REVIEW ARTICLE

Zirconia Abutments in Implant Dentistry: A Review

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ABSTRACT

Dental implants are one of the best options to restore oral functions conservatively and effectively. Areas with missing teeth, especially in the anterior zone are considered challenging in restoration. Tooth colored abutment is expected to give better esthetic outcomes when compared with the metallic abutments which are one of the main goals in implant dentistry especially in the esthetic zone, and Zirconia abutments are one of the new techniques in implant dentistry. Hence, this review highlights on zirconia abutments and dentistry.
Keywords: Abutments, dentistry, implant, Zirconia.

INTRODUCTION

Restoring oral functions in modern prosthetic dentistry is a primary concern now a day's especially with the recent advancement in prosthetic dentistry. For the optimal restoration of oral functions, mastication, phonetics, esthetics, psychological and social abilities must be included[1]. This is because of the high esthetic demands required in this zone in addition to the functional demand. Zirconia abutments are one of the new techniques in implant dentistry, tooth colored abutment is expected to give better esthetic outcomes when compared with the metallic abutments, which is one of the main goals in implant dentistry, especially in the esthetic zone[2].

Although metal abutment is traditionally used in both anterior and posterior areas with good survival rates and minimal complications, the increase in the need for highly esthetic restorations has derived us from seeking more esthetic options[3-6]. However, abutments made of metal have some significant problems as it may cause a grayish color reflection from the gingiva. This problem is more prominent in patients having a thin gingival thicknesswith less than two millimeters, especially if this patient has a gummy smile.To reduce this gray reflection, shoulder porcelain may be utilized. However, the removal of excess cement is difficult, which may cause gingival irritation afterwards[7-9].

History of ceramic abutments: To overcome the problems of metallic implant abutmentsin 1993, Prestipino and Ingberintroduced the firstabutment which was made of ceramicand was composed of a densely sintered aluminahaving to diameters either small or large. These abutments were relatively strong and with high resistance to shearing force. The alumina ceramic material was highly biocompatible and had lower thermal conductivity in addition to their optically favorable characters[10,11]. Unfortunately, when this material was utilized for crown construction, it was found to have much lower mechanical properties than that of the metal-ceramic restorations.[12]The problem of lowered mechanical properties of sintered aluminaled to further research for a material with higher mechanical properties. By the introduction of copy milling machines (Celay, Mikrona, Switzerland) which was another method of ceramic fabrication other than sintering, it was utilized to produce a custom made implant abutments. This was done by using alumina blocks called InCeram[13].

An important step made by Nobel Biocare company was the development of a customizable ceramic abutment called CerAdapt®. This abutment was prepared of highly pure and sintered aluminum oxide. It demonstrated significantly higher mechanical properties when compared to the previous abutments. CerAdapt was indicated for the anterior and premolar areas with a single crown, or short span fixed partial dentures. This abutment was constructed by taking an impression at the implant level then the abutment is constructed with rotary instruments like a die. Try in is then done and a screw-retained final restoration is constructed afterwards. The abutment was attached to the implant body using the gold screw. This abutment was shown to have a high success rate in the long term, follow up periods[2,11,14-16].

Glauser et al., described a new material in 2004 called yttrium stabilized Zirconia which was densely sintered, so it had a very high mechanical property when compared to alumina. Ceramic abutments were parallel in development with CAD/CAM (Computer-aided design/ Computer-aided manufacturing) technology. This was a breakthrough in abutment construction because it was an easier and faster alternative to the copy milling method. Zirconia abutments were first made using copy milling method. First, a customized acrylic resin pattern was made to the shape of the abutment. This pattern was duplicated on the copy milling machine[11,17,18]. The utilization of CAD/CAM technology in dentistry allowed for the construction of custom made abutments that can be made from either ceramics or titanium. Ceramic abutments, especially those made from Zirconia, has many esthetic, biological and mechanical advantages. From the biological prospective zirconia abutments when compared to titanium, was found to have a lower potential for bacterial adhesion.[19]Also, zirconia abutments do not have any corrosive or galvanic activity[20,21].

