Brazilian Dental Journal (2020) 31(4): 374-379
http://dx.doi.org/10.1590/0103-6440202001806-4760-bdj-31-04-374

ISSN 0103-6440

Implant Volume Loss, Misfit, Screw Loosening, and Stress In Custom Titanium and Zirconia Abutments

Sales Antônio Barbosa Jr[1], Ataís Bacchi[2], Valentim Adelino Ricardo Barão[1], Yara Teresinha Corrêa Silva-Sousa[3], João Felipe Bruniera[3], Ricardo Armini Caldas[4], Rafael Leonardo Xediek Consani[1]

[1]Department of Prosthodontics and Periodontology, Piracicaba Dental School, UNICAMP – Universidade Estadual de Campinas, Piracicaba, SP, Brazil
[2]Department of Prosthodontics, School of Dentistry, IMED – Faculdade Meridional, Passo Fundo, RS, Brazil
[3]Department of Dentistry, UNAERP – Universidade de Ribeirão Preto, Ribeirao Preto, SP, Brazil
[4]Department of Prosthodontics, UFSC – Universidade Federal de Santa Catarina, Florianopolis, SC, Brazil

Correspondence: Prof. Dr. Rafael Leonardo Xediek Consani, Avenida Limeira, 901, 13414-903 Piracicaba, SP, Brasil. Tel: +55-19-2106-5296. e-mail: rconsani@fop.unicamp.br

The aim of this study was to verify the effect of the implant volume loss, vertical misfit between abutment and prosthetic platform, prosthetic screw loosening torque, and screw stress distribution in titanium and zirconia abutments. Ten CAD/CAM system custom abutments of each material were milled and attached to the titanium implants. The implant volume loss was evaluated by microtomography, the vertical misfit with optical microscopy, and digital torque wrench measured the prosthetic screw loosening. All experimental analyses were performed before and after mechanical cycle (1,000,000 cycles, 100 N/2 Hz). Virtual models of the structures were created for finite element analysis, and the stress on the screw obtained with von Mises procedure. Data were analyzed using an independent t-test, two-way ANOVA for repeated measures, and Tukey's HSD test (α=0.05). There was no significant difference in the implant volume loss for the two abutment materials (p=0.662). Titanium abutments provided higher loosening torque values after mechanical cycling (p<0.001). Lesser marginal misfit was obtained with titanium abutments before and after mechanical cycling (p<0.001). The stress distribution on the screw was similar between abutment materials. In conclusion, CAD/CAM custom titanium abutment reduced the marginal misfit and increased the torque maintenance of prosthetic screws when compared to CAD/CAM custom zirconia abutment.

Key Words: titanium and zirconia, custom abutment, marginal misfit, screw stress.

Introduction

Despite the recognized success of dental implants, mechanical problems associated with implant-supported single crowns are still a challenge to the dentist, mainly in relation to loosening and fracture of the prosthetic screws (1,2). For the single crowns, the cemented technique is generally an adequate esthetic solution to cover the screw access hole, especially for tilted implants (3).

The maintenance of prosthetic screw torque is extremely important, since the retention does not influence the fracture resistance but has a relevant effect on the failure pattern of the specimens. However, CAD/CAM milled lithium-disilicate crowns seem to be a preserving factor for dental implants (4). Vestibular fractures are restricted to ceramic abutments and lesser gingival discoloration with zirconia abutments; but there is no differences in patient's esthetic satisfaction between ceramic and metal abutments. For the anterior region, implant with internal connection and custom metal abutment showed the least mechanical complications (5).

For aesthetic reasons, ceramic abutments were associated to implant-supported rehabilitations in the early 1990s to avoid the pigmentation caused by titanium abutments due to interaction between wear and corrosion occurred when masticatory forces combine with the saliva in the oral cavity (6). CAD/CAM manufacturing method improves management of the subgingival depth of the crown/abutment interface and enhances the esthetic of the restoration (7).

The best way to obtain a suitable relation between the gingival depth and adjacent dental structure is with custom abutment and subgingival margin between 0.5 to 1 mm, considered important factor in preventing inflammation caused by cement residue and food debris (8). In addition, custom abutments are significantly stronger than the trade abutments but its fit is less precise. However, the mechanical strength and the adjustment level were not different for both abutments and showed clinically acceptable limits (9).

With the CAD/CAM system is possible to mill metal blocks or pre-sintered ceramic zirconia blocks. The zirconia abutment must be milled with larger dimensions before the sintering process, fact that may cause dimensional changes in the abutment. On the other hand, the abutment fitting problems generally favor the loosening of the prosthetic screw or possible fracture (4).

Previous study showed that the CAD/CAM abutment appear to show a fit and marginal adaptation level comparable to those trade abutment for most of the systems evaluated, while zirconia abutment revealed a good adjustment level in the interface with dental implants (10). In addition, the copy-milled zirconia abutment does not fit as accurately as trade abutment titanium; however, the less precise fit of the custom zirconia abutment did not affect the ability to maintain the applied torque (11). On the other hand, the fracture resistance of titanium and zirconia abutments with internal connection under simulating cyclic masticatory load showed that 1-piece zirconia abutments exhibited a significantly lower fracture resistance than titanium abutments (12).

Therefore, there is concern that zirconia may damage the implant surface when in oral function. Previous study showed greater wear on the zirconia-titanium internal hexagon interface when compared to titanium-titanium interface (13). In contrast, a three-dimensional finite element analysis showed that the zirconia implant generated the lowest stress in cortical bone, and the zirconia abutment resulted in lower von Mises and compressive stresses than the titanium abutment in implant and cortical bone (14).

Although internal connections are the most used due to greater stability, the external hexagon implants are used for decades and have still large application today in totally implant-supported prosthesis. Given these considerations, it would be appropriate to evaluate the marginal fit between abutment and implant, the screw stability, the implant volume reduction, and stress at screw in implants with external hexagon connections submitted to mechanical cycling. The study hypotheses were that titanium and zirconia abutments would not show relevant differences on: 1) passivity of the abutment, 2) maintenance of the initial torque, 3) implant volume loss, and 4) concentration level of stress on the screw.

Material and Methods

Twenty external hexagon implants with a regular platform (4.1 mm in diameter) and dimensions of 11 mm in length and 3.75 mm in diameter were used (Titamax; Neodent, Curitiba, PR, Brazil). The implants were randomly divided into two groups, according to the titanium or zirconia abutment material (n=10). Each implant was fixed in epoxy-based resin block (F160 A+B; Axson, São Paulo, SP, Brazil) with aid of a parallelometer.

A trade abutment (UCLA; Neodent) was used to make a matrix in low shrink acrylic resin (Pattern Resin LS; GC South America, Sao Paulo, SP, Brazil) with shape and dimensions of a first mandibular molar. The crown was prepared with an occlusal thickness of 1.5 mm and axial walls of 1.2 mm. An acrylic resin matrix was scanned with CAD/CAM system (Neodent Digital) and used for the abutments preparation (n=10/group) in commercially pure titanium or a polycrystalline tetragonal zirconia stabilized by