

A systematic Review on Aluminium Hip-Implants

Kuldeep Narwat, Assistant Professor, Department of Mechanical & Chemical Engineering, Galgotias University

Abstract

The research trends related to widely accepted and popular Aluminium implants were visualised through Review analysis. This Review analysis had been conducted to understand the active authors, organizations, journals, and countries involved in the research domain of “Aluminium hip-implants”. All published articles related to “Aluminium hip-implants” from “Scopus”, were analyzed using the Meta Analysis to develop analysis tables and visualization maps. This article had set the objective to consolidate the scientific literature regarding “Aluminium hip-implants” and also to find out the trends related to the same. The leading Journals were the Journal of Bone and Joint Surgery, Material Science and Engineering and Journal of Material Processing Technology. The most active country was the United States of America. The leading organization engaged in the research regarding Aluminium-implants was the Chinese Academy of Sciences, China. The most active authors who had made valuable contributions related to Vanadium-implants were Li J and Jacobs J.J

Keywords: Aluminium Hip-implants, Material engineering, Review analysis, Meta Analysis,

1. Introduction

Artificial manmade devices for replacing defective or damaged body parts were known as implants. Aluminium had been widely used for hip implants (Hebeisen and Cox, 2004)(Hebeisen, Cox and Rampulla, 2004)(Heimke, Griss and Jentschura, 1976)(Hinrichs, Boudriot and Griss, 2000)(Boutin, 1972, 1974). Hip implants are the leading type of implants and several metals are used for the preparation of hip implants and hip surgeries. The major threats associated with hip implants are corrosion of Aluminium implants. However, the threat of corrosion of Aluminium implants can be handled by the surface coating; by using advances in material engineering and by using Aluminium free implants. The other challenges before the Aluminium hip implants are the allergy or hypersensitivity associated with Aluminium implants. The possible issues related to the toxicity of Aluminium implants should also be further investigated. However, the toxicity and allergy of Aluminium implants are comparatively negligible and thus much safer than several counterparts. There is evidence for the fact that Aluminium oxide coatings can enhance and improve the life of hip implants (Christel *et al.*, 1986)(Ingram, 1988)(Kedra *et al.*, 1987). Another issue associated with Aluminium implants is the high level of serum Aluminium level (Grübl *et al.*, 2006). Issues of cracks were also associated with Aluminium based implants (Kubota *et al.*, 1998).

Material engineering and surface engineering can play a significant role in improving the performance and life of Aluminium hip-implants along with measures for reducing toxicity and hypersensitivity of the metal. This Review analysis will be a useful platform for future researchers by realizing the top researchers, organizations, and countries involved in research regarding Aluminium hip-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 Review analysis systematically.

1.1 Research Objectives

- To consolidate the literature regarding Aluminium hip-implants
- To find out the trends related to research in Aluminium hip-implants

1.2 Research Questions

- Who are the active researchers working on Aluminium hip implants?
- Which are the main organizations and countries working on Aluminium-based hip-implants?
- Which are the main journals on Aluminium hip-implants?

2. Research Methodology

Scopus files had been used for this article. For the article selection, the Boolean used was TITLE-ABS (Aluminium hip). 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

This first round of search produced an outcome of 711 documents, in 15 languages, out of which 607 documents were in English. The classification of document categories is shown in Table 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 404 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 1954 had been shown in Figure 1.