Abutment used in implant dentistry: Implant abutments can be classified in many ways according to specific criteria in each type. Abutments can be classified according to the method of connection to the restoration (i.e. crown) into a one-piece abutment and crown that is screw-retained, a two-piece with separate abutment and screw-retained crown or a two-piece with separate abutment and cemented crown. Another classification is according to material which may be titanium, base metal alloys, noble alloys, alumina, Zirconia and metal reinforced ceramic abutment. According to abutment connection, it may be

either internal or external connection. Color of the abutments can also vary from metallic, gold, pure or customized white and customized pink for the gingival area. Finally, abutments can be classified according to the method of manufacturing into prefabricated abutments, casted abutments, copy-milled abutments and CAD-CAM abutments[5].

Classification of ceramics: Ceramics represent one of the best choices in dental materials from the esthetic point of view. This is because of the high stability in color in addition to its biocompatibility. Also, the high hardness of this material allows it to maintain surface polish which prevents plaque retention. Ceramics, when compared with titanium, was found to cause less pro-inflammatory cytokine levels in the gingival crevicular fluid, which promote better gingival attachment[22,23]. Dental ceramics can be classified into four main categories. The first category is the glass-based systems which are composed mainly of silica (SiO_2) and have a flexural strength of 70-100 MPa. The second category is the glass-based systems with fillers which are further classified into a feldspathic glass containing low to moderate amounts of leucite, glass containing high amounts of leucite and most recently lithium-disilicate glass-ceramics. This category is mainly composed of silica with crystalline fillers in the form of leucite or lithium disilicate. The flexural strength is relatively high when compared to the glass-based systems, which is 120–300 MPa due to the crystalline fillers, which limit the crack propagation[22]. The third category is the crystalline-based systems with glass fillers which are mainly composed of alumina or Zirconia toughened alumina with a little amount of glass fillers. The increased percentage of the crystalline alumina or Zirconia toughened alumina led to a high increase in flexural strength to more than 300 MPa. However, it also led to a marked decrease in translucency[22,24]. Finally, the fourth category is the polycrystalline solids which are composed of oxide ceramics. Oxide ceramics may be either alumina (Al_2O_3) or Zirconia (ZrO_2). Alumina based type has a flexural strength of 275–700 MPa. While in the zirconia-based type the flexural strength is 800–1500 MPa[22].

Alumina and Zirconia represent the highest strength ceramics composed of polycrystalline oxides that are densely packed without any glassy components. Zirconia has a higher strength than alumina, and its fracture toughness is approximately twice as that of alumina.[25]The high mechanical properties of Zirconia make it more suitable to be utilized as an abutment in implant dentistry. The main factor behind this marked increase in the mechanical properties of Zirconia is the phase transformation of crystals. At room temperature zirconia has monoclinic crystal shape which is larger in volume than the tetragonal crystal shape by 4.5%. The tetragonal crystal shape is formed at a firing temperature which is about 1170^0C-2370^0C. The addition of yttria (Y_2O_3) to Zirconia was able to stabilize the tetragonal crystal shape at room temperature[26]. This material is called yttria-stabilized tetragonal Zirconia. The most important feature in this material is the ability to transform its crystalline structure at room temperature when subjected to stresses such as those occurring during crack propagation. Yttria-stabilized tetragonal Zirconia can transform from tetragonal crystal shape to monoclinic crystal shape when such stresses occur. This markedly enhances its ability to absorb these stresses. Absorption of stresses occurs by the increase in volume caused by the crystalline transformation of this material. This induces compressive stresses inside the material which counteract the tensile stresses involved in the crack propagation and thus increase its flexural strength[27,28].

Biomechanical aspects of zirconia abutments: During mastication, implant abutments are subjected to fatigue, especially when there is a wet environment and cyclic loading as seen in the oral cavity. This cyclic loading negatively affects ceramic materials and decreases its lifetime. Cyclic loading was found to cause very great damage in the ceramic materials. However, this type of fracture commonly occurs in veneering restoration rather than the abutment itself[29,30]. Also, fractures in the abutment itself or the fixation screw can occur in ceramic abutments. However, it is important to know that fracture in the ceramic materials is complex and multifactorial and cannot be related only to the material as patient-related factors may also affect its outcome. So it is not surprising to find these types of failures may also occur in titanium abutments[31,32]. To evaluate the biomechanical properties of ceramic abutments, it must have both biological and mechanical qualities which are equal or even higher than the corresponding abutments which are made of titanium. From the mechanical aspect, the zirconia abutment has nearly similar mechanical properties to that of titanium. Also, the biological quality of zirconia abutments was found to be more superior than titanium abutments. However, the brittleness of ceramics in general and the susceptibility to crack propagation is a major drawback with these abutments[31,32].

