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

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Abstract
Titanium is one of the most used metals for implants. Thebibliometric analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of "Titanium-implants".All published articles related to "Titanium-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-implants"and also to find out the trends related to the same.The most active journals in this research domainwere the International Journal of Oral and Maxillofacial Implants and Clinical Oral Implants Research. The most active country was the United States of America. The leading organization engaged in the research domain was the Gothenburg University of Sweden. The most active authors were Alberktsson T and Buser D

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

INTRODUCTION

An engineered medical device to replace a missing or damaged biological structure is known as an implant. Different types of metals and materials [1]–[4]are used to create implants and the most popularly used metals and alloys for bio-implants are stainless steel, cobalt-chromium alloy, and Titanium[5]. 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. Rough surfaced implants have better bone anchoring and biomechanical stability and surface treatment of Titanium implants can achieve these features [6]. Similarly, various types of surface treatments can be conducted on Titanium to improve its competency to be used as a material for bio-implants [7].

Titanium is a commonly used material for bio-implants. The high success rate of Titanium implants with rare cases of failure and problems of toxicity resulted in the popularity of Titanium implants [8].Other advantages associated with Titanium bio-implants are corrosion resistance, biocompatibility, and mechanical resistance [9]; high biocompatibility due to low electrical conductivity, corrosion resistance, and lower reaction [10].

Despite having various advantages associated with Titanium-based bio-implants, there are some minor issues associated with Titanium bio-implants.Bio corrosion of Titanium implants in presence of bacteria is an issue of Titanium implants [11][12][13]. Another concern related to Titanium implants is the Titanium hypersensitivity or Titanium allergy, leading to even an

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implant failure [14][15][16].The full knowledge of allergy-related to Titanium is still an under-explored area of study [17].Titanium has only a very minute allergic risk, the patient history should be checked and a patch test should be conducted to reduce the Titanium allergic risk [18]. Similarly, the release of Titanium particles from the bio-implants may lead to bone losses in addition to Titanium allergy [19][20]. Yellow nail syndrome, having the symptoms of nail changes, respiratory disorders, and lymphedema had also been observed as an issue associated with Titanium-based bio-implants[21][22].

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 Titanium-implants
b) To find out the trends related to research in Titanium-implants

1.2 Research Questions

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

RESEARCH METHODOLOGY

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE (“Titanium-implants”)on 19/01/2021. 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 [23]–[29].

RESULTS AND DISCUSSION

1.1 Results

This first round of search produced an outcome of2349 documents, in21languages, out of which 2211 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 1907 English articles (both open access and others) andhad been used to conduct bibliometric analysis and visualization using VOS Viewer. The English research articles in this domain since 1959 had been shown in Figure 2.

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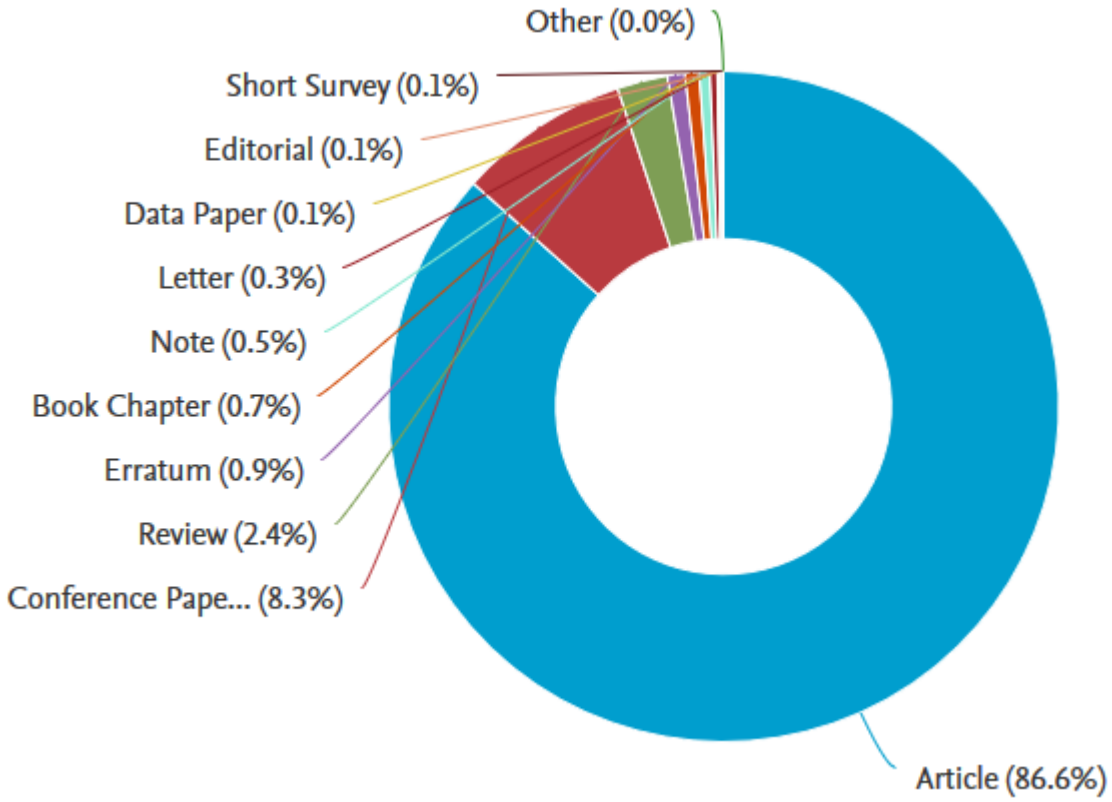

