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Zirconia Ceramics Mechanical and Esthetic Outcome in Anterior Region- A Systemic Review and Meta Anaylsis

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Abstract

Introduction: For the replacement of the lost tooth in the anterior region the implants are most commonly preferred. The Titanium implant is the most common with the variety of abutments. Recently the zirconia has been preferred for its esthetics. But still the mechanical outcome is unclear. With the advent of Computer-aided design and computer-aided manufacturing (CAD-CAM) custom zirconia abutments with titanium connections are readily available. Hence in this study we intend to conduct a systematic review for the esthetic and the mechanical properties in the zirconia abutments in particular to the anterior region.

Material and methods: We conducted the search for the data from the online sources like the "EMBASE", "Pubmed", "Scopus" and other sources. Terms searched were zirconium, single tooth abutments and implant zirconium. The follow-up for one year was the minimum that was considered. The data extraction and meta-analysis were based on the PRISMA guidelines. For the assessment of the risk factors and the variables the statistical analysis was done keeping $p<0.05$ as significant.

Results: Twenty studies were finalized from the 200 studies considered for the review. Twelve defined mechanical properties, and fifteen defined esthetics. Abutment fractures was seen in 5 studies. No variation was noted in the prefabricated and custom abutments or internal and external implant connection concerning fractures or/ screw loosening. Good to excellent esthetic

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integration in terms of restorations and soft-tissue color and the presence and height of papillae was reported.

Conclusions: The main advantage of the zirconia abutment is the Esthetics. There are notable concerns about the mechanical properties. There is paucity of the literature regarding zirconia abutments with titanium inserts. The predictions for these designs however look encouraging.

Keywords: Zirconia ceramics, Mechanicals Properties, Esthetics, Meta Analysis.

Introduction

Supplanting a missing maxillary anterior tooth with an implant-supported crown is a test since progress depends on various mechanical and esthetic contemplations. Esthetics has been considered as significant as the nature of osseointegration and implant survival.[1] In an esthetic assessment, the color, shape, and surface nature of the restoration and of the peri-implant soft tissues are totally thought of. Titanium (Ti) has been viewed as the standard abutment material, yet esthetic abutments were introduced to address the concerns about the grayish part of peri-implant mucosa. Among them, zirconia (Zir) has been more popular than different ceramics, like alumina, due to its better mechanical properties.[2] Today, numerous zirconia abutments are financially accessible for all implant varieties. These abutments were created to have the cemented crowns, however screw retained crowns can likewise be used. [3,4] Bidra and Rungruanganunt[5] analyzed the survival, mechanical, esthetic results of implant abutments utilized in the anterior area. They inferred that Zir abutments were suggested from the esthetic perspective, particularly for patients with low mucosal tissues, due to more readily shade matching. A new survey of their esthetic results affirmed their improved gingival tone and proclaimed that Zir had comparative soft tissue recession, probing depths, bleeding on probing, marginal bone level, and patient-reported outcomes as Ti.[6] However, Zir abutments had more mechanical problems than Ti abutments.[5] The absence of mechanical strength is in this manner the vital restriction for the more extensive selection of Zir abutments. The limitation of abutment angulation and the negligible Zir thickness are presently better known.[7,8] Additionally, the utilization of custom and zirconia abutments with titanium inserts has extended. These abutments are made out of a pre-assembled Ti prosthetic part supporting a custom Zir abutment. After fabrication and refinement, the abutment is adhesively cemented to the titanium base, and the subsequent restoration is screw-held on the implant.[9,10] The titanium base has been reported to reinforce the abutment in vitro.[3,11-14] Clinical investigations on the esthetic results of these studies are inadequate. Hence in this study we intend to conduct a systematic review for the esthetic and the mechanical properties in the zirconia abutments in particular to the anterior region.

