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REVIEW ARTICLE

Zirconia Abutments in Implant Dentistry

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ABSTRACT

Esthetic parameters have become integral aspects in defining success and failure of an implant. All-ceramic abutments have started to play a major role in achieving an esthetically successful result. The material itself, however, is not the exclusive determinant for esthetic success. It is the appropriate design and proper handling of the material and the abutment that enables the clinician to achieve esthetic outcomes that were not possible with traditional metal alloys. The focus of this systematic review was to assess the published data on the zirconia dental implant abutment.

Keywords: Zirconia, Esthetic abutment, Custom abutment.

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INTRODUCTION

Fixed implant-borne single crowns and fixed dental prostheses (FDPs) have become an accepted treatment option for the rehabilitation of partially dentate patients. Published data have demonstrated high success rates for implants placed in partially edentulous arches for the replacement of both single teeth[1] and multiple teeth.[2] However, the use of implants to replace missing teeth in the esthetic zone is challenging. The restorations are subjected, especially in patients with a gummy smile or a high lip line, to direct visual comparison with the adjacent natural teeth. Perfect three-dimensional implant positioning and well-designed superstructures are therefore essential to mimic the appearance of a natural tooth and to achieve an optimal esthetic outcome.[3]

Dental implants and abutments are usually fabricated out of commercially pure titanium, primarily because of its well-documented biocompatibility and mechanical properties. However, despite numerous modifications to the fabrication and design of metal abutments, there is still the disadvantage of metallic components showing through when such abutments are used.[4] The resultant dull greyish background may give the soft tissue unnatural bluish appearance. The presence of a gray gingival discoloration may be attributed to a thin gingival biotype that is incapable of blocking reflective light from the metallic abutment surface.[5] Thus, recent years have shown a consistent trend toward esthetic improvements in implant restorative materials and in treatment outcome. To achieve optimal mucogingival esthetics; ceramic abutments were developed.

Demands for highly esthetic restorations have been raised by increasing number of patients which has led to introduction of tooth colored ceramic implant abutments produced in densely sintered alumina. Compared to metal abutments, these new abutments offered optically favorable characteristics, low corrosion potential, high biocompatibility and low thermal conductivity.[6] On the other hand, restorations made out of such ceramic cores were weaker when compared to metal-ceramic restoration.[7] Unfortunately referred clinical studies have additionally referred to fracture risk to alumina abutments during laboratory work and after abutment connection.[8-10]

Such controversies led to further investigations into new designs and materials for ceramic abutments. Due to these mechanical shortcomings in their mechanical properties yttrium oxide stabilized zirconia was introduced as an alternative material for implant abutments and it has overtaken alumina as a preferred ceramic abutment material.[4]

Why Zirconia?

The unique stress-induced transformation toughening mechanism in zirconia vastly improves its mechanical strength and reliability which has led to the increased use of zirconia as a ceramic biomaterial in both medicine and dentistry. In dentistry, zirconia has been considered for clinical applications, such as frameworks for all-ceramic crowns and fixed partial denture,[12] brackets for orthodontic treatment and as an implant and implant abutments.

The increased use of zirconia as an abutment material calls for a systematic reevaluation of available data on zirconia.

The mechanical properties of zirconia abutments: There were 11 studies included in this category.[12-22] Of these 10 studies, 4 studies[13-15] evaluated the strength of the zirconia abutment after thermomechanical fatigue or after cyclic loading whereas the remaining 6 studies[12,17-22] evaluated strength using static load only. In the experiment without cyclic loading of zirconia abutments Yildrim et al[12] reported a mean fracture load of the zirconia abutments of 737 N. This finding has also been confirmed by other researchers.[19,20] The fracture strength against cyclic loading or thermomechanical fatigue was, however, reduced

significantly.[13-16] Gehrke et al[16] reported decreased strength of zirconia from 672 N without cyclic loading to less than 405 N after cyclic loading using loads between 100 and 450 N for up to 5,000,000 loading cycles. Thermo mechanical fatigue studies[13-15] on zirconia at loads of less than 50 N for 1,200,000 loading cycles showed decreased strength (between 457 and 281 N) compared to the results of Yildrim et al. Three studies compared the strength of zirconia abutments with alumina abutments. Two of them showed that zirconia abutments had significantly higher strength than alumina abutments, whereas one failed to show any significant difference between them. Although it is not possible to compare fracture strength values between various studies because of differences in study design, the reviewed articles demonstrated that zirconia abutments could be used in the anterior region of the dentition safely, where as the physiologic maximal occlusal forces reach approximately 300 N.[23,24]

A histologic evaluation of peri-implant soft tissue responses around zirconia abutments from in vivo studies:[25-28] These studies indicated that zirconia was a suitable abutment material compared to titanium concerning tissue responses. Furthermore, peri-implant soft tissues around zirconia exhibit the potential to heal faster than when in contact with titanium.