Biological properties of zirconia abutments: Acceptable biological properties for any material can be manifested in the absence of any allergic or inflammatory reaction when it becomes in contact with both soft and hard tissues.[34] Although titanium is very popular as a material for abutment and implant construction, some allergic reaction was reported with a prevalence of 0.6%. Despite titanium, allergy is relatively uncommon, but it is still a concern for some patients and hypersensitivity was found to be an important etiologic factor in the failure of dental implants.[35-37] Zirconia has good biological properties with a long history of its use inside the human body without causing any adverse reactions.In dental implants usually, a part of the abutment becomes in contact with both soft and hard tissues. So it is essential to put a material with high biocompatibility adjacent to these structures to promote both osseointegration and proper soft-tissue attachment[38,39].

A study by Do Nascimento et al., was performed to assess the amount of microorganisms in oral biofilm on the surface of titanium and zirconia abutments. The study showed a significantly lower number of pathogenic microorganisms on the surface of zirconia abutments when compared with titanium abutments.[40]Another study by Pandoleon et al., investigated the biological effects of yttria-stabilized zirconia abutments, lithium disilicate abutments and titanium alloy abutments on proliferation, viability and attachment properties of gingival fibroblasts. The results

showed no significant differences between yttria-stabilized zirconia abutments and other types of abutments, and all the abutments showed a favorable response of gingival fibroblasts[41]. Also biocompatibility of zirconia abutment was investigated in comparison with abutments made of gold alloy and abutments made of titanium. Results of this study showed nearly similar biocompatibility of zirconia and titanium abutment. On the other hand, gold alloy abutments showed improper integration of soft tissue[42]. A systematic review by Linkevicius and Vaitelis was conducted to evaluate the effect of zirconia abutments in comparison with titanium abutments on the soft tissues around the implants. It was concluded that except for the superior esthetic results of Zirconia abutments on the soft tissues around the implants, zirconia abutments did not show any significant difference over the titanium abutments[43].

A recent study by De Freitas et al., compared amount and types of bacteria around zirconia and titanium abutments with that of natural teeth. The results of the study failed to find any significant differences in bacterial colonization between the three groups. So it was concluded that both zirconia and titanium abutments are colonized by a bacteria that are closely related to the bacteria of the neighboring remaining teeth[44]. On the other hand, Welander et al., reported a lower amount of bacterial plaque around zirconia abutments when compared with titanium abutments. Also, several leukocytes at the epithelial surface around the zirconia abutments were significantly lower than titanium. This suggested a higher survival rate for the zirconia abutments as the amount of bacterial plaque is one of the major caused for the failure of dental implants[42]. Another study that also found the favorable biological response of zirconia abutments was made by Ismail et al., which compared titanium, gold alloy, and zirconia abutments. The study concluded that although all of the three materials showed high biocompatibility in terms of the amount of biofilm formation, zirconia abutments showed the most favourable biologic and aesthetic response[45]. Kajiwara et al., also attempted to compare both zirconia abutments and metal abutments with natural teeth regarding the amount of blood flow in the soft tissue around them. The results of the study revealed significantly higher blood flow around the zirconia abutments when compared to the metal abutments. It also showed that the amount of blood flow around the zirconia abutments was nearly similar to that of natural teeth. This may suggest better maintenance of immune functions due to the improved blood circulation around the zirconia abutments.[38]

Mechanical properties of zirconia abutments: Zirconia abutments, when compared to alumina abutments, has higher strength and fracture resistance. One of the main problems of alumina abutments was their susceptibility to fracture during insertion. However, this problem was never reported to occur with zirconia abutments. The long term clinical stability of zirconia abutments were reported to be nearly similar to titanium abutments. This encouraged many CAD/CAM systems to incorporate zirconia abutments for all types of implant systems.[46]A systematic review by Gou et al., found that Zirconia abutments with internal connection and metal component (two-piece) showed much lower fracture rates than the zirconia abutments with an external connection. Also, it was advocated that proper preparation and load distribution on these abutments should be done to avoid fracture. It was also found that over preparation and overloading was found to be the main cause of fracture in zirconia abutments[47]. Although it was found that abutments made of titanium werestronger than zirconia abutments, the design of the abutments was also an important determining factor for the abutment strength. Abutments with conical and internal connections were found to be stronger than hexagonalexternal connection abutments[48,49,50].

