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# Mechanism of Osseous Healing in Zirconia Dental Implants - a Short Review

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**Abstract:** Dental implants have secured a place as an upcoming and genuine treatment modality. The mechanism behind the successful placement of implants is osseointegration. While Titanium and titanium alloys are one of the most commonly used materials for dental implants, recent studies have identified the useful use of zirconia in implants. However, the information available regarding the osseous healing of these implants is yet far from sufficient and is a subject entailing further research. The aim of the present review paper is to summarize the mechanisms involved in the process of bone healing around zirconia dental implants.

**Keywords:** Implants, Zirconia, Osseointegration, Bone Healing

## 1. Introduction

Since their advent in dentistry which was nearly four decades ago, dental implants have established themselves a position as a successful and interesting treatment modality, which have revolutionized the fate of missing teeth [1]. This surgical component (dental implant) integrates with the bone of the jaw, and holds immense application in dental prosthesis such as a crown, bridge, denture, facial prosthesis or to act as an orthodontic anchor [2], [3]. The mechanism behind the successful placement of implants is osseointegration, which is the biological fixation of implants, creating a direct bone-to-implant anchorage without an intervening connective tissue layer [3].

Titanium and titanium alloys are one of the most widely used materials for dental implants, demonstrating favorable results of osseointegration and good healing following implant placement [4]. However, it is accompanied with several drawbacks that are not limited to its aesthetic parameters, owing to the greyish color that compromises aesthetics [5]. Possible accumulation of titanium ions surrounding the dental implants are another factor owing to its disadvantage [5]. Based on these requirements, available ceramic materials are being initiated and considered as a feasible substitute to titanium [6].

Recently, studies have demonstrated that zirconium oxide partially stabilized with yttrium is a promising alternative to titanium, with superior properties as a far-reaching implant material owing to its tooth-like ivory color [7]. Along with its superior biologic properties, it also demonstrates a high degree of biocompatibility and high flexure strength, thus exhibiting a minimum ion leakage in contrast to titanium [7]. Furthermore, the material composition and surface topography of the implant material are key factors for bone-implant contact, therefore various chemical and physical surface adjustments have been perceived to improve bone healing [8]- [11]. Current approaches incorporate the use of sandblasting followed by acid etching, nanotechnology, and laser technology as well as the application of the bioactive coatings (calcium phosphate, bisphosphonate, and collagen), sintering particles onto the implant surface in order to promote bone healing around the implants [12]. However, the information available regarding the osseous healing of these implants is yet far from sufficient and is a subject entailing further research.

The aim of the present review paper is to summarize the mechanisms involved in the process of bone healing around zirconia dental implants. This paper also lays an emphasis on the current potential and osteoconducive ability of zirconia implants with different surfaces.

## 2. Healing Around Zirconia Implants

It is recognized that the exterior topography, chemistry and coarseness alter the frequency and state of the fresh tissue formed at the implant surface [12]. Alterations made on the surface can improve the healing process along with osseointegration leading to superior bone-implant contact proportion [9]. Roughened exteriors have revealed supremacy in its osseous healing in comparison to their even, machined forerunners [9]- [13].

Franchi et al. [14], [15] studied peri-implant mass of zirconia covered and acid etched titanium implants They also observed peri-implanted tissues for separate exteriors at three months [14], [15]. It was noted that implant surface organization showed intense influence on frequency and modality of per-implant osteogenesis. Osseous gathering was seen to be elevated by rough surfaces seen in zirconia-based implants. Cranin et al. [16] studied the osseointegration of implants with surface coatings like zirconia or alumina, drawing conclusions that zirconia can be higher-ranked than alumina.

Similar studies [17], [18] conducted observed the bone contact values of the various zirconia sandblasted as well as titanium surfaces, as well as machined titanium surfaces. Conclusions that were drawn noted that the sand-blasted particles of zirconia have superior values of surface coarseness. The healing procedure and efficiency of Zirconia implants varies based on the alterations in the exterior topography. The implants may be available as unmodified, or can be modified with either chemical or mechanical modifications. If chemically surface modified, acid etching followed by sandblasting have shown to display effective osseointegration results.

