**Zirconia implant abutments: A review.**

Gomes AL, Montero J.


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**Abstract**

Objectives: An increasing aesthetic demand within developed populations conducted to the fabrication of metal-free restorations and to a wide use of ceramic materials, due to its excellent characteristics of biocompatibility and aesthetics. With the incessant increase of commercial labels involved in this technological advance, a review is imposed on ceramic abutments, specifically on zirconia. We made a search of articles of peer-reviewed Journals in PubMed/Medline, crossing the terms "Dental Abutments", "Dental Porcelain" and "Zirconia". The review was divided by subtopics: zirconia physical and mechanical properties, precision fit in the implant-abutment interface, zirconia abutments strength and, finally, bacterial adherence and tissues response. Several studies demonstrate that zirconia abutments offer good results at all the levels but relevant issues need further studies and evaluation. One of the most important is the clinical long term success of zirconia abutments on implants, given that in the literature there are no sufficient in vivo studies that prove it.

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**A systematic review of the performance of ceramic and metal implant abutments supporting fixed implant reconstructions.**

Sailer I, Philipp A, Zembic A, Pjetursson BE, Hämmerle CH, Zwahlen M.


Comment in:


**Abstract**

OBJECTIVES: The objective of this systematic review was to assess the 5-year survival rates and incidences of complications associated with ceramic abutments and to compare them with those of metal abutments.
METHODS: An electronic Medline search complemented by manual searching was conducted to identify randomized-controlled clinical trials, and prospective and retrospective studies providing information on ceramic and metal abutments with a mean follow-up time of at least 3 years. Patients had to have been examined clinically at the follow-up visit. Assessment of the identified studies and data abstraction was performed independently by three reviewers. Failure rates were analyzed using standard and random-effects Poisson regression models to obtain summary estimates of 5-year survival proportions.

RESULTS: Twenty-nine clinical and 22 laboratory studies were selected from an initial yield of 7136 titles and data were extracted. The estimated 5-year survival rate of ceramic abutments was 99.1% [95% confidence interval (CI): 93.8-99.9%] and 97.4% (95% CI: 96-98.3%) for metal abutments. The estimated cumulative incidence of technical complications after 5 years was 6.9% (95% CI: 3.5-13.4%) for ceramic abutments and 15.9% (95% CI: 11.6-21.5%) for metal abutments. Abutment screw loosening was the most frequent technical problem, occurring at an estimated cumulative incidence after 5 years of 5.1% (95% CI: 3.3-7.7%). All-ceramic crowns supported by ceramic abutments exhibited similar annual fracture rates as metal-ceramic crowns supported by metal abutments. The cumulative incidence of biological complications after 5 years was estimated at 5.2% (95% CI: 0.4-52%) for ceramic and 7.7% (95% CI: 4.7-12.5%) for metal abutments. Esthetic complications tended to be more frequent at metal abutments. A meta-analysis of the laboratory data was impossible due to the non-standardized test methods of the studies included.

CONCLUSION: The 5-year survival rates estimated from annual failure rates appeared to be similar for ceramic and metal abutments. The information included in this review did not provide evidence for differences of the technical and biological outcomes of ceramic and metal abutments. However, the information for ceramic abutments was limited in the number of studies and abutments analyzed as well as the accrued follow-up time. Standardized methods for the analysis of abutment strength are needed.

Marginal adaptation of all-ceramic crowns on implant abutments.

Att W, Hoischen T, Gerds T, Strub JR.


Abstract

BACKGROUND: Studies focusing on the marginal accuracy of all-ceramic crowns on implant abutments are in short supply.

PURPOSE: This study evaluated the marginal accuracy of all-ceramic crowns on different implant abutments.

