Osseointegration in Zirconia Implants Stumbling into Evidence

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ABSTRACT

Osseointegration is a critical factor for the clinical success of any oral implants. The unique characteristics of zirconia as a material for dental implants being high toughness and strength, aesthetic factor, excellent osseointegration behaviour and biocompatibility.

Implants with rough surface favour bone anchoring, biomechanical stability, increased bone implant contact and removal torque or push in strength values compared to smooth surface implants.

Greyish discoloration of peri-implant mucosa is a challenge especially in anterior titanium implant restoration. Zirconia abutments customized for single crown showed excellent survival for 5 years. Restoring single tooth and up to 3 adjacent missing teeth with zirconia implants are compatible to titanium implants. Evidence exists on improved osseointegration on surface modification of zirconia implants with enhanced cell response. Zirconia implants with modified surface displays features of osseointegration similar to titanium implants. Results are promising for dental application in future. (Int J Biomed Sci 2022; 18 (1): 1-4)

Keywords: Zirconia implants; Osseointegration; Zirconia abutments; Surface modification

INTRODUCTION

Zirconia was first introduced to implants in the form of coatings, to improve the osseointegration in titanium implants (1). Zirconia implants were introduced to dentistry in 2006. The unique characteristics of zirconia such as high toughness, strength, fatigue resistance, corrosion resistance, aesthetics, excellent osseointegration behaviour, biocompatibility and positive tissue response. Research has been formulated to modify the zirconia surface in zirconia implants to make it desirable for better cell growth, proliferation and differentiation and improve the bone implant contact to make it comparable to titanium implants.

Osseointegration is biological fixation of implant relating to direct bone to implant contact (BIC) without an intervening connective tissue layer (2). BIC is considered as a key indicator for successful osseointegration which...
governs the overall success and survival of an implant. Major advantage of zirconia is the phase transformation inside the materials which increases the crack propagation resistance. However the meta stability character of zirconia also causes its aging in the presence of water. Researchers have approached with the addition of oxides to stabilize the crystal structure transformation during firing at elevated temperature and improve the physical properties. The disadvantage of phase transformation is that, during the transformation, there is 4% volume change, which results in formation of ceramic cracks. Oxides such as ceria, yttrium, alumina, magnesia and calcia have been used to stabilize the structure of zirconia when calcination temperature changes. Y-TZP (yttrium–stabilized tetragonal zirconia polycrystalline ceramics) and NANOZR (ceria-stabilized zirconia Nano composites) are included for wide spreadimplant application.

NANOZR is highly resistant to low-temperature degradation and suitable for load bearing application in dental implants. According to few studies, NANOZR is a good material, as it has a very good osseo integration capacity. Lasers particularly carbon dioxide lasers are commonly used to enhance the wettability and decreased surface roughness of zirconia implants (3).

SURFACE MODIFICATION TECHNIQUES TO IMPROVE THE OSSEOINTEGRATION

Polishing
Polishing is done using silicon carbide polishing paper and diamond suspension with polishing machine. Smooth surface creates a favourable circumstance for epithelial cell proliferation.

Sandblasting and acid etching
Most common procedures for implant surface modification are sandblasting and acid etching. This surface modification creates increased surface area for implant osseointegration. Zirconia implants had increased removal torque value and incorporation of fluoride at zirconia surface could enhance osteoblastic differentiation and interfacial bone formation. However proper protocol and care is needed, when treating zirconia surface with sandblasting to avoid micro cracks and reduction in strength on the surface.

Ultraviolet light treatment
UV treatment is an effective physiochemical method for surface modification of zirconia implants. UV light induces electron excitation, increases surface energy and creates a hydrophilic surface. Hydrophilicity is a key factor for attachment, proliferation and differentiation of osteoblasts. UV treatment is a promising modality to promote increased bone implant contact around zirconia implants.

Laser treatment
Many studies have reported using lasers to modify surface properties of zirconia. This treatment improves surface energy and wettability which plays a key role in cell adhesion. However lasers cause micro cracks and induces phase transformation which may impair the long term stability of zirconia dental implants.