Figure 1: Classification of the documents on "Titanium-implants", Source: www.scopus.com

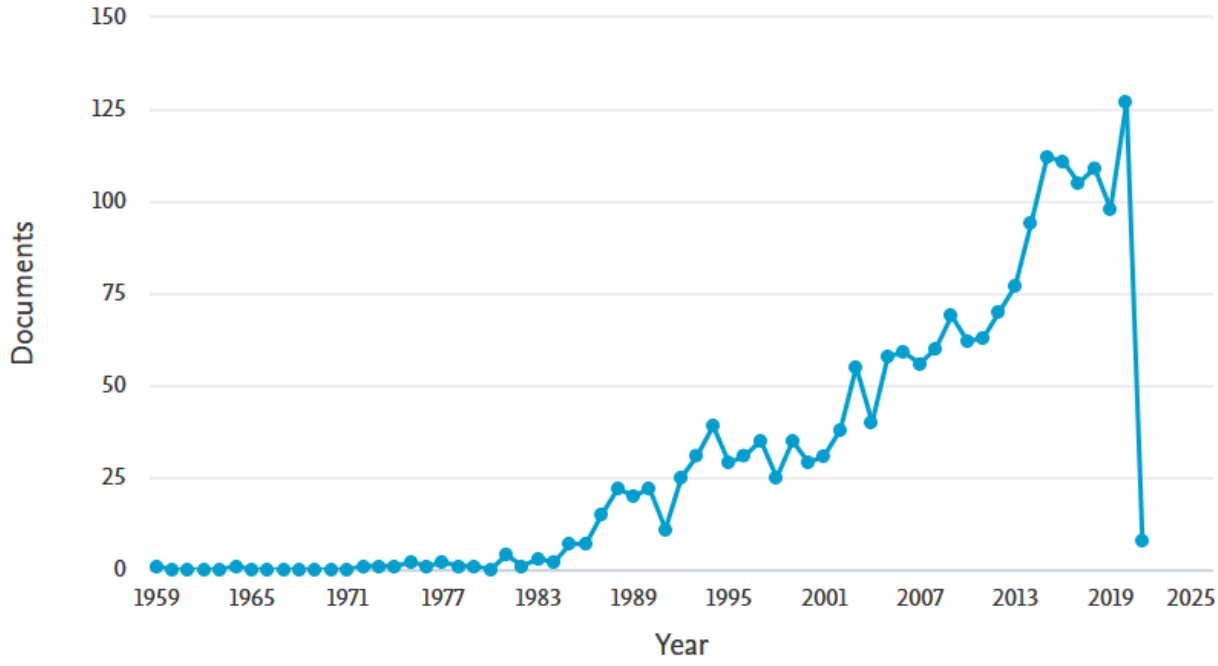

Figure 2: Period wise publication of articles, Source: WWW.scopus.com

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 15and the minimum number of citations of authors as one. This combination plotted the map of22 authors, in nineclusters. The overlay visualization map of co-authorship analysis plotted

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in Figure 3, points out the major researchers with their strong co-authorship linkages and clusters involved.