MATERIALS AND METHODS: Ninety-six standardized maxillary central incisor crowns (48 alumina and 48 zirconia) were fabricated for each of the six test groups (n = 16) (Ti1, titanium abutments-alumina crowns; Ti2, titanium abutments-zirconia crowns; Al1, alumina abutments-alumina crowns; Al2, alumina abutments-zirconia crowns; Zr1, zirconia abutments-alumina crowns; Zr2, zirconia abutments-zirconia crowns). The crowns were adhesively luted using a resin luting agent. The marginal gaps were examined on epoxy replicas before and after luting as well as after masticatory simulation at 200x magnification.
RESULTS: The geometrical mean (95% confidence limits) marginal gap values before cementation, after cementation, and after masticatory simulation were group Ti1: 39(37-42), 57(53-62), and 49(46-53); group Ti2: 43(40-47), 71(67-76), and 64(59-69); group Al1: 57(54-61), 87(85-90), and 67(65-69); group Al2: 66(63-69), 96(90-101), and 75(72-78); group Zr1: 54(51-57), 79(76-82), and 65(63-67); and group Zr2: 64(60-68), 85(80-91), and 75(70-81). The comparison between non-cemented and cemented stages in each group demonstrated a significant increase in the marginal gap values after cementation in all groups (p < .001), while the comparison between cemented and aged stages in each group showed a significant decrease in the marginal gap values in groups Al1, Al2, and Zr1 (p < .0001). This reduction was not significant for groups Ti1, Ti2, and Zr2 (p > .05).

CONCLUSION: The marginal accuracy of all tested restorations meets the requirements for clinical acceptance.

In vitro study of the influence of the type of connection on the fracture load of zirconia abutments with internal and external implant-abutment connections.

Sailer I, Sailer T, Stawarczyk B, Jung RE, Hämmerle CH.


Abstract

PURPOSE: To determine whether zirconia abutments with an internal connection exhibit similar fracture load as zirconia abutments with an external connection.

MATERIALS AND METHODS: The following zirconia abutments were divided into four groups of 20 each: StraumannCARES abutments on Straumann implants (group A), Procera abutments on Branemark implants (group B), Procera abutments on NobelReplace implants (group C), and Zirabut SynOcta prototype abutments on Straumann implants (group D). The abutments were fixed on their respective implants either internally via a secondary abutment (A) or a metallic coupling (C) (two-piece) or directly externally (B) and internally (D) (one-piece). In each group, 10 abutments were left unrestored (A1 to D1). Ten received glass-ceramic crowns (A2 to D2). Static loading was performed according to the ISO norm 14801 until failure. The bending moment was calculated for comparison of the groups and subjected to statistical analysis (Student t test).

RESULTS: The mean bending moments of the unrestored abutments were 371.5 +/- 142.3 Ncm (A1), 276.5 +/- 47.6 Ncm (B1), 434.9 +/- 124.8 Ncm (C1), and 182.5 +/- 136.5 Ncm (D1). Two-piece internally connected abutments exhibited higher bending moments than one-piece internally (C1 versus D1 P = .003, A1 versus D1 P = .03) or externally (B1 P = .004) connected abutments. The groups with restorations did not show different bending moments than those without restorations. The mean bending moments of the restored abutments were 283.3 +/- 44.8 Ncm (A2), 291.5 +/- 31.7 Ncm (B2), 351.5 +/- 58 Ncm (C2), and 184.3 +/- 77.7 Ncm (D2). Group C2 exhibited the highest bending moment (P < .05). Internally connected one-piece abutments (D2) were weaker than all other groups (D2 versus A2 P = .002; D2 versus B2 P = .001; D2 versus C2 P = .0003).
CONCLUSIONS: The type of connection significantly influenced the strength of zirconia abutments. Superior strength was achieved by means of internal connection via a secondary metallic component.

Load fatigue performance of implant-ceramic abutment combinations.

Nguyen HQ, Tan KB, Nicholls JI.


Dental Department, Alexandra Hospital, Singapore.

Abstract

PURPOSE: The mechanical properties and functional load performance of implant restorations coupled with metal abutments have been studied widely. However, the fatigue performance of the newly introduced ceramic implant abutments has not been reported. This study investigated the load fatigue performance of four implant systems and their corresponding zirconia ceramic abutments at the manufacturers’ recommended torque levels.