Coating
Different coatings have been applied to improve the surface properties of zirconia implants. Many researchers have proposed hydroxyapatite coatings, as it has a similar mineral composition to bone and thus shows bioactive properties that enhance osseointegration. Calcium phosphate is also used as bioactive coating. Studies have reported both hydroxyapatite and calcium phosphate have shown poor stability and weak bond strength. To overcome this tricalcium phosphate and zirconia powder are added, which acts as drug delivery system.

DISCUSSION
Osseointegration is biological fixation of implant relating to direct bone to implant contact (BIC) without an intervening connective tissue layer. BIC is a key indicator for osseointegration which governs the overall success and survival of any implant. Surface properties of biomaterials play a key role in osseointegration of zirconia implants. Pure form of zirconia occurs in two major forms: The crystalline zirconia which is soft, white and ductile. The amorphous form which is bluish-black powder in nature. The powder form of zirconia is refined and finally treated with high temperature to yield an optically translucent form of crystalline zirconia. After purification powdered form of zirconia is filled in malleable dies and processed under high temperature and pressure to form homogenous implant of exact dimension. Zirconia is mostly used in stabilized state. The tetragonal phase is metastable. If sufficient quantities of metastable tetragonal phase are present, an applied stress concentrate can cause tetragonal phase to convert into monoclinic phase with volume expansion. This phase transformation can put the cracks into compression retarding its growth.
and enhancing fracture toughness.

Though transformation toughening improves fracture strength and toughness, it hampers the phase integrity and makes implant susceptible to aging. Mechanical degradation of zirconia due to moisture and stress. Aging affects the mechanical properties of zirconia, and it depends on stress, grain size, porosity and stabilizers added to it.

Macro designs of zirconia implants such as depth of the thread, diameter, and implant neck design are few of the important criteria that should be evaluated before selecting implant system. Any sharp or pointed thread design with a narrow diameter, notch, or any surface modification like acid etching should be avoided to prevent local stress concentration and fracture of implants. Zirconia implants with less than 3.25 mm are not recommended for clinical use.

Implants with rough surface favour bone anchoring, biomechanical stability, increased bone implant contact and removal torque or push in strength values compared to biomechanical stability, increased bone implant contact and removal torque or push in strength values compared to smooth surface implants.

Greyish discoloration of peri-implant mucosa is a challenge especially in anterior titanium implant restoration. Zirconia abutments customized for single crown showed excellent survival for 3 years. Restoring single tooth and up to 3 adjacent missing teeth with zirconia implants are compatible to titanium implants. One year survival of zirconia implants is 95%. Zirconia abutments available for zirconia implants are CAD custom abutment, abutments with titanium inserts and zirconia abutments with less than 20 to 30 degree to prevent fracture.

Fusion-sputter zirconia implants demonstrated a degree of osseointegration and interfacial biomechanical stability comparable to titanium implants (4).

Researchers have studied that in 2 piece zirconia implants the fracture toughness is lower, when compared with 1 piece zirconia implants in loaded and unloaded situations. Hence one piece zirconia implants are commonly used. Narrow line zirconia implants are not recommended, minimal diameter of zirconia implants being 3.25 mm. One piece zirconia implants with delayed loading and modified surface topography is generally recommended in the anterior region.

Ceria stabilized zirconia has shown to have better biological activity comparable to titanium and has a potential as a fixture for dental implants (5).

Studies have reviewed zirconia and titanium in dentistry and concluded that zirconia implantsshewed less adhesion of bacteria than titanium in an in vivo study. Zirconia implants with modified surface displays features of osseointegration similar to titanium implants. Results are promising for dental application in the future, with research on long term survival of zirconia implants.

CONCLUSION

Zirconia is a good candidate for dental implant for single crowns and up to 3-unit fixed partial dentures especially in anterior regions. Promising results in short term clinical studies has been shown. Evidence exists on improved osseointegration on the surface modification of zirconia implants with enhanced cell response. Zirconia implants with modified surface, displays features of osseointegration similar to titanium implants. Results are promising for dental application in future.

REFERENCES