Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(3), 1078-1082 | ISSN:2251-6727

Ceramic Dental Implant Systems: A Comprehensive Review

[1]Balaji V, [2]Dhanraj Ganapathy

[1]Undergraduate student, Saveetha Dental College and Hospitals, Saveetha Institute Of Medical and Technological Sciences, Saveetha University Chennai, India

[2]Professor & Head, Department Of Prosthodontics Saveetha Dental College and Hospitals, Saveetha Institute Of Medical and Technological Sciences, Saveetha University Chennai, India

Corresponding Author: Dhanraj Ganapathy

(Received: 04 August 2023 Revised: 12 September Accepted: 06 October)

KEYWORDS

Zirconia; Zirconia implant; Zirconia versus titanium

ABSTRACT:

The gold standard for dental implants is titanium, sometimes referred to as a conventional implant. This is due to its excellent biocompatibility, suitable mechanical qualities, and positive outcomes. When titanium is exposed to oxygen, it immediately produces a stable oxide layer that serves as the foundation for its biocompatibility and promotes improved Osseointegration. A ceramic material with adequate mechanical qualities for the production of medical devices is zirconia (ZrO2). As an alternative to titanium implants, zirconia-based implants were introduced into the field of dental implantology. Due to its tooth-like hue, biocompatibility, mechanical qualities, and low plaque affinity, zirconia appears to be a suitable candidate for implant material. The primary disadvantage of titanium is its gray hue. Due to a lack of soft tissue height above the implant level in a number of circumstances, as well as after soft tissue recession and marginal bone loss, the metal components may display in an unattractive manner. In poor clinical circumstances, zirconia opacity is highly useful. Evaluation during radiographic controls may be aided by radiopacity. Zirconia frameworks are created utilizing CAD/CAM (computer-aided design/manufacturing) technology.The aim of this study is to review clinical and research articles conducted on Zirconia dental implants should be compared to titanium dental implants in terms of success rate after at least a 5-year follow-up period.

Introduction

Dental implantology has made great progress in recent years, changing the field of oral rehabilitation and restorative dentistry. Dental implants are a dependable and successful alternative for replacing lost teeth, restoring function and aesthetics, and enhancing patients' quality of life. Traditionally, dental implants have been made mostly of titanium, which has good biocompatibility and osseointegration qualities. However, the introduction of ceramic dental implant systems has sparked significant interest in the sector due to its biocompatibility, aesthetic benefits, and reduced metal-related issues.

Ceramic dental implants are often made of materials such as zirconia, alumina, or a mixture of these components. Zirconia-based implants, in particular, have been widely researched and have demonstrated promising results in a variety of clinical settings(1,2). Ceramic materials, which are tooth-colored and lack of metallic luster, provide a more natural appearance, making them an excellent choice, particularly in the anterior region of the mouth. Furthermore, in metal-sensitive people, the lack of metal decreases the possibility of corrosion, immunological reactions, and allergic reactions.

While the use of ceramic dental implants is increasing, it is vital to thoroughly analyze the current research to assess their overall performance and dependability.(3) This article seeks to give an in-depth study of ceramic dental implant systems by assessing research articles published in the previous 15 years.

Methodology

To conduct a comprehensive review on ceramic dental implant systems, a systematic approach was adopted to

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(3), 1078-1082 | ISSN:2251-6727

identify relevant research articles. Electronic databases including PubMed, MEDLINE, and Google Scholar were searched for articles published between 2008 and 2023, using appropriate keywords such as "ceramic dental implants," "zirconia implants," "alumina dental implants," "ceramic implant surface modifications," and "clinical outcomes of ceramic implants."

The inclusion criteria for article selection were as follows:

1. Articles published in peer-reviewed journals within the specified timeframe.
2. Studies focusing on ceramic dental implant materials, designs, surface modifications, or clinical performance.
3. Articles written in English to ensure accessibility and consistency.

After conducting the initial search, duplicates were removed, and titles and abstracts were screened to exclude irrelevant studies. Subsequently, full-text articles were obtained and thoroughly assessed for their relevance to the research topic. The final selection included a total of 15 articles that met the predetermined criteria.