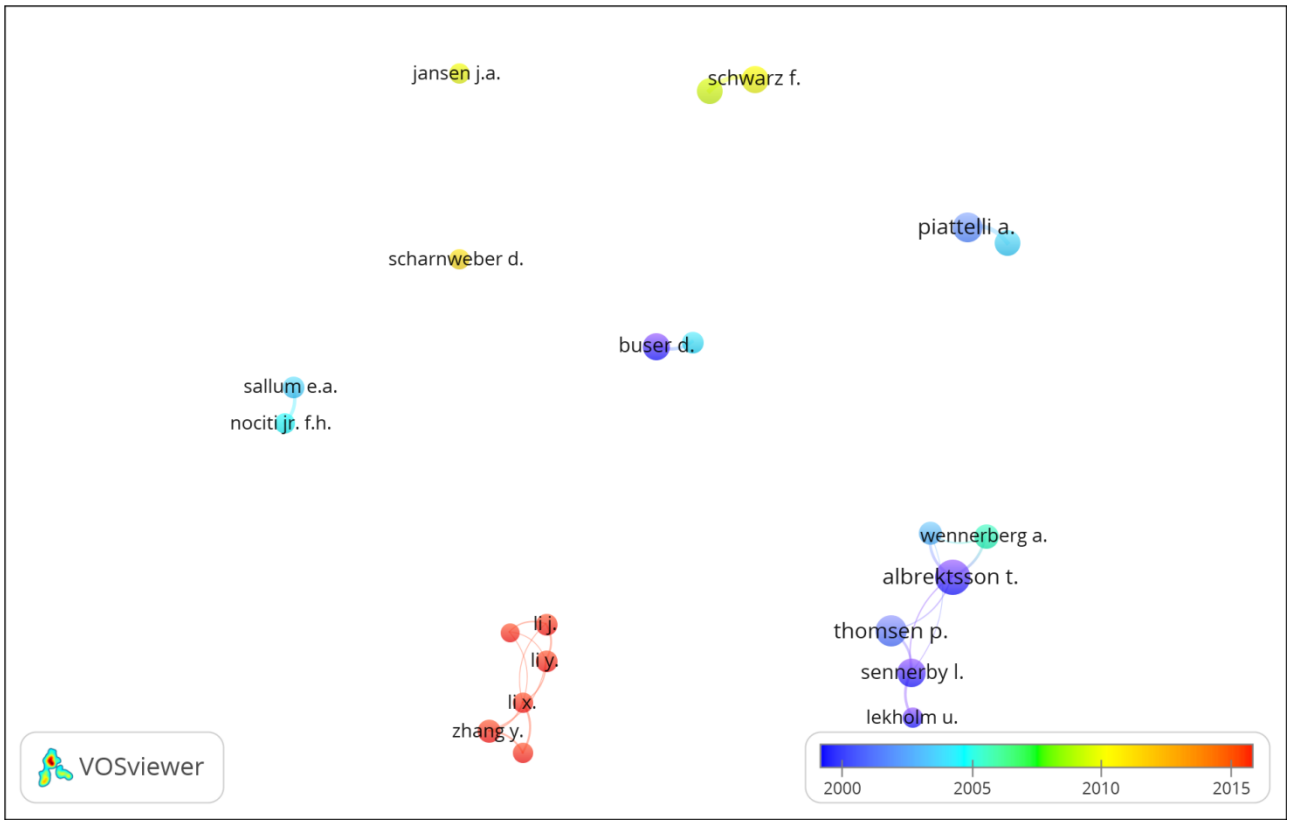

Figure 3: Co-authorship analysis on basis of authors

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 publicationand co-authorship links	Alberktsson T	50	6235	124.7	166
Authors with the highest citations	Buser D	29	6469	223.1	125

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as200. This combination plotted the map of 44thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Figure 4.