MATERIALS AND METHODS: Three different diameters (narrow, regular, and wide) of the Replace Select and Branemark systems and two different diameters (4.1 mm and 5.0 mm) of the Osseotite NT and Osseotite NT Certain systems provided 10 implant-abutment test groups. The abutments tested were Procera zirconia, Zireal posts, and Certain ZiReal posts. Each group had a sample size of five. A rotational load fatigue machine applied a 21-N load to the specimens at an angle of 45 degrees to produce an effective bending moment of 35 Ncm at a test frequency of 10 Hz. The number of cycles to failure was recorded.

RESULTS: Twenty-nine of the 50 implant-abutment combinations tested failed. Eighteen abutments fractured. Seven implant fractures and 16 abutment screw fractures were seen, along with some damage to the implant platform in some specimens. No significant difference was seen between the implant systems, but significant differences were observed between the implant diameters. A subsequent one-way analysis of variance revealed statistically significant differences between the 10 implant-abutment test groups.

CONCLUSIONS: Rotational load fatigue testing performance of zirconia abutments is dependent on the abutment diameter. Failure modes varied according to system design characteristics.

Zirconium implant abutments: fracture strength and influence of cyclic loading on retaining-screw loosening.


Abstract

OBJECTIVE: The purpose of this study was to determine the fracture strength of zirconium implant abutments and the torque required to unfasten the retaining screw before and after applying cyclic loading to the implant-abutment assembly. The dynamic behavior and stress distribution pattern of zirconium abutments were also evaluated.

METHODS AND MATERIALS: Static and cyclic loading of 7 XiVE implants with straight Cercon zirconium abutments were simulated under worst-case conditions. Cyclic loading tests were performed via a servohydraulic dynamic testing machine at loads between 100 and 450 N, for up to 5 million loading cycles, at 15 Hz. The dynamic behavior of the zirconium abutments was analyzed by finite element modeling and Pro/Mechanica software, comparing van-der-Mises and maximum stress levels.

RESULTS: Cercon zirconium-ceramic abutments exhibited a maximum fracture strength of 672 N during static loading and 269 N at 800,000 to 5 million cycles runout point, and 403 N at 10,000 cycles runout point during cyclic loading. The mean torque value required to unfasten the abutment retaining screws after (initial) tightening was 21 Ncm +/- 1 and 20 Ncm +/- 1 (measurement accuracy +/- 2 Ncm) after loading with up to 5 million cycles respectively. Torque values decreased minimally and screw loosening did not occur. Within the limited number of test specimens (7), the difference was statistically significant (P = .015). FEM analysis displayed higher stress peaks up to 800 MPa at the cervical aspect of the zirconium abutment and at the apical third of its retaining screw at an external load of 250 N.

CONCLUSION: Within the limitations of this study, zirconium implant abutments exceeded the established values for maximum incisal bite forces reported in the literature and tightly fit into the titanium implant after several millions of loading cycles.

Microgap between zirconia abutments and titanium implants.

Baixe S, Fauxpoint G, Amtz Y, Etienne O.

Abstract

PURPOSE:

The aim of this study was to evaluate in vitro the microgap between different zirconia abutments and their titanium implants.

MATERIALS AND METHODS:

Four systems were evaluated: Procera zirconia (Nobel Biocare) (Nb), Cercon Balance Anterior (Dentsply Friadent) (Ba), ZirDesign (Astratech) (Zd), and Straumann Cares ceramic (Straumann) (Ca). Five assemblies were assessed for each system. The assemblies were embedded in epoxy, cut along their long axes, and polished. Scanning electron microscopic observations were made along the first 100 microm of the gap on each side at maximal magnification. Images were combined and gap measurements were made 10 microm apart. A two-way analysis of variance was performed on the data.