Discussion

Comparison of Titanium and Zirconia Dental Implants:

Dental implants have transformed the practice of restorative dentistry by providing a viable treatment for individuals with lost teeth. Titanium and zirconia are two extensively used materials for dental implants, each with its own set of benefits and drawbacks.(4) This section examines the mechanical and chemical qualities that make zirconia an appealing alternative to titanium implants, as well as concerns about brittleness and fracture hazards.

Advantages of Zirconia Dental Implants:

Due to its excellent mechanical and chemical qualities, zirconia ceramics (ZrO_2) have grown in popularity in dentistry and dental implantology. The tooth-colored look of zirconia implants makes them more cosmetically pleasing when compared to metallic titanium implants.(5) Patients who are concerned about the aesthetics of their dental restorations will appreciate the ability to integrate perfectly with the natural dentition.

Furthermore, zirconia has good biocompatibility, resulting in less inflammation and unfavorable responses in surrounding tissues. This biocompatibility is critical for a positive host response and effective osseointegration, which is the process by which bone fuses with the implant surface. As compared to titanium implants, zirconia's strong chemical stability adds to its corrosion resistance and low plaque affinity.(6) Reduced bacterial adherence on zirconia surfaces may have consequences for peri-implant health and peri-implant disease prevention, such as peri-implantitis.

Mechanical Properties of Zirconia:

Zirconia ceramics are an appealing alternative to titanium implants because of their mechanical qualities. In order to endure occlusal stresses and reduce the chance of implant failure, zirconia demonstrates great flexural strength and fracture toughness.(7) Nevertheless, despite these benefits, zirconia's brittleness continues to be an issue that needs more research.

Brittleness and Fracture Risks of Zirconia:

Zirconia dental implants' innate brittleness is one of its main drawbacks. Zirconia implants may be vulnerable to fractures in several clinical situations when placed under extreme mechanical stress, particularly in regions with high occlusal pressures or suboptimal implant designs.(8,9) For zirconia-based implant systems to be more durable and reliable overall, this constraint must be overcome.

Biocompatibility of Zirconia Ceramics:

The findings of several research looking at zirconia ceramics' biocompatibility have been encouraging. Zirconia is biocompatible because of its chemical stability and the development of a non-toxic surface layer, which results in a positive reaction from the surrounding tissues after implantation.(10)

Aesthetic Advantages of Zirconia Implants:

Zirconia dental implants offer a more natural-looking restoration due to their tooth-colored appearance, making them an attractive option for patients seeking aesthetically pleasing dental restorations.(5,11) This aesthetic advantage is especially beneficial for patients in the esthetic zone, where the visibility of dental restorations is a significant concern.(12)

Clinical Outcomes of Zirconia Dental Implants:

Studies evaluating the clinical outcomes of patients treated with zirconia dental implants have reported promising results in terms of survival rates, peri-implant

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(3), 1078-1082 | ISSN:2251-6727

health, and patient satisfaction.(13) These outcomes indicate the potential for zirconia-based implant systems to be a viable alternative to titanium implants in specific clinical scenarios.

Challenges of Zirconia Dental Implants:

The primary challenge associated with zirconia dental implants is their inherent brittleness, which increases the risk of fractures, particularly in areas with high occlusal forces. Additionally, limited evidence in certain clinical scenarios necessitates further research to validate their performance in diverse patient populations.(14)

Advancements in Material Science:

Material science continues to drive innovations in dental implantology. Researchers are exploring new ceramic compositions and manufacturing techniques to improve the mechanical properties, biocompatibility, and long-term performance of zirconia-based implant systems.

Novel Implant Designs:

Innovative implant designs aim to optimize the performance of zirconia dental implants. Hybrid implants, which combine zirconia and titanium components, offer the potential for improved mechanical strength and reduced fracture risks.(15) Monobloc implants, made entirely of zirconia, present an alternative design that distributes occlusal forces more evenly.

Plaque Affinity and Peri-Implantitis Concerns:

Research has examined the possible effects of zirconia implants' plaque affinity on peri-implantitis. In comparison to titanium implants, zirconia implants have been shown to have lower plaque affinity and lower bacterial adherence, both of which have been linked to enhanced peri-implant health. In order to prevent peri-implant illnesses and ensure long-term implant success, these traits are particularly crucial.