Materials and methods

We conducted the search for the data from the online sources like the “EMBASE”, “Pubmed”, “Scopus” and other sources. Terms searched were zirconium, single tooth abutments and implant zirconium. The follow-up for one year was the minimum that was considered. The primary outcome variables were mechanical(Abutment fracture, screw loosening, and abutment chipping) and esthetic (patient’s satisfactions). The articles only in English were considered. The reviews and the new technique proposals were excluded. Two reviewers were employed to do the review and the disputes settled. The data extraction and meta-analysis were based on the PRISMA

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guidelines. For the assessment of the risk factors and the variables the statistical analysis was done keeping $p<0.05$ as significant.

Results

The flowchart describing the selection of the articles is described in Figure 1. Only 20 articles were selected for the study. Six retrospective studies,[20-25] 6 prospective studies,[26-31] and 8 randomized controlled trials (RCTs) were included.[4,32-38] Six studies compared the presentations of Zir abutments with Ti, Au, or Al_2O_3 abutments.[20,24,26,29,31,32] The randomization in 3 RCTs was not related to Ti or Zir abutment but rather to the implant surface, implant abutment interface, or treatment timing.[4,34,35] Only the Carrillo et al[32] study compared Ti and Zir abutments. Paolantoni et al[33] investigated 2 zirconia abutment designs, Thoma et al[37] studied pink veneering, and Wittneben et al[38] compared prefabricated with CAD/CAM custom abutments. In 3 studies, the type of zirconia abutment was not specified.[23,25,36] Twelve studies defined the mechanical behavior of zirconia abutments (Table 1), and mechanical complications was different in all. Only 5 studies [21,26,32,33,37] reported fractures, with fracture percentage varying from 1.2% to 8%. In a total of 659 abutments, 15 fractures were reported. Esthetic outcomes were mostly reported through soft tissue-contour indices and patient satisfaction questionnaires (Table 2). The pink esthetic score (PES) was established by a contrast with a reference tooth.[39] This scale (scoring of 0, 1, or 2) defines 7 peri-implant mucosal components. This PES/WES(white esthetic score) considered both mucosal and dental components, with 10 points for both the parts. The PES was used in 3 studies,[30,34,35] and PES/ WES was used in 6 studies.[4,23-25,27,38] With PES, a score >10 is considered good and that >12 is considered excellent. With PES/WES, the acceptability threshold is 6. Borges et al[29] applied PES scoring to describe papillae. All indices considered that authors reported "very good to excellent" esthetic results and patient satisfaction, even if no significant correlation between objective scores and patient questionnaires was found.[24] According to PES scoring, the most difficult esthetic parameters to achieve were root convexity, soft-tissue color and texture,[24,35] and level of mucosa.[4,27,30]

Table 1. Mechanical properties

Study	Follow-up (Year)	Number of Patients (Abutments)	Zirconia Abutment Type	Abutment Fracture	Abutment Loosening
Borges et al. (2014)[29]	1	36	Custom	0	0
Carrillo de Albornoz et al. (2014)[32]	1	25	Prefabricated	2	0
Hosseini et al. (2013)[31]	3	59 (98)	52 prefabricated	0	0
Lops et al. (2015)[26]	2	77	14 prefabricated +20 custom	1	1(prefabricated) and 1 (custom)
Paolantoni et al. (2016)[33]	4	65 (74)	29 prefabricated	3 (2 pieces)+2 (1	0

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			(cemented)+35 prefabricated (screw-retained)	piece)	
Passos et al. (2016)[21]	Up to 12	150	Prefabricated +custom	6	1
Rinke et al. (2015)[22]	>5	27 (42)	Prefabricated	0	2
Santing et al. (2013)[27]	1.4	60	Custom	0	0
Takeshita et al. (2015)[23]	1.5	18 (21)	Not specified	0	0
Thoma et al. (2016)[37]	1	20	Custom	1	0
Wittneben et al. (2017)[38]	1	40	20 prefabricated +20 custom	0	0
Zembic et al. (2015)[28]	11	16 (31)	Custom	0	2