Zirconia abutments showed more wearability to the internal part of the titanium implant body combined with deformation of the implant neck when compared with abutments made of titanium. This may lead to damage of the internal part of the implant connection that could cause prosthetic failures following several years of abutment insertion. Studies also demonstrated an increase in wear of the internal part of implant connectionwith zirconia abutments with the increase of loading cycles. However, this effect was shown to be self-limiting[51-53]. However, most of these studies were done in vitro, so they may not represent the actual clinical situation in the oral cavity. Gehrke et al., found that different designs of customized zirconia abutments with CAD/CAM when they are geometrically identical will not show any difference in mechanical strength. On the other hand, two-piece hybrid CAD/CAM abutments which are made of Zirconia showed higher fatigue values and fracture resistance than that of the onepieceCAD/CAMzirconiaabutments. So it was concluded that two-piece hybrid zirconia abutments might be recommended in areas of high stresses such as premolar and molar areas[54].

A study by Shabanpour et al., investigated the effect of abutment diameter on the fracture resistance of both zirconia and titanium abutments which are either prefabricated or copy milled. The study found that abutment body fractures were more common in zirconia abutments than titanium abutments. Also, prefabricated abutments showed higher fracture resistance than that of the copy milled type. It was concluded that narrow diameter of the abutment impose a high risk of fracture in the body of the abutment when it is made of Zirconia, so small diameter implants with small abutments should be preferably made of titanium[55]. On the other hand, a study by Albosefi et al., that measured a load of fracture in Zirconia custom made abutments with a thickness of 0.7 mm versus an abutment thickness of 1 mm. Angulation was also assessed of these abutments by comparing the zero angulation abutments with a 15 degree angled abutments. The results showed that the thickness of the custom zirconia abutments did not have any significant effect on the strength of the abutments. In contrast, the angled abutments had lower fracture load than that of the straight abutments[56]. Another study that emphasizes the effect of angulation between the abutment and implant body investigated the fracture resistance in zirconia abutments with different implant angulations. The abutments were made constant in their position, and the implant apices were positioned at angles zero, 20 degrees to the facial and 20 degrees to the lingual. The results showed that when the implant body is position 20 degree to

the lingual, this will give the highest fracture resistance. Zero degrees also showed high fracture resistance and the lowest fracture resistance was seen when the implant body is position 20 degree to the facial[57].

Esthetic properties of zirconia abutments: It was found that utilization of abutments made of Zirconia can significantly enhance the matching of color of the restoration to that of natural teeth. It also prevents the appearance of the gray color in the peri-implant mucosa, which may enhance the esthetic outcome of the restoration, especially in the anterior zone[58]. Jemt described the esthetic criteria of peri-implant soft tissue and developed a simple scoring method that included the papilla index scores, whether or not there is soft tissue discoloration and if there is any margins of titanium are visible[59]. A recent approach to further enhance the esthetics in the soft tissue area is dyed fluorescent Zirconia. It was shown that white rather than opaque zirconia abutments with a fluorescent dye could have an optical property more similar to that of the natural teeth with excellent tissue tolerance and adequate gingival health. The beneficial effect in this method lies in the high translucency of the material that increases its brightness[60]. On the other hand, a study by Thoma et al., investigated the esthetic properties of the fluorescent hybrid zirconia abutment and compared it to the opaque zirconia abutments using spectrophotometric analysis. The results of the study found that in normal gingival thickness which is more than 2 mm the fluorescent hybrid zirconia abutment did not show any significant difference in terms of esthetics than that of opaque conventional zirconia abutments. However, in cases with gingival thickness, less than 2 mm the fluorescent hybrid zirconia abutment showed significantly lower esthetic outcome when compared to the conventional zirconia abutments. This was attributed to the fact that white fluorescent Zirconia can induce too much brightness which can be reflected on the soft tissues causing deterioration of the esthetic outcome[61].

CONCLUSION

Zirconia abutments in implant dentistry seem to demonstrate an excellent short-term technical and with very biological results. However, to evaluate the long-term success, further studies are necessary.

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