isfahan University of Medical Sciences, Iran. (Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Dental Materials Research Centre, Isfahan University of Medical Sciences	Iran	3	76	17

Co-authorship analysis of the countries engaged in the research on “surface modification of 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.

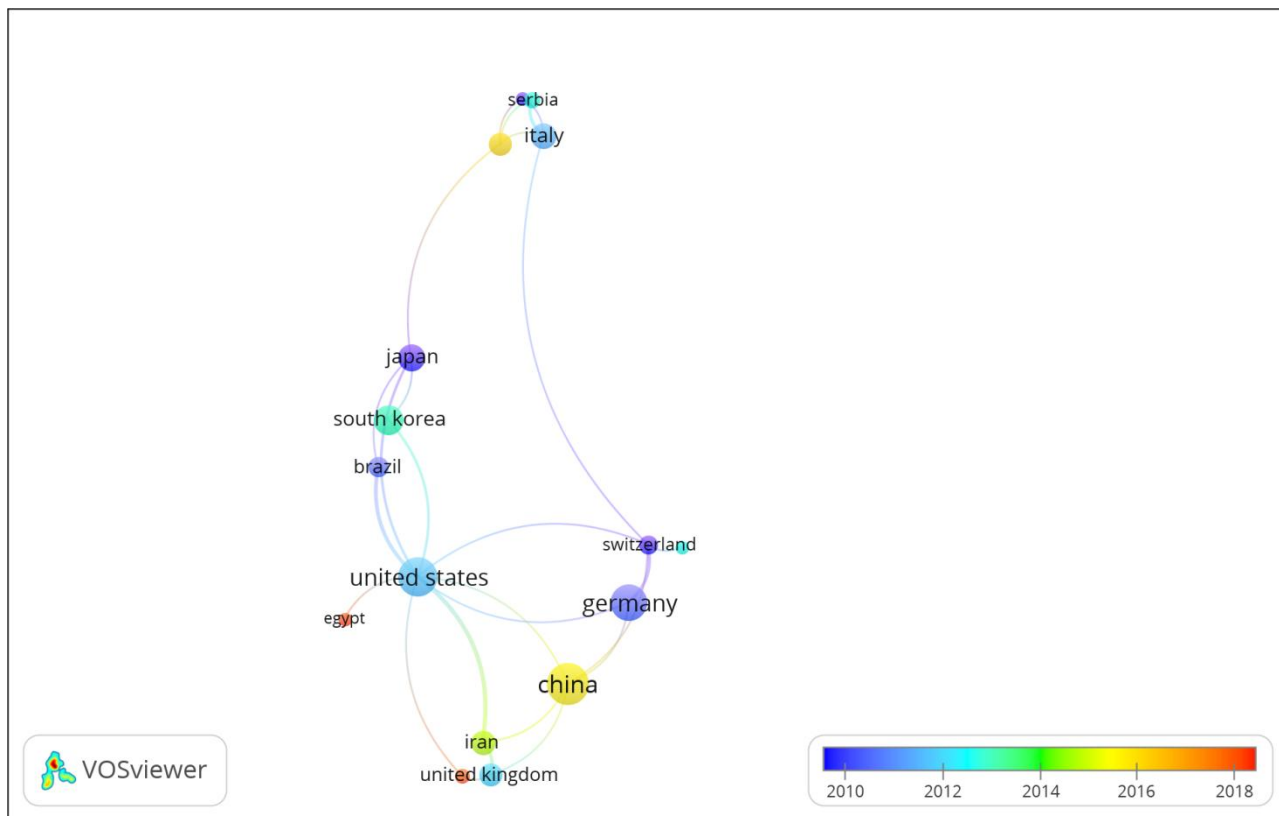


Figure 5: Co-authorship analysis on basis of countries

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	China	38	777	11
The country with the highest citations	Germany	28	1131	5
The country with the highest co-authorship links	United States of America	32	702	22

The most active country in this research domain was China, Germany, and the USA, with the highest number of publications, citations, and co-authorship links respectively.

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 “surface modification of 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	Co-authorship
Journal with the highest publications	Clinical Oral Implants research	11	353	4
Journal with the highest citations	Biomaterials	5	1170	7
Journal with the highest co-authorship links	Journal of Bio-medical Materials Research	7	696	11

From the above discussion regarding the bibliometric patterns in the research regarding surface modification of implants, this research had observed a gradual increase in research interest regarding surface modification of 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 Wang X. and De Wild M. with the highest publication and co-authorship; and citations respectively (Refer to table 1). The overlay analysis of top countries researching surface modification of implants indicates that China, Germany, and the USA were 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 Clinical Oral Implants Research, Biomaterials, and Journal of Bio-medical Materials Research. From these wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding surface modification of implants.

CONCLUSION

Surface modification of implants was an interesting research domain and the most active journals related to this research domain were the Clinical Oral Implants Research, Biomaterials, and Journal of Bio-medical Materials Research. The most active countries were China, Germany, and the USA. The leading organization engaged in the research regarding surface modification of implants was the Dental Materials Research Centre, Isfahan University of Medical Sciences, Iran. The most active authors who had made valuable contributions related to surface modification of implants were Wang X. and De Wild M. This research domain offers a new avenue for researchers and future research can be on innovations in surface modification of implants.

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