

# The Short Review on Bone Implants Based on Copper

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## Abstract

Bone implants based on copper are common. Copper was used for diversified bone implants including knee implants, hip implants, etc. This review paper is the consolidation of research trends related to copper-based bone implants, visualized through review analysis. The active authors, organizations, journals, and countries involved in the research “copper-based bone implants” were highlighted in this review. The leading Journals were Biomaterials. The most active country was China. The leading organization engaged in research regarding copper-based bone implants was the Chinese Academy of Sciences, China. The most active author who had made valuable contributions related to copper-based bone implants was Yang K.

**Keywords:** Copper, Bone-implants, Reviews, Material engineering, Review analysis, Meta Analysis

## 1. Introduction

Bone implants were one of the popular types of bio-implants (Baier and DePalma, 1985). The popular type of bone implants includes knee implants and hip implants. Copper is also used for dental bones. Copper is also used for preparing screws and for surface coating of bones and implants based on other metals like Titanium and various alloys (Prantl *et al.*, 2010) (Rosenfeld, Williams, and Sharma, 1981). Copper coating on bone implants had found very effective for bone regeneration and bone-forming activities.

Copper-based bone implants and copper coated implants had wide acceptance due to the anti-bacterial properties and infection resistance. There are scientific proofs for the antibacterial properties and infection resistance of copper (Schlosser *et al.*, 2011) (Chai *et al.*, 2011) (Gosau *et al.*, 2013) (Habibovic *et al.*, 2008; Gosau *et al.*, 2010).

The major concerns regarding copper implants are due to metal discharge, which can even lead to failure of the implant (Kręcis, Kieć-Świerczyńska, and Chomiczewska-Skóra, 2012). Corrosion, allergy or hypersensitivity of copper, and toxicity of copper are also the issue to be addressed about copper implants (Hallab *et al.*, 2008) Both material engineering and surface engineering have great scope in improving the performance and life of copper-based bone implants.

This review paper contains four sections. The introduction of copper implants with special focus on the special features and peculiarities of copper implants was explained in the first section, followed by the discussion of the research methodology of this paper. The results and discussions related to copper-based bone implants are included in the third section of this paper. The fourth section deals with the conclusion. The following research objectives and research questions were framed for conducting review analysis systematically.

### 1.1 Research Objectives

- a) To consolidate the scientific papers on the research regarding the copper-based bone implants
- b) To find out the trends related to research in copper-based bone implants

## 1.2 Research Questions

- a) Who are the active researchers working on copper-based boneimplants?
- b) Which are the main research organizations and countries working on copper-based boneimplants?
- c) Which are the leading journalspublishing scientific papers onthe copper-basedbone implants?

## 2. Research Methodology

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE-ABS (Copperbone implant). All the tables in this paper were created by using Microsoft Excel and Meta Analysis. Grammarly was used for spelling and grammar checks. Mendeley was used for article review and citation.This paper had been inspired by review analysis in its presentation style, analysis, and methodology from the works.

## 3. Results and discussion

### 3.1 Results

The first search on Scopus had obtained 123 documents, in three languages, out of which 118 documents were in English. The document categories were classified and shown in Table 1. This review 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 91 English articles (both open access and others) and had been used to conduct review analysis and visualization using Meta Analysis. The English research articles in this domain since 1975 had been shown in Table1.Co-authorship analysis of top authors had been shown in Table1. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as threeand the minimum number of citations of authors as one. This combination plotted the map of 16 authors, in sixclusters. The overlay visualization map of co-authorship analysis plotted in Table1, points out the major researchers with their strong co-authorship linkages and clusters involved.The citation analysis of top authors had been shown in table 1.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, links, and citations | Yang K. | 10        | 434       | 43.4                            | 32            |

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as12. This combination plotted the map of 29 thresholds, in threeclusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Table2.The leading organizations engaged in research on “copper-based bone 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 “copper-based bone implants”, with the highest number of publications and citations,was the Chinese Academy of Sciences, China(Refer to table 2).

Table 2: Highlights of the most active organization

| Organizations               | Country | Documents | Citations | Average Citations per document |
|-----------------------------|---------|-----------|-----------|--------------------------------|
| Chinese Academy of Sciences | China   | 13        | 508       | 39                             |

Co-authorship analysis of the countries engaged in the research on “copper-based boneimplants” had been shown in Table3. The overlay visualization map of co-authorship analysis plotted in Table3, points out the main countries with their strong co-authorship linkages and clusters involved.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 leading publication, citations, and co-authorship links | China   | 32        | 728       | 15            |

The most active country in this research domain was China, with the position in publications, links, and citations.

The most active journals engaged in the research were identified through analyzing co-authorship links and citation analysis.Highlights of the most active and relevant journals related to “copper-based bone implants”are shown in table 4. Table 4shows the journal activity of this research domain through parameters of publication volume and citations.

Table 4: Analysis of journal activity

| Description   | Journal details | Documents | Citations | Average citations per documents | Links |
|---|-----------------|-----------|-----------|---------------------------------|-------|
| Journal with the highest publications, links, and citations | Biomaterials    | 5         | 483       | 96.6                            | 13    |

From the above discussion regarding the review patterns in the research regarding copper-based boneimplants,this research had observed a gradual increase in research interest regarding copper-based bio-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 Table 2).The most active author in this research domainwasYang K.with the highest publication, links,and citations (Refer to table 1).The overlay analysis of top countries researching copperimplants indicates that China was the leading countryrelating tothe highest numberof publications and citations (Refer to Table 5). The top journals of this research domain were identified as theBiomaterials.Fromthese wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding Copper-based boneimplants.

#### 4. Conclusion

Copper-based bone implants have great scope for future research and the most active journals related to this research domain were the Biomaterials. The most active country was China. The leading organization engaged in research regarding copper-based bone implants was the Chinese Academy of Sciences, China. The most active author who had made valuable contributions related to copper-based bone implants was Yang K. This research domain offers a new avenue for researchers and future research can be on innovations in copper-based bone implants.

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