RESULTS:

Scanning electron micrographs showed a mean marginal microgap of 0.89 microm (SD 1.67) for all assemblies. Significant differences (P < .001) were observed between mean (+/- SD) microgap measurements of the four tested systems: Ba = 0.38 +/- 0.28 microm; Zd = 0.55 +/- 0.23 microm; Nb = 1.83 +/- 3.21 microm; Ca = 0.90 +/- 0.59 microm. The mean microgap of the first 20 microm of the outer region (1.66 microm) was significantly (P < .001) larger than the mean microgap (0.56 microm) of the inner region (30 to 100 microm).

CONCLUSIONS:

Within the limitations of this study, the mean microgap observed for all tested systems was less than 2 microm. For each system, the microgap decreased quickly from the outer region to the inner. The mean gap was larger for flat-to-flat connection systems, compared to internal-connection systems with a conical interface. These results demonstrate smaller microgaps compared to those described in the literature for titanium abutments. The precise fit of these abutments could lead to better biologic and biomechanical behavior.

An overview of zirconia ceramics: basic properties and clinical applications.

Manicone PF, Rossi Iommetti P, Raffaelli L.

Abstract

Zirconia (ZrO2) is a ceramic material with adequate mechanical properties for manufacturing of medical devices. Zirconia stabilized with Y2O3 has the best properties for these applications. When a stress occurs on a ZrO2 surface, a crystalline modification opposes the propagation of cracks. Compression resistance of ZrO2 is about 2000 MPa. Orthopedic research led to this material being proposed for the manufacture of hip head prostheses. Prior to this, zirconia biocompatibility had been studied in vivo; no adverse responses were reported following the insertion of ZrO2 samples into bone or muscle. In vitro experimentation showed absence of mutations and good viability of cells cultured on this material. Zirconia cores for fixed partial dentures (FPD) on anterior and posterior teeth and on implants are now available. Clinical evaluation of abutments and periodontal tissue must be performed prior to their use. Zirconia opacity is very useful in adverse clinical situations, for example, for masking of dischromic abutment teeth. Radiopacity can aid evaluation during radiographic controls. Zirconia frameworks are realized by using computer-aided design/manufacturing (CAD/CAM) technology. Cementation of Zr-ceramic restorations can be performed with adhesive luting. Mechanical properties of zirconium oxide FPDs have proved superior to those of other metal-free restorations. Clinical evaluations, which have been ongoing for 3 years, indicate a good success rate for zirconia FPDs. Zirconia implant abutments can also be used to improve the aesthetic outcome of implant-supported rehabilitations. Newly proposed zirconia implants seem to have good biological and mechanical properties; further studies are needed to validate their application.

Clinical trials in zirconia: a systematic review.

Al-Amleh B, Lyons K, Swain M.


Department of Oral Rehabilitation, Faculty of Dentistry, University of Otago, Dunedin, New Zealand. alamleh@gmail.com

Abstract

Zirconia is unique in its polymorphic crystalline makeup, reported to be sensitive to manufacturing and handling processes, and there is debate about which processing method is least harmful to the final product. Currently, zirconia restorations are manufactured by either soft or hard-milling processes, with the manufacturer of each claiming advantages over the other. Chipping of the veneering porcelain is reported as a common problem and has been labelled as its main clinical setback. The objective of this systematic review is to report on the clinical success of zirconia-based restorations fabricated by both milling processes, in regard to framework fractures and veneering porcelain chipping. A comprehensive review of the literature was completed for in vivo trials on zirconia restorations in MEDLINE and PubMed between 1950 and 2009. A manual hand search of relevant dental journals was also completed. Seventeen clinical trials involving zirconia-based restorations were found, 13 were conducted on fixed partial dentures, two on single crowns and two on zirconia implant...
abutments, of which 11 were based on soft-milled zirconia and six on hard-milled zirconia. Chipping of the veneering porcelain was a common occurrence, and framework fracture was only observed in soft-milled zirconia. Based on the limited number of short-term in vivo studies, zirconia appears to be suitable for the fabrication of single crowns, and fixed partial dentures and implant abutments providing strict protocols during the manufacturing and delivery process are adhered to. Further long-term prospective studies are necessary to establish the best manufacturing process for zirconia-based restorations.