Kohal et al[25] evaluated and compared the conditions of soft and hard tissues in contact with zirconia and titanium implants in monkeys. The authors concluded that bone and soft tissues appeared to integrate with zirconia as well as titanium. The soft tissue barrier formed around titanium and zirconia abutments displayed equal and stable conditions following 2 and 5 months of healing. On the other hand, gold-platinum abutment sites demonstrated an apical shift of the barrier epithelium and the level of marginal bone over the same time period.

Degidi et al[26] conducted a human histologic study to compare peri-implant soft tissues in contact with titanium and zirconium oxide healing caps. The inflammatory infiltrate was observed more frequently in the peri-implant soft tissues around titanium healing caps compared to the zirconia healing caps.

Plaque accumulation or bacterial adhesion onto zirconia from both in vitro and in vivo studies[29-35]: Generally, lower plaque formation was recorded on zirconia specimens compared to other evaluated materials. Nakazato et al[29] hypothesized that the implant surface properties might play important roles in bacterial adherence during the early stages of plaque formation after being affected to a greater extent by the material's surface roughness than by its surface free energy.

Rimondini et al[31] however, were able to evaluate the role of bacterial adhesion on zirconia and titanium specimens with both *in vivo* and *in vitro*. *S. mutans* typically exhibited significantly increased attachment to zirconia specimens compared to titanium specimens after an incubation period of 36 hours *in vitro*. *In vivo*, however zirconia specimens accumulated significantly fewer bacteria than titanium specimens after 24 hours. The long-term effect of plaque accumulation on zirconia and titanium abutments was investigated by Bollen et al.[30] Clinical and microbiological examination after 12 months failed to reveal any major differences qualitatively or quantitatively between supra- and subgingival plaque from the abutment material surfaces. Conclusions from these findings suggest that zirconia might reduce early bacterial adhesion (<24 hours) compared to titanium. However, it is still unclear whether this characteristic of zirconia is of any clinical benefit.

The survival of zirconia abutments from clinical studies:[36-38] Only three papers in the fourth group were found in this group. Two of them were prospective clinical trials and the remaining was a randomized controlled trial (RCT). The results of the two prospective studies showed good clinical performance in the anterior and premolar regions for zirconia abutments without fracture and peri-implant lesion during the observation periods (40 and 48 months respectively). In addition, the RCT showed that zirconia abutments could also function well in the molar region without technical problems, such as abutment fracture, screw loosening and loss of crown retention.

Glauser et al[36] evaluated both peri-implant hard and soft tissue reactions to experimental zirconia abutments following the patients 1, 12 and 48 months postinsertion. Clinical evaluations including assessment of the condition of the peri-implant mucosa were performed.

In the RCT[38] 22 patients (14 women, 8 men; mean age: 41.3 years) who were in need of implant-supported single crowns (n = 40) in the canine, premolar and molar regions were included. At abutment connection, 20 customized all-zirconia abutment or 20 customized titanium abutments were assigned randomly. During the follow-up period, no technical problems were observed despite the fact that 27% of zirconia abutments supported crowns in the molar region. Hence, the abutment survival rate was 100%.

CONCLUSION

On the basis of the available data, the following conclusions can be drawn as follows:

- Evidence from clinical studies suggest that mechanical properties of zirconia abutments are suitable for them to be used in anterior area. No sufficient evidence of use of zirconia as a posterior implant abutment.

- From the animal and human histologic studies reviewed, it can be concluded that zirconia is a suitable implant abutment material which has been confirmed in the clinical studies confirming healthy peri-implant tissue.
- Zirconia appears to have a lower tendency for surface-bound bacterial plaque at an early stage. More studies are required for long-term effect on plaque accumulation tendency of zirconia abutments.
- The more number of clinical studies on zirconia are warranted to come to a conclusive evidence for its definitive application as an abutment material however, initial results are definitely encouraged.

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