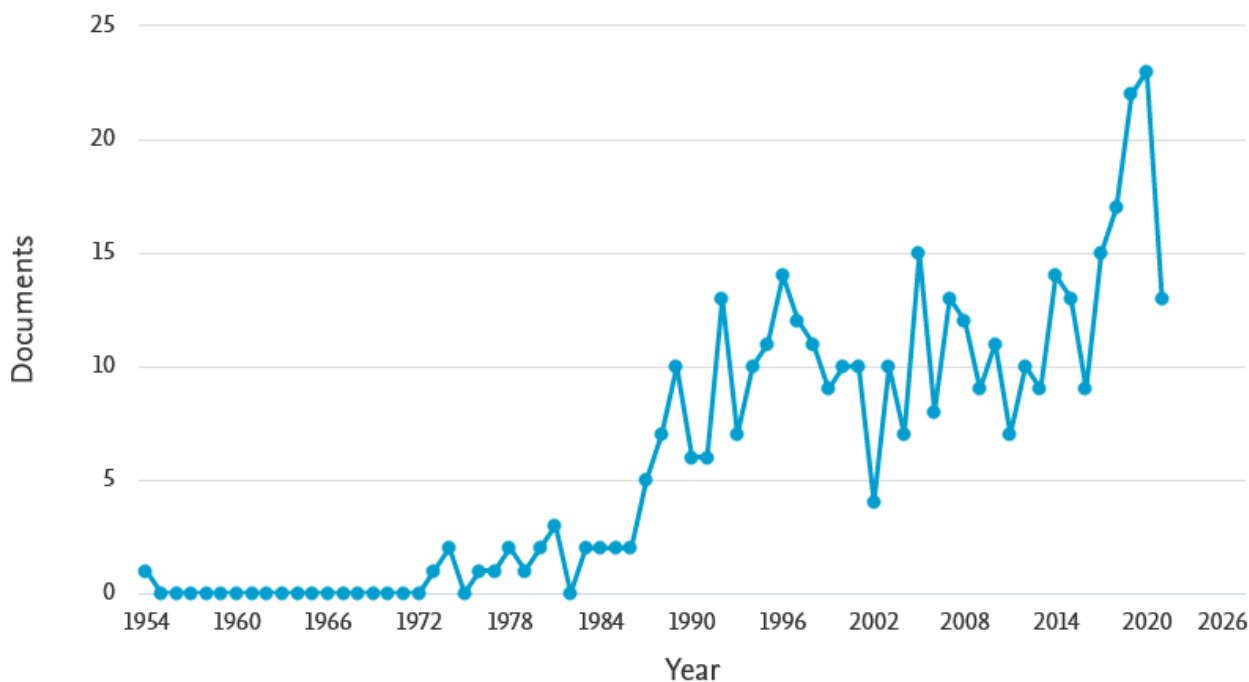


Figure 1: Period wise publication of articles

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 four and the minimum number of citations of authors as one. This combination plotted the map of 30 authors, in 12 clusters. 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, 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	Li J.	12	135	11.25	86
Authors with the highest citations	Jacobs J.J	9	1229	136.5	33

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 23 thresholds, in two clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Table2.

The leading organizations engaged in research on “Aluminium knee-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 “Aluminium knee-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	17	170	10

Co-authorship analysis of the countries engaged in the research on “Aluminium knee-implants” 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 highest publication, citations, and co-authorship links	United States of America	94	5601	29

The most active country in this research domain was the United States of America, with the highest number of publications, 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 “Aluminium knee-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	Material Science and Engineering	14	591	42.2	7
Journal with highest co-authorship	Journal of Materials Processing technology	4	144	38	12
Journal with the highest citations	Journal of Bone and Joint Surgery	6	1633	272	7

From the above discussion regarding the Review patterns in the research regarding Aluminium hip-implants, this research had observed a gradual increase in research interest regarding Aluminium hip-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 Table 2). The most active authors in this research domain were Li J. and Jacobs J.J with the highest publication and co-authorship links; and citations respectively (Refer to table 1). The overlay analysis of top countries researching Aluminium-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 Table 5). The top journals of this research domain were identified as the Journal of Bone and Joint Surgery, Material Science and Engineering and Journal of Material Processing Technology. From these wide sources of information, researchers can focus on top journals where they can identify the most relevant and highly cited articles regarding Aluminium-implants.