Recent advances in materials for all-ceramic restorations.

Griggs JA.


Abstract

The past 3 years of research on materials for all-ceramic veneers, inlays, onlays, single-unit crowns, and multi-unit restorations are reviewed in this article. The primary changes in the field were the proliferation of zirconia-based frameworks and computer-aided fabrication of prostheses, and a trend toward more clinically relevant in vitro test methods. This article includes an overview of ceramic fabrication methods, suggestions for critical assessment of material property data, and a summary of clinical longevity for prostheses constructed of various materials.

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⇒ http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2833171/?tool=pubmed

State of the art of zirconia for dental applications.

Denry I, Kelly JR.


Abstract

Zirconia has been recently introduced in prosthetic dentistry for the fabrication of crowns and fixed partial dentures, in combination with CAD/CAM techniques. This review encompasses the specific types of zirconia available in dentistry, together with their properties. The two main processing techniques, soft and hard machining, are assessed in the light of their possible clinical implications and consequences on the long-term performance of zirconia. An update on the status of clinical trials occurring worldwide is provided.

Ceramic abutments and ceramic oral implants. An update.

Kohal RJ, Att W, Bächle M, Butz F.

**Zirconia as a dental implant abutment material: a systematic review.**

Nakamura K, Kanno T, Milleding P, Ortengren U.


**Abstract**

**PURPOSE:**

The focus of this systematic review was to assess the published data concerning zirconia dental implant abutments from various aspects.

**MATERIALS AND METHODS:**

To identify suitable literature, an electronic search was performed using PubMed. The keywords "zirconia," "zirconium," "ceramic," "dental abutments," "dental implants," "plaque," and "bacteria" were included. Titles and abstracts were screened, and literature that fulfilled the inclusion criteria was selected for a full-text reading. Articles were divided into four groups: (1) studies on the mechanical properties of zirconia abutments, (2) studies on the peri-implant soft tissues around zirconia abutments, (3) studies on plaque accumulation on zirconia, and (4) clinical studies on the survival of zirconia abutments.

**RESULTS:**

The initial literature search resulted in 380 articles. For groups 1 to 4, 11, 4, 7, and 3 articles satisfied the inclusion and exclusion criteria, respectively. Only 1 randomized clinical study was identified. Review of the selected articles showed that zirconia abutments were reliable in the anterior region from both biologic and mechanical points of view. Furthermore, zirconia abutments may represent a material surface less attractive for early plaque retention compared to titanium. Three clinical follow-up studies indicated that zirconia abutments could function without fracture and peri-implant lesions.

**CONCLUSIONS:**

Based on the reviewed literature, zirconia has the potential to be used as a dental abutment material, although some issues have to be studied further.

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**Randomized controlled clinical trial of customized zirconia and titanium implant abutments for canine and posterior single-tooth implant reconstructions: preliminary results at 1 year of function.**

Sailer I, Zembic A, Jung RE, Siegenthaler D, Holderegger C, Hämmerle CH.
Abstract

OBJECTIVES:

The aim of this study was to test whether or not customized zirconia abutments exhibit the same survival rates in canine and posterior regions as titanium abutments, and to compare the esthetic result of the two abutment types.

MATERIAL AND METHODS:

Twenty-two patients with 40 implants in posterior regions were included and the implant sites were randomly assigned to 20 customized zirconia and 20 customized titanium abutments. All-ceramic (AC) and metal-ceramic (MC) crowns were fabricated. In all except two cases, the crowns were cemented on the abutments using resin or glass-ionomer cements. Two zirconia reconstructions were screw retained. At baseline, 6 and 12 months, the reconstructions were examined for technical and biological problems. Probing pocket depth (PPD), plaque (PI) and bleeding on probing (BOP) were assessed and compared with natural control teeth. Furthermore, the difference of color (DeltaE) of the peri-implant mucosa and the gingiva of control teeth was evaluated by means of a spectrophotometer (Spectroshade). The data were analyzed with Student's unpaired t-test, ANOVA and regression analyses.

