A critical Review on Aluminium Implants

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Abstract

This research paper is consolidated visualisation of research trends in Aluminium implants using Review analysis. This research will help to understand the active authors, organizations, journals, and countries involved in the research of "Aluminium implants". All published articles related to "Aluminium 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 implants" and also to find out the trends related to the same. The leading Journals were the Biomaterials and International Journal of Oral and Maxillofacial Implants. The most active country was the United States of America. The leading organization engaged in research regarding Aluminium implants was the Sao Paulo University of Brazil. The most active authors who had made valuable contributions related to Aluminium implants were Boven B.D and Jacobs J.J.

Keywords: Aluminium implants, Reviews, Material engineering, Review analysis, Meta Analysis,

1. Introduction

Several metals are used to prepare medical implants and Aluminium metal is used for medical implants and for preparing medicines. Moreover, Aluminium is also used as a coating for various medical implants and for preparing implants. Aluminium based materials were used for various types of tissue repairs and tissue replacements (Alexander *et al.*, 1985)(Bayer, Tiwari and Megaridis, 2008). The aluminium oxide coating is used for dental ceramic implants (Büsing *et al.*, 1983)(Cook, Anderson and Lavernia, 1983)(Cook, Klawitter and Weinstein, 1981)(Cook, Weinstein and Klawitter, 1982, 1983; Cook *et al.*, 1983); bone regeneration (Isa Majluf, Harán Vega and Moreno Zárate, 2007); hip implants (Christel *et al.*, 1986)(Ingram, 1988)(Kedra *et al.*, 1987); knee implants (Dörner *et al.*, 2006); Aluminium wire implants. Similarly, Aluminium implants are also surface coated with other materials for enhancing their performance. Themajor challenge associated with Aluminium oxide implants is corrosion of the Aluminium implants.

The allergy or hypersensitivity; and toxicity; high level of serum Aluminium level (Grübl *et al.*, 2006) and lead to various complicated health issues. the Aluminium silicates used for controlling bleeding had found toxic at minor levels to endothelial cells and macrophage (Bowman *et al.*, 2011). The photodynamic toxicity due to Aluminium phthalocyanine tetrasulfonate medication (Glassberg *et al.*, 1991). Similarly, there are chances of Aluminium toxicity can happen through contaminated dialysis fluid.

Aluminium implants can be better protected through coating with multi-layers. Such coatings can be good measures against corrosion. (Andreeva and Skorb, 2014); nano-diamond composite coatings on Aluminium(Blum and Molian, 2009). Graphite powders on Aluminium; Nanocrystalline oxide coatings on Aluminium implants (Curran, 2012).

Both material engineering and surface engineering can play a significant role in improving the performance and life of Aluminium–implants along with measures for reducing toxicity and hypersensitivity of the metal. 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

a) To consolidate the literature regarding Aluminium implants
b) To find out the trends related to research in Aluminium implants

1.2 Research Questions

a) Who are the active researchers working on Aluminium implants?
b) Which are the main organizations and countries working on Aluminium implants?
c) Which are the main journals working on Aluminium implants?

2. Research Methodology

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

This first round of search produced an outcome of 1594 documents, in 21 languages, out of which 1467 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 of1100English 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 1938 had been shown in Figure 1.