Table 2. Esthetic properties

Study	Zirconia Abutment Type	Control Abutment Type	Indices	Outcomes
Barwacz et al. (2016)[34]	Custom, Atlantis		PES	No statistical difference
Bashutski et al. (2013)[36]	Not specified		PPI and patients' satisfaction	Not significant.
Borges et al. (2014)[29]	Custom, Atlantis	Custom, Ti-Ni and Au-Ti	Papilla score from PES	No significant difference for papilla presence
Branzén et al. (2015)[20]	36 custom	8 custom Ti, 10 prefabricated Al2O3 CeraOne	PI and satisfaction questionnaire	No significant difference for papilla presence

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Carrillo de Albornoz et al. (2014)[32]	11 prefabricated, SPY-ART	14 prefabricated, Ti SPY EASY	ICAI-mucosa	No significant difference
Den Hartog et al, (2013)[4].	Custom, Procera+Ti insert		PES WES	No significant difference
Fürhauser et al. (2017)[30]	Custom, Procera		PES	12.6
Hosseini et al. (2013)[31]	52 prefabricated	46 prefabricated, Ti and Au	CIS et OHIP-49	
Kolerman et al. (2017)[25]	Not specified Not specified		PES WES	15.5
Rieder et al. (2016)[35]	Ti insert, Straumann CARES		PES	significant difference for between various types
Santing et al. (2013)[27]	Custom, Straumann CARES		PES WES ICAI	6.9 7.5
Takeshita et al. (2015)[23]	Not specified		PES WES	No significant difference
Thoma et al. (2016)[37]	Custom, Atlantis, pink veneered and nonveneered		PI	No significant difference after 1 year
Vanlioglu et al. (2014)[24]	10 prefabricated, IPS e-max Straumann	45 Ti Anatomic Straumann	PES WES patient satisfaction questionnaire	No difference
Wittneben et al. (2017)[38]	20 prefabricated, IPS e-max (A)+20 Custom, Straumann CARES (B)		PES WES	No difference between prefabricated and custom abutments

Discussion

The mechanical behavior, complications reported in this analysis are in unison with the study of Bidra and Rungruanganunt.[5] Thin screw walls, for external implant-abutment connections, and implant neck, for internal implant-abutment connections, were identified as frail areas prone to fracture. No specific failure time scheme was described. Heterogeneity in the study designs restricted a comparison of the mechanical outcomes. Also, the heterogeneity among zirconia abutment design made evaluations defective. Consequently, if any complications happened or

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not was problematic to conclude. In most of the studies implants with internal connections are used. In the only 2 retrospective studies external connection were used. Zembic et al[28] reported only 2 screw loosening events, and Branzen et al[20] did not report any complications at all. The hypothesis made by Bidra[5] about a possible trend toward abutment screw loosening with external connections was not supported in the present review, although it has been supported by in vitro findings.

CAD-CAM abutments was used in 2 new studies[4,35] have been published and neither detailed mechanical complications. To prevent mechanical complications, manufacturers have limited the indications for Zir abutments to specific angulation. Actually, stock abutments provide a maximum angulation of 15 to 20°, whereas Atlantis CAD-CAM custom abutments, for example, are not suggested for angulation >30°. Narrow diameter implants and abutments have been hypothesized to be more susceptible to fracture because of the thinness of the zirconia components. [32]

With regards to the esthetic results good color integration[6], adapting to mucosal surface were reported. Prior correction of the periodontal defects was done in all studies. Rieder et al[35], Den Hartog et al[4] found no differences after 1 year in the PES/WES scores.

We also noted that by veneering esthetics of the abutments can be improved. Statistically significant improvement in color with pink anodization of Ti abutments or Ti implant necks compared with the gray titanium, yet still inferior to Zir abutments.[16,43] Pink veneering of zirconia looks encouraging.[18,37] The zirconia material can be considered for esthetic areas if crown material and soft-tissue quality, color, and contour are well thought off.

Conclusion

From our study it can be concluded that Zirconia abutments are superior than titanium abutments in terms of color, surface of soft tissues, better for thin peri-implant mucosa. No difference was demonstrated between zirconia and titanium regarding papilla presence and height. Fractures of are seldom seen in zirconium ceramics and <20 to 30 degrees angulation is the indication. Further research is warranted like zirconia abutments with titanium inserts to elucidate the mechanical and esthetic properties in the anterior region for the zirconium ceramics.

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