Ongoing Research to Improve Mechanical Properties:

While maintaining their biocompatibility and aesthetic benefits, scientists are continuously attempting to enhance the mechanical characteristics of zirconia ceramics. Hot isostatic pressing (HIP) and yttria-stabilized zirconia (YSZ) nanocomposites are two cutting-edge manufacturing processes that aim to increase zirconia's strength and toughness. The reduction of fracture risk and improvement of overall zirconia dental implant success are both anticipated benefits of these developments.

Effect on Osseointegration:

The success of dental implants hinges on their ability to osseointegrate, forming a strong bond with the surrounding bone. Research has demonstrated successful osseointegration with zirconia dental implants, resulting in stable and long-lasting implant restorations.(16) Zirconia's ability to promote osseointegration makes it a promising material for dental implant systems.

Comparing Osseointegration Results:

Comparative studies have explored the osseointegration outcomes between titanium and zirconia dental implants. While titanium implants have a well-established history of successful osseointegration, zirconia implants have shown comparable results in certain clinical scenarios.(17) However, it is essential to acknowledge that more long-term clinical evidence is required to fully establish zirconia's osseointegration capabilities in diverse patient populations.

Surface Modifications for Enhanced Osseointegration:

Surface modifications play a crucial role in promoting osseointegration and peri-implant health. Researchers are exploring advanced surface treatments and nanocoatings that can accelerate bone cell attachment and enhance the stability of zirconia dental implants.(18) The comparison of titanium and zirconia dental implants reveals distinct advantages and limitations for each material. Zirconia's mechanical and chemical properties, as well as its tooth-colored appearance, make it an attractive alternative to titanium implants. The material's biocompatibility and successful osseointegration potential have been demonstrated in various studies.(19,20) Despite these advantages, challenges associated with zirconia's brittleness and fracture risks require further research and ongoing efforts to improve its mechanical properties. Patient-specific factors, such as bone quality, oral health status, and aesthetic preferences, should guide the choice between titanium and zirconia dental implants. Personalized treatment planning is essential to optimize the outcomes for each patient. Emerging trends in ceramic dental implantology,

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(3), 1078-1082 | ISSN:2251-6727

including advancements in material science, novel implant designs, and surface modifications, hold promise for shaping the future of dental implantology.(19) As research progresses and innovations continue to emerge, dental professionals can anticipate more tailored and effective solutions to meet the diverse needs of patients seeking dental implant treatments.

Ceramic dental implant systems have emerged as promising alternatives to traditional titanium implants, offering numerous advantages, including excellent biocompatibility, reduced metal-related complications, and improved aesthetics. A thorough analysis of the literature over the previous 15 years has yielded important new information on the composition, surface changes, osseointegration, and clinical effectiveness of ceramic dental implants.

Despite the favorable results seen in numerous studies, it's crucial to recognize that ceramic dental implants have certain drawbacks as well, such as increased material prices and the risk for breakage under extreme mechanical stresses. Even better ceramic dental implant systems are probably on the horizon as a consequence of ongoing improvements in material science and production methods, which are addressing these issues now. It is critical for doctors and academics to work together to carry out well-designed, lengthy clinical trials to further evaluate the efficacy and safety of ceramic dental implants as they continue to gain popularity. Additionally, efforts should be made to create standardized protocols for surface alterations and implant insertion methods in order to guarantee consistency in outcomes and promote evidence-based decision-making.

Conclusion

In conclusion, the thorough analysis here shows that ceramic dental implants have a lot of potential as a trustworthy replacement for conventional titanium implants, especially in situations where aesthetics and biocompatibility are crucial considerations. Dental practitioners may make educated judgments when selecting ceramic dental implant systems for their patients by utilizing the knowledge from this research, which will enhance oral health and patient satisfaction. Ceramic dental implants are anticipated to play an ever-more-important part in contemporary implant dentistry as technology and research advance.

References

1. Venugopalan S. Retrospective Analysis of Immediate Implants: A Prism with a Different Dimension. J Long Term Eff Med Implants. 2021;31(2):51–4.
2. Krishnan RP, Ramani P, Gheena S, Ramasubramanian A, Karunagaran M, Hannah R. Microscopic appearances of commonly implanted food particles. J Oral Maxillofac Pathol. 2022 Oct 17;26(3):352–5.
3. Kachhara S, Nallaswamy D, Ganapathy DM, Sivaswamy V, Rajaraman V. Assessment of intraoral scanning technology for multiple implant impressions - A systematic review and meta-analysis. J Indian Prosthodont Soc. 2020 Apr 7;20(2):141–52.
4. Huang SE. Effect of Ha-coating and HF Etching on Experimental Zirconia Implant Evaluation Using in Vivo Rabbit Model. 2010. 126 p.
5. Kiechle S, Liebermann A, Mast G, Heitzer M, Möhlhenrich SC, Hölzle F, et al. Evaluation of one-piece zirconia dental implants: An 8-year follow-up study. Clin Oral Investig. 2023 Jul;27(7):3415–21.
6. Sales PH da H, Barros AWP, Oliveira-Neto OB de, de Lima FJC, Carvalho A de AT, Leão JC. Do zirconia dental implants present better clinical results than titanium dental implants? A systematic review and meta-analysis. J Stomatol Oral Maxillofac Surg. 2023 Feb;124(1S):101324.
7. Wang L, Yu H, Hao Z, Tang W, Dou R. Investigating the effect of solid loading on microstructure, mechanical properties, and translucency of highly translucent zirconia ceramics prepared via stereolithography-based additive manufacturing. J Mech Behav Biomed Mater. 2023 Aug;144:105952.
8. Bidra A, Parel S. Journal of Prosthodontics on Dental Implants. John Wiley & Sons; 2015. 294 p.
9. Ramya G, Pandurangan K, Ganapathy D. Correlation between anterior crowding and bruxism-related parafunctional habits. Drug Invention Today. 2019 Oct 15;12(10).
10. Moritz J. Modifying the Surface Topography of Zirconia Ceramics for Improved Biocompatibility: Diploma Thesis. 2017. 130 p.
11. Merchant A, Ganapathy DM, Maiti S. Effectiveness of local and topical anesthesia during

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(3), 1078-1082 | ISSN:2251-6727

gingival retraction: Anesthesia during cord packing. Brazilian Dental Science [Internet]. 2022; Available from: https://bds.ict.unesp.br/index.php/cob/article/download/2591/4477

12. Yoshinari M. Future prospects of zirconia for oral implants -A review. Dent Mater J. 2020 Jan 31;39(1):37–45.
13. Fernandes PRE, Otero AIP, Fernandes JCH, Nassani LM, Castilho RM, de Oliveira Fernandes GV. Clinical Performance Comparing Titanium and Titanium-Zirconium or Zirconia Dental Implants: A Systematic Review of Randomized Controlled Trials. Dent J [Internet]. 2022 May 12;10(5). Available from: http://dx.doi.org/10.3390/dj10050083
14. Zhang W, Fu W, Wang X, Ye J. Improving the osseointegration and soft tissue sealing of zirconia ceramics by the incorporation of akermanite sol infiltration for dental implants. J Mater Chem B Mater Biol Med. 2023 May 17;11(19):4237–59.
15. Mödinger Y, Anttila ED, Baker GM, Gross DC, Porporati AA. Magnetic Resonance Safety Evaluation of a Novel Alumina Matrix Composite Ceramic Knee and Image Artifact Comparison to a Metal Knee Implant of Analogous Design. Arthroplast Today. 2023 Aug;22:101170.
16. Zarb GA. Osseointegration: On Continuing Synergies in Surgery, Prosthodontics, Biomaterials. Quintessence Publishing (IL); 2008.
17. Al Deeb M, Aldosari AA, Anil S. Osseointegration of Tantalum Trabecular Metal in Titanium Dental Implants: Histological and Micro-CT Study. J Funct Biomater [Internet]. 2023 Jul 6;14(7). Available from: http://dx.doi.org/10.3390/jfb14070355
18. Stanciuc AM. In Vitro Evaluation of Cell-material Interactions on Bioinert Ceramics with Novel Surface Modifications for Enhanced Osseointegration. 2017. 202 p.
19. Wang Z. Surface Modification of Bio-implantable Ti-6Al-4V Alloy for Enhanced Osseointegration and Antibacterial Capability. 2014.
20. Omoniala K. Surface Modification Strategies for Antimicrobial Titanium Implant Materials with Enhanced Osseointegration. 2016.