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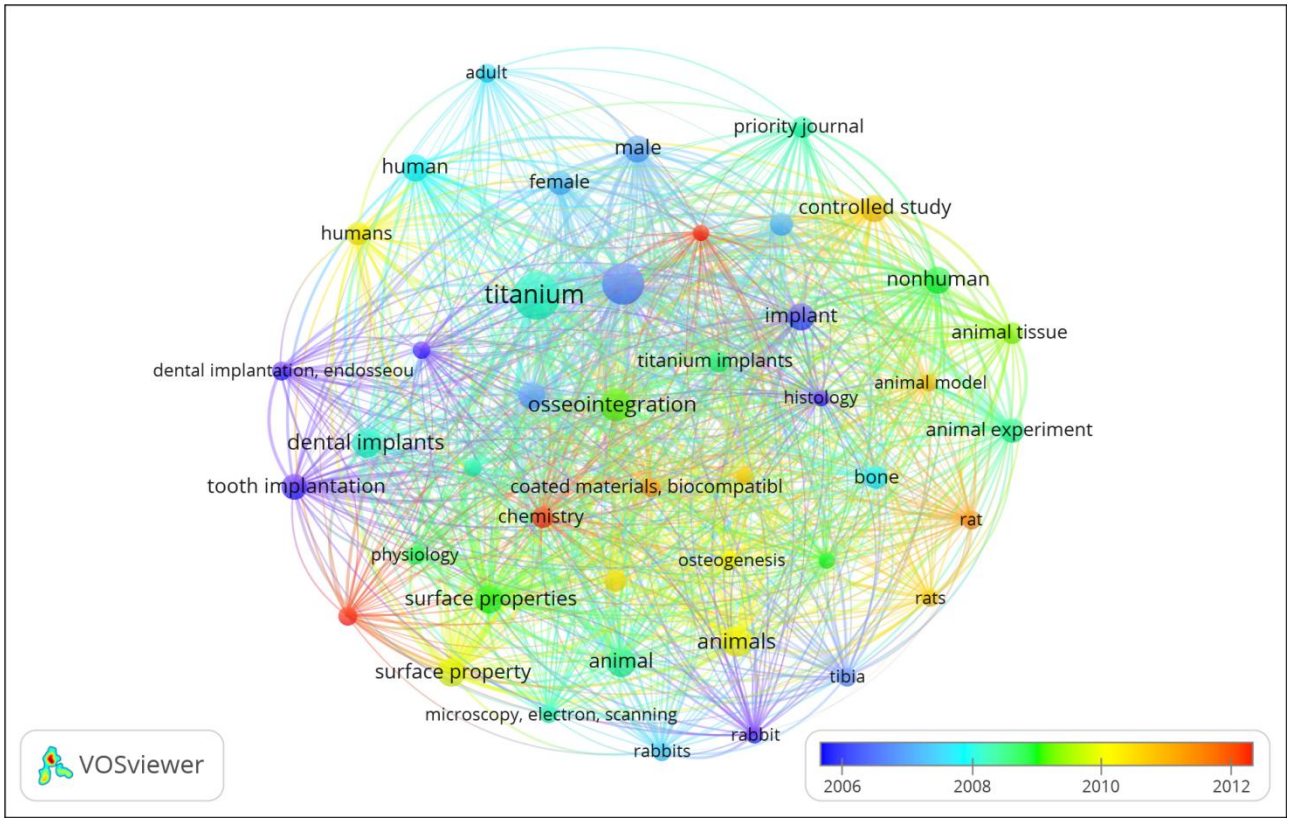

Figure 4: Co-occurrence analysis on basis of all keywords

The leading organizations engaged in research on "Titanium-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-implants", with the highest number of publications and citations,was the Gothenburg University of Sweden(Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Gothenburg University	Sweden	157	12759	81.26