4. Conclusion

Aluminium -implants was an interesting research domain and the most active journals related to this research domain was the Journal of Bone and Joint Surgery, Material Science and Engineering and Journal of Material Processing Technology. The most active country was the United States of America. The leading organization engaged in the research regarding Aluminium-implants was the Chinese Academy of Sciences, China. The most active authors who had made valuable contributions related to Vanadium-implants were Li J and Jacobs J.J. This research domain offers a new avenue for researchers and future research can be on innovations in Aluminium-implants.

References

1. Boutin, P. (1972) 'Total arthroplasty of the hip by fritted Aluminium prosthesis. Experimental study and 1st clinical applications [Arthroplastie totale de la hanche par prothèse en alumine frittée. Etude expérimentale et premières applications cliniques.]', *Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur*, 58(3), pp. 229–246.
2. Boutin, P. (1974) 'Total hip arthroplasty with aluminium prosthesis [ARTHROPLASTIE TOTALE DE LA HANCHE PAR PROTHESE EN ALUMINE]', *Acta Orthopaedica Belgica*, 40(5–6), pp. 744–754.
3. Christel, P. *et al.* (1986) 'ALUMINIUM OXIDE CERAMIC-TITANIUM ALLOY MATERIALS FOR TOTAL HIP REPLACEMENT.', in Lin O.C.C., C. E. Y. S. (ed.) *Materials Science Monographs*. Taipei, Taiwan: Elsevier, Amsterdam, Neth, pp. 277–288.
4. Grübl, A. *et al.* (2006) 'Serum aluminium and cobalt levels after ceramic-on-ceramic and metal-on-metal total hip replacement', *Journal of Bone and Joint Surgery - Series B*, 88(8), pp. 1003–1005. doi: 10.1302/0301-620X.88B8.17870.
5. Hebeisen, J. C. and Cox, B. M. (2004) 'The effect of HIP processing on the properties of A356 T6 cast Aluminium steering knuckles', *SAE Technical Papers*. doi: 10.4271/2004-01-1027.
6. Hebeisen, J. C., Cox, B. M. and Rampulla, B. (2004) 'HIP of Aluminium castings', *Advanced Materials and Processes*, 162(4), pp. 38–40.
7. Heimke, G., Griss, P. and Jentschura, G. (1976) 'Two years of clinical experience with aluminium oxide ceramic parts for hip joint replacement [ZWEI JAHRE KLINISCHE ERFAHRUNGEN MIT A12O3 KERAMIKTEILEN FÜR DEN HUFTGELENKERSATZ]', *Medizinal Markt*, 24(9), pp. 310–313.
8. Hinrichs, F., Boudriot, U. and Griss, P. (2000) 'Ten-year results of a cemented mild grit blasted Titanium-Aluminium-Vanadium stem in Total-Hip-Arthroplasty [10-Jahres-ergebnisse mit einem zementierten feingestrahnten Titan-Aluminium-Vanadium-Hüftendoprothesenschaft]', *Zeitschrift für Orthopädie und Ihre Grenzgebiete*, 138(1), pp. 52–56. doi: 10.1055/s-2000-10113.
9. Ingram, A. J. (1988) 'Soft tissue sarcoma associated with Aluminium oxide ceramic total hip arthroplasty.', *Clinical Orthopaedics and Related Research*, (235), pp. 311–312.
10. Kedra, H. *et al.* (1987) 'Biocorundum--a new/type of poreless ceramic material of Aluminium oxide for the manufacture of the elements of hip joint prosthesis. Biological and technological studies [Biokorund--nowa odmiana bezporowatego spieku ceramicznego z tlenku glinu--przeznaczon]', *Polimery w medycynie*, 17(1–2), pp. 3–28.
11. Kubota, M. *et al.* (1998) 'Crack propagation properties on hip-treated cast Aluminium alloys', *Materials Science Research International*, 4(3), pp. 193–199.
12. Subramanian, B., Ananthakumar, R. and Jayachandran, M. (2010) 'Microstructural, mechanical and electrochemical corrosion properties of sputtered titanium-Aluminium - nitride films for bio-implants', *Vacuum*, 85(5), pp. 601–609. doi: 10.1016/j.vacuum.2010.08.019.