Indistinguishable observations have been made for the osseous integration values for machined zirconia with titanium implants, leading to the resolution that zirconia is as osteoconducive as titanium, along with its supplemental benefits. Depprich et al [19] directed a study on mini pigs to observe the bone contact values of zirconia implants equated with titanium. The focus of the research was to evaluate the osseous healing of zirconia implants with titanium implants which have a coarser surface but otherwise similar implant geometries. The outcome implied that zirconia implants with altered surfaces exhibit values of bone contact indistinguishable to those of titanium implants. These outcomes are hopeful in using zirconia in future dental applications.

Accordingly, roughened zirconia surfaces are competent of attaining elevated solidity in bone than machined zirconia. Alterations via sandblasting markedly enhances the osseoinductive potential of machined zirconia [20], [21]. Including not only a pronounced osseous to implant contact value, sandblasted and acid etched zirconia implants are also perceived with appreciable torque robustness and firmness in bone. Homogenous results have been detected post the alleviation stage in the two implant surfaces [22]. It would be unassailable to indicate that sandblasting followed by acid etch is the gold standard technique for obtaining a substantial osseous contact, sealing that there is a corroboration for a finer consequence of surface-modified zirconia over titanium implants. Nonetheless, it is considered inaccurate to manifest comparative statistics without establishing surface coarseness. Even a machined zirconia exterior may differ significantly in abrasiveness as is the case for blasted, acid etched, or other modified surfaces. Consequently, variations in results are feasible for the same surface topography.

## 3. Bone Healing Around Dental Implants

Studies show evidence that zirconia particularly with a moderately rough surface is satisfactory for osteoblasts and amalgamates into bone tissue [23]- [26]. Surface adjustments generate micro-rough implant surfaces accelerating the osseointegration process of titanium implants [24]. Sandblasting followed by acid-etching presently is reckoned as the pre-eminent method for generating these micro-rough surfaces [24]. Chemically modified surfaces conclude in higher hydrophilicity, moreover enhancing the pace of osseous contact of the implant surface [17], [27]. It is a competent fact that a reasonable bone integration value is achievable post the alleviation period independent of implant material and surface treatment for zirconia implants.

Bone healing around zirconia dental implants manifests the pattern and order of intramembraneous osteogenesis with generation of woven bone initially accompanied by forming parallel-fibered and lamellar bone, manifesting earlier in trabecular bone than in compact bone [24], [28], [29] (See table 1). While the introductory initial bone may be found on the implant surface approximately a week post its formation, osseous remodeling begins between 6 and 12 weeks and extends throughout life [28]. The healing process may include primary or secondary bone healing. In the former healing phase, there is a well-organized osseous formation with minimal granulation tissue formation (See table 2) [30]. The latter may have granulation tissue formation and infection at the sight, having a prolonged healing period. This state would be undesirable as there are chances of fibrocartilage formation instead of bone. However, studies have not reported any differences in the osseointegration and bone healing around zirconia and titanium implants [29]- [31].

***Table 1.*** *Healing around zirconia dental implants.*

| | |
|---|---|
| Week 1 | Distinct gaps between implant and the bone filled with matrix rich regeneration tissue, the gaps filled with remodeling blood clot |
| Week 4-6 | Formation of Woven Bone - Being exposed to extra-cellular fluid, non-collagenous proteins and growth factors are set free and initiate repair. |
| Week 12 | Lamellar bone formation. Intimate contact of lamellar bone to implant surface. |
| 8-12 Weeks | Healing Period |

***Table 2.*** *Phases involved in the healing around zirconia dental implants.*

| | |
|---|---|
| Phase I – Injury phase INJURY PHASE | Starts immediately post implant insertion |
| Phase 2- Phase II - Granulation phase | 2-3 weeks post implantation. Formation of new local connective tissue, new capillaries and supporting cells begins. |
| Phase 3- Phase III - Callus phase | 4-6 weeks post insertion- evidence of new osseous formation. Initially rapid remodeling occurs which slows down and continues throughout life. The complete healing probably takes longer than 3-6 months. |

## 4. Conclusion

Diverse factors appear to simulate necessary roles in the osseointegration of modified zirconia implants, whilst it is unsettled which are the most paramount. Observations have revealed enhanced bone contact values with zirconia implants, and it is necessary for further investigations to be regulated in order to lay emphasis on the multifactorial outcomes and on the materials and alterations made on the implants.

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