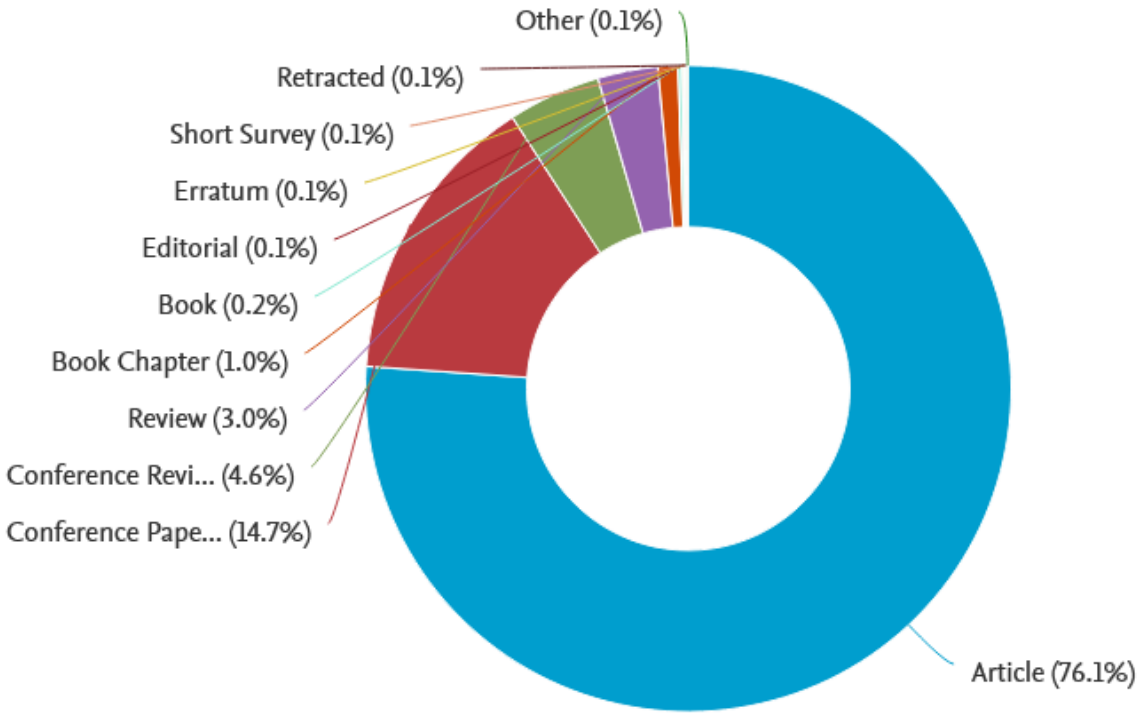

Figure 1 1: Classification of the documents on “Aluminium implants”,

Co-authorship analysis of top authors had been shown in Table 3. For a better presentation of the analysis, the parameters used were the minimum number of documents of an author as five and the minimum number of citations of authors as one(Singh and Kumar, 2013). This combination plotted the map of 31authors, in 16 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.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 links	BoyanB.D	14	640	45.5	78
	Schwartz.Z	14	640	45.5	78
Authors with the highest citations	Jacobs J.J	9	1378	153	35

In Co-occurrence analysis, we had used all keyword analyses, by keeping the minimum number of occurrences of a keyword as100. This combination plotted the map of 27 thresholds, in three clusters. The overlay visualization of co-occurrence analysis of keywords has been shown in Table2.The leading organizations engaged in research on “Aluminium 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 implants”, with the highest number of publications and citations, was the Sao Paulo State University, Brazil(Refer to table 2).

Table 2: Highlights of the most active organization

Organizations	Country	Documents	Citations	Average Citations per document
Sao Paulo State University	Brazil	25	433	17.3

Co-authorship analysis of the countries engaged in the research on “Aluminium 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 leading publication, citations, and co-authorship links	United States of America	346	12049	126

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

The most active journals engaged in the research were identified through analysing co-authorship links and citation analysis. Highlights of the most active and relevant journals related to "Aluminium 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	International Journal of Oral and Maxillofacial Implants	53	1987	37.3	78
Journal with the highest citations and links	Biomaterials	34	2910	86.	80

From the above discussion regarding the Review patterns in the research regarding Aluminium implants,this research had observed a gradual increase in research interest regarding Aluminium 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 authors in this research domain were Boven B.D and Jacobs J.J. with the highest publication and 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 and citations (Refer to Table 5). The top journals of this research domain were identified as the Biomaterials and International Journal of Oral and Maxillofacial Implants. 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 have great scope for future research and the most active journals related to this research domain was the Biomaterials and International Journal of Oral and Maxillofacial Implants. The most active country was the United States of America. The leading organization engaged in research regarding Aluminium implants was the Sao Paulo University of Brazil. The most active authors who had made valuable contributions related to Aluminium implants were Boven B.D and Jacobs J.J. This research domain offers a new avenue for researchers and future research can be on innovations in Aluminium-based implants.