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

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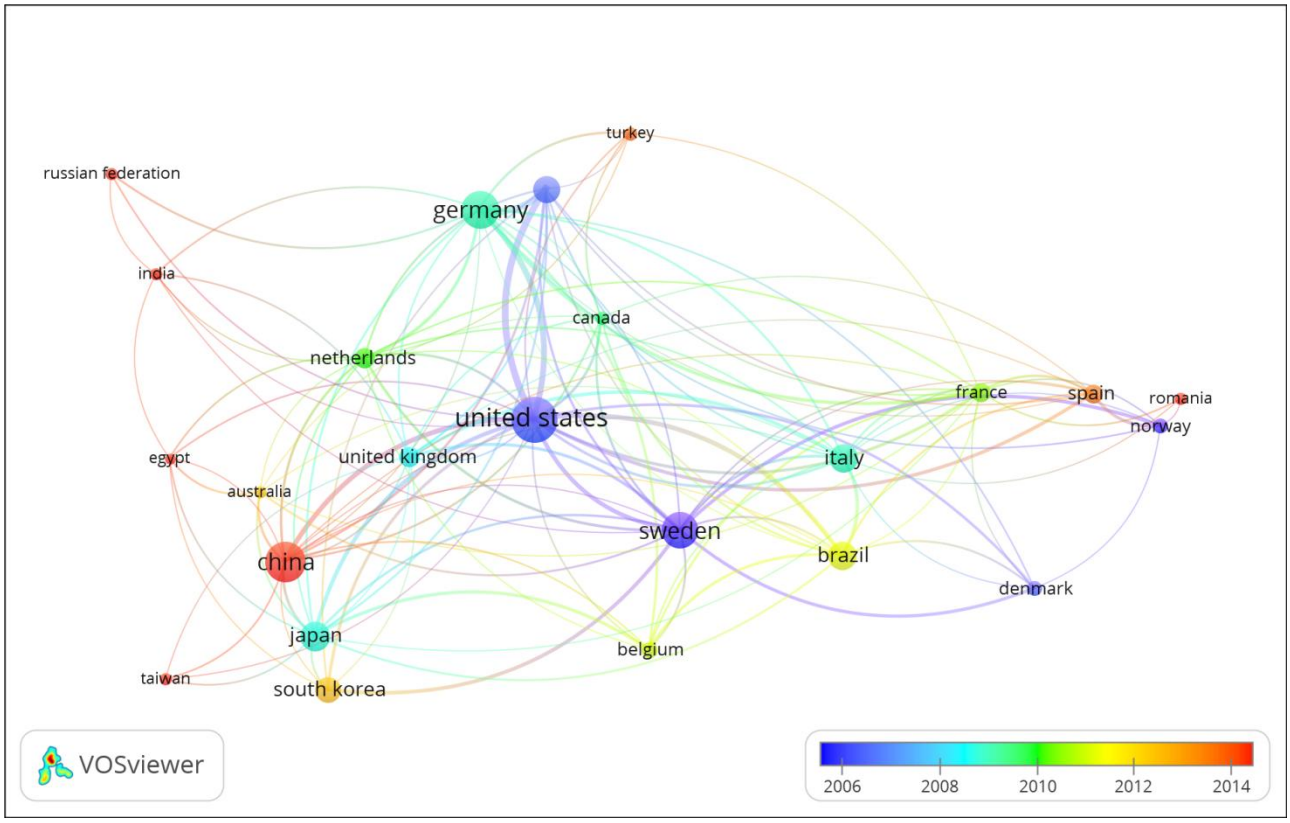

Figure 5: Co-authorship analysis on basis of countries

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 acountry 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	318	16349	188

The most active country in this research domain was the United States of America, with the highest number ofpublications, 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-implants”are shown in table 4. Table 4shows the journal activity of this research domain through parameters of publication volume, citations, and co-authorship linkages.

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Table 4: Analysis of journal activity

Description	Journal details	Documents	Citations	Average citations per documents
Journal with the highest publications	International Journal of Oral and Maxillofacial Implants	180	7016	710
Journal with the highest citations and links	Clinical Oral Implants Research	151	9319	751

From the above discussion regarding the bibliometric patterns in the research regarding Titanium-implants,this research had observed a gradual increase in research interest regarding Titanium-implantsfrom 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 domainwere Alberktsson T and Buser Dwith the highest publicationand co-authorship links; and citations respectively(Refer to table 1).The overlay analysis of top countries researching pacemaker batteriesindicates that the United States of America was the leading countryrelating tothe highest numberof publications, citations, and co-authorship links(Refer to figure 5). The top journals of this research domain were identified as the International Journal of Oral and Maxillofacial Implants and Clinical Oral Implants Research.Fromthese wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding Titanium-implants.

CONCLUSION

Titanium-implantwas an interesting research domain and the most active journals related to this research domain were the International Journal of Oral and Maxillofacial Implants and Clinical Oral Implants Research.The most active countrywas the United States of America.The leading organization engaged in the research regarding Titanium-implants was the Gothenburg University of Sweden. The most active authors who had made valuable contributions related topacemaker batterieswere Alberktsson T and Buser D with the highest publication and co-authorship links; and citations respectively.This research domain offers a new avenue for researchers and future research can be on innovations in Titanium-implants. The future work may be done on the use of other materials and technologies [30], [31] in the medical field.

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