RESULTS:

Twenty patients with 19 zirconia and 12 titanium abutments were examined at a mean follow-up of 12.6 +/- 2.7 months. The survival rate for reconstructions and abutments was 100%. No technical or biological problems were found at the test and control sites. Two chippings (16.7%) occurred at crowns supported by titanium abutments. No difference was found regarding PPD (meanPPD(ZrO2) 3.4 +/- 0.7 mm, mPPD(Ti) 3.3 +/- 0.6 mm), PI (mPI(ZrO2) 0.2 +/- 0.3, mPI(Ti) 0.1 +/- 1.8) and BOP (mBOP(ZrO2) 60 +/- 30%, mBOP(Ti) 30 +/- 40%) between the two groups. Both crowns on zirconia and titanium abutments induced a similar amount of discoloration of the soft tissue compared with the gingiva at natural teeth (DeltaE(ZrO2) 8.1 +/- 3.9, DeltaE(Ti) 7.8 +/- 4.3).

CONCLUSIONS:

At 1 year, zirconia abutments exhibited the same survival and a similar esthetic outcome as titanium abutments.

Fracture resistance and failure location of zirconium and metallic implant abutments.

Aramouni P, Zebouni E, Tashkandi E, Dib S, Salameh Z, Almas K.
Abstract

AIM:
The purpose of this study was to evaluate the fracture resistance and failure location of single-tooth, implant-supported, all-ceramic restorations on different implant abutments subjected to a maximum load.

METHODS AND MATERIALS:
Forty Certain 3i implants and 20 ITI Straumann implants were used in this study in combination with 20 UCLA abutments, 20 ZiReal abutments, and 20 synOcta Ceramic Blanks to form three groups according to abutment type. All 60 abutments were prepared with standard measurements: a 1.0 mm deep chamfer, 2.0 mm of incisal reduction, and a total height of 7 mm. Sixty IPS Empress 2 full ceramic crowns were fabricated and cemented on each abutment with a resin cement. Static loading was simulated under maximum loading and fracture locations were noted.

RESULTS:
The mean load to failure data and standard deviations for the three groups were as follows: Group 1 (792.7 N +/- 122.5) and Group 3 (793.6 +/- 162.3) showed no significant difference in fracture resistance while the values for specimens in Group 2 (604 N +/- 191.1) had the lowest mean value and were significantly lower. In Group 1, 16 crowns and four abutment fractures were reported, while in Group 3, 17 crowns and three abutments fractured. Group 2 actually showed three types of fractures. Two specimen fractures were located at the implant level, six with fractures occurring within the Empress 2 all-ceramic crown, and the remaining 12 failures were located at the abutment level.

CONCLUSION:
Within the limitations of this laboratory study, the following conclusions were drawn: The mean load-to-failure values for all three groups were well above the reported normal maximal incisal load range. The load to failure for both the zirconium oxide (ZrO2) abutments (ZiReal on 3i Certain implants and synOcta Ceramic Blanks on SLA ITI Straumann implants) had mean fracture loads of 792.7 N (+122.6) and 604.2 N (+191.2), respectively. The zirconium oxide (ZrO2) ZiReal and titanium (UCLA) abutments on the 3i Certain implants had statistically significantly higher fracture loads (792.7 N and 703.7 N, respectively) than those recorded for the 3i Ceramic Blank abutments on the SLA ITI Straumann implant (604.2 N). The ITI Straumann Ceramic Blank abutments showed uniform fracture behavior. Fracture mainly emanated from the cervical buccal aspect of the abutment.

CLINICAL SIGNIFICANCE:
The three abutments tested showed they can withstand clinical loads above the normal range of mastication.