References

1. Alexander, H. *et al.* (1985) 'ABSORBABLE COMPOSITES AS ORTHOPEDIC IMPLANTS.', in *Transactions of the Annual Meeting of the Society for Biomaterials in conjunction with the Interna*. San Diego, CA, USA: Soc for Biomaterials, San Antonio, TX, USA, p. 215.
2. Andreeva, D. V and Skorb, E. V (2014) *Multi-layer smart coatings for corrosion protection of aluminium alloys and steel*, *Handbook of Smart Coatings for Materials Protection*. Elsevier Inc. doi: 10.1533/9780857096883.2.307.
3. Bayer, I. S., Tiwari, M. K. and Megaridis, C. M. (2008) 'Biocompatible poly(vinylidene fluoride)/cyanoacrylate composite coatings with tunable hydrophobicity and bonding strength', *Applied Physics Letters*, 93(17). doi: 10.1063/1.3009292.
4. Bernard, P. *et al.* (1993) 'Rehabitation and ingrowth on the surface of total knee prostheses. Experimental study. Preliminary results [Ancrage et effets de surface dans les prothèses totales de genou Etude expérimentale - Note préliminaire]', *Orthopedie Traumatologie*, 3(2), pp. 93–96. doi: 10.1007/BF01795792.
5. Blum, R. and Molian, P. (2009) 'Liquid-phase sintering of nanodiamond composite coatings on aluminum A319 using a focused laser beam', *Surface and Coatings Technology*, 204(1–2), pp. 1–14. doi: 10.1016/j.surfcoat.2009.06.025.
6. Bowman, P. D. *et al.* (2011) 'Toxicity of aluminum silicates used in hemostatic dressings toward human umbilical veins endothelial cells, HeLa cells, and RAW267.4 mouse macrophages', *Journal of Trauma - Injury, Infection and Critical Care*, 71(3), pp. 727–732. doi: 10.1097/TA.0b013e3182033579.
7. Büsing, C. M. *et al.* (1983) 'Morphological demonstration of direct deposition of bone on human aluminium oxide ceramic dental implants', *Biomaterials*, 4(2), pp. 125–127. doi: 10.1016/0142-9612(83)90052-2.
8. 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.
9. Cook, S. D. *et al.* (1983) 'Quantitative histologic evaluation of LTI carbon, carbon-coated aluminum oxide and uncoated aluminum oxide dental implants', *Journal of Biomedical Materials Research*, 17(3), pp. 519–538. doi: 10.1002/jbm.820170311.
10. Cook, S. D., Anderson, R. C. and Lavernia, C. J. (1983) 'Histologic and microradiographic evaluation of textured and nontextured aluminum oxide dental implants', *Biomaterials, Medical Devices, and Artificial Organs*, 11(4), pp. 259–269. doi: 10.3109/10731198309118812.
11. Cook, S. D., Klawitter, J. J. and Weinstein, A. M. (1981) 'The influence of implant elastic modulus on the stress distribution around LTI carbon and aluminum oxide dental implants', *Journal of Biomedical Materials Research*, 15(6), pp. 879–887. doi: 10.1002/jbm.820150612.
12. Cook, S. D., Weinstein, A. M. and Klawitter, J. J. (1982) 'Parameters affecting the stress distribution around LTI carbon and aluminum oxide dental implants', *Journal of Biomedical Materials Research*, 16(6), pp. 875–885. doi: 10.1002/jbm.820160612.
13. Cook, S. D., Weinstein, A. M. and Klawitter, J. J. (1983) 'The retention mechanics of LTI carbon, carbon-coated aluminum oxide, and uncoated aluminum oxide dental implants', *Journal of Biomedical Materials Research*, 17(5), pp. 873–883. doi: 10.1002/jbm.820170514.
14. Curran, J. A. (2012) 'Nanocrystalline oxide coatings on Al, Ti & Mg: The state of the art in plasma electrolysis', in *National Association for Surface Finishing Annual Conference and Trade Show 2012, SUR/FIN 2012*. Las Vegas, NV, pp. 211–225.
15. Daley, B. *et al.* (2004) 'Wear debris from hip or knee replacements causes chromosomal damage in human cells in tissue culture', *Journal of Bone and Joint Surgery - Series B*, 86(4), pp. 598–606. doi: 10.1302/0301-620x.86b4.14368.
16. Dörner, T. *et al.* (2006) 'Implant-related inflammatory arthritis', *Nature Clinical*

Practice Rheumatology, 2(1), pp. 53–56. doi: 10.1038/ncprheum0087.

17. Farhat, T. *et al.* (2013) 'Research in congenital heart disease: A comparative Review analysis between developing and developed countries', *Pediatric Cardiology*, 34(2), pp. 375–382. doi: 10.1007/s00246-012-0466-6.
18. Glassberg, E. *et al.* (1991) 'Hyperthermia potentiates the effects of aluminum phthalocyanine tetrasulfonate-mediated photodynamic toxicity in human malignant and normal cell lines', *Lasers in Surgery and Medicine*, 11(5), pp. 432–439. doi: 10.1002/lsm.1900110508.
19. 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.
20. Ingram, A. J. (1988) 'Soft tissue sarcoma associated with aluminum oxide ceramic total hip arthroplasty.', *Clinical Orthopaedics and Related Research*, (235), pp. 311–312.
21. Isa Majluf, M., Harán Vega, J. and Moreno Zárate, G. (2007) 'Guided bone regeneration using aluminum oxide membrane in combination with osseointegrated implants [Regeneración ósea guiada utilizando membrana de óxido de aluminio en combinación con implantes oseointegrados]', *Revista Espanola de Cirugia Oral y Maxilofacial*, 29(4), pp. 260–269.
22. Kedra, H. *et al.* (1987) 'Biocorundum--a new/type of poreless ceramic material of aluminum 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.
23. Singh, H. and Kumar, R. (2013) 'Measuring the utilization index of advanced manufacturing technologies: A case study', in *IFAC Proceedings Volumes (IFAC-PapersOnline)*. Saint Petersburg: IFAC Secretariat, pp. 899–904. doi: 10.3182/20130619-3-RU-3018.00395.
24. Subramanian, B., Ananthakumar, R. and Jayachandran, M. (2010) 'Microstructural, mechanical and electrochemical corrosion properties of sputtered titanium-aluminum-nitride films for bio-implants', *Vacuum*, 85(5), pp. 601–609. doi: 10.1016/j.vacuum.2010.08.019.