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# **Root-Analogue One-Piece Zirconia Implants: An Overview**

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# ABSTRACT

Zirconia has emerged as a promising alternative to titanium in dental implantology due to its exceptional mechanical, mechanical and biological properties. This review discusses zirconia dental implants, focusing on their influence on osseointegration, one-piece designs, immediate placement after tooth extraction, and root-analogue implant designs. Studies proved that zirconia implants achieve osseointegration that is comparable to titanium implants however, they have the advantage of reduced biofilm formation and favorable early healing. One-piece zirconia implants eliminate the fixture-abutment interface, reducing peri-implant complications. Immediate placement of zirconia implants has shown success rates similar to delayed protocols. Root-analogue zirconia implants enhance stress distribution and esthetics but require further investigations. Although zirconia implants show acceptable outcomes, concerns regarding long-term predictability, crestal bone loss, and the need for additional clinical trials remain. This review underscores the advancements and limitations of zirconia implants, highlighting the necessity for continued research to optimize their clinical performance and long-term success.

*Keywords:* Zirconia implants, root-analogue implants, root-form implants, one-piece implants, osseointegration, biocompatibility, dental implantology, titanium implants, immediate implant placement.

# 1. Introduction

Zirconia, a material recognized for its exceptional physical, chemical, and mechanical properties, has gained significant attention in biomedical fields, particularly in dental implantology. Notable characteristics of zirconia include its great strength, hardness, wear resistance, corrosion resistance, and modulus of elasticity comparable to steel. These properties have positioned zirconia as a favorable alternative to titanium in dental implants. The first reference to zirconia in medicine dates back to 1969, and its use has since evolved from orthopedic applications to dental prosthetics, especially in the 1990s. This review explores the application of zirconia in dental implantology, focusing on one-piece zirconia implant design, osseointegration, and the impact of surface modifications.

# 2. Osseointegration of Zirconia Implants

Zirconia implants exhibit osseointegration comparable to titanium implants, a vital factor for their clinical success. According to various studies, zirconia surfaces show a reduction in biofilm formation compared to titanium, which may make zirconia less prone to peri-implantitis which is a common complication of dental implants. A study by (Nothdurft et al 2015) demonstrated that zirconia promotes higher fibroblast cell proliferation that enhanced the early healing phase after implantation.

Histological studies on osseointegration, such as those by (Depprich et al 2008) and (Rothamel et al 2007), confirmed that zirconia implants integrate effectively with bone tissue. In both studies, zirconia implants displayed good bone formation, albeit slightly less efficient than titanium in the initial stages of healing. Over time, however, both titanium and zirconia implants achieved similar osseointegration results, with woven and lamellar bone formation.

Meta-analyses further affirm these findings. (Lorusso et al 2020) reported a 98.3% one-year survival rate and 97.2% two-year survival rate for zirconia implants, indicating their reliability. (Silva Remísio MJ et al 2023) also observed

no significant difference in bone-to-implant contact between zirconia and titanium implants, suggesting that zirconia can match titanium in terms of osseointegration.

#### **3. One-Piece Zirconia Implants**

The one-piece implant design combines the surgical implant and prosthetic abutment into a single unit, eliminating the fixture-abutment interface. This design eliminates complications such as screw loosening and micro-gap formation which improves peri-implant tissue health. The one-piece zirconia implant offers several advantages, including reduced risk of plaque accumulation and easier control over crown margins and gingival contours.

Clinical studies have investigated the performance of one-piece zirconia implants in various regions. For instance, (Finne et al 2007) and (Oliva et al 2007) reported high success rates and excellent soft tissue health following the placement of one-piece zirconia implants. (Borgonovo et al 2013) observed a survival rate of 100% for zirconia implants in their study, with only slight marginal bone loss after four years. Moreover, (Siddiqi et al 2016) found that one-piece zirconia implants displayed good osseointegration in animal models, suggesting their potential for clinical use.

However, despite these promising outcomes, there are concerns regarding the long-term predictability of one-piece zirconia implants. (ArRejaie et al 2019) found that while the survival rates of zirconia implants were comparable to titanium implants, they reported greater crestal bone loss. Further clinical trials are required to determine the long-term performance of these implants.

#### 4. Immediate Implant Placement with Zirconia

Immediate implant placement, introduced in 1976, has become an accepted protocol in dental implantology due to its reduced treatment time and increased patient satisfaction. This approach involves placing an implant immediately after tooth extraction, promoting bone preservation and faster healing. Several studies, such as (Glauser and Schupbach 2022) and (Kiechle et al 2023), demonstrated that zirconia implants placed immediately post-extraction exhibit favorable bone integration and esthetic outcomes, with no significant difference compared to titanium implants.

(Aydin et al 2019) further highlighted the potential of one-piece zirconia implants in the anterior region, reporting high survival rates and favorable esthetic outcomes. Additionally, the study by (Alkhouri et al 2023) showed no significant difference in crestal bone loss between immediate and delayed placement of zirconia implants, suggesting that both options are viable alternatives to titanium implants.

# 5. Root-Analogue Zirconia Implants

Root-analogue implants (RAIs), designed to replicate the natural root structure, offer a more physiologically aligned approach to tooth replacement. Studies on zirconia root-analogue implants have shown promising results in terms of stress distribution in the surrounding cortical bone. (Dantas et al 2020) found that root-analogue implants exhibited better stress distribution than conventional implants, which could reduce the risk of bone damage.

Clinical trials by (Böse et al 2020) further demonstrated the clinical feasibility of zirconia RAIs, with the latter study exploring the effects of customized 3D-printed and milled zirconia RAIs. However, while the biomechanical properties of zirconia RAIs are favorable, their performance can vary depending on anatomical design, as noted by (Aldesoki et al 2024).

Despite the promising potential of zirconia RAIs, research remains limited, and studies on their biological and esthetic outcomes are sparse. (Passanha et al 2018) called for further investigations into the influence of different surface treatments and designs on the long-term success of zirconia RAIs. (Padhye et al 2023) reported lower success rates for immediate RAIs zirconia implants, highlighting the need for further studies to confirm their reliability.

#### Conclusion

Zirconia implants, particularly root-analogue and one-piece designs, present a viable alternative to titanium implants in dental prosthetics. The osseointegration of zirconia implants is comparable to titanium, with benefits such as reduced biofilm formation and favorable fibroblast cell response. One-piece zirconia implants offer advantages in terms of reduced complications and better soft tissue health. Immediate placement of zirconia implants also shows promise, with high survival rates and favorable bone integration outcomes.

However, further research is needed to fully assess the long-term performance of zirconia implants, especially rootanalogue zirconia implants, and to determine the optimal surface treatments and design modifications for enhanced clinical success. Despite some challenges, zirconia implants represent an exciting advancement in dental implantology, offering a promising solution for patients seeking aesthetic and functional restorations.

#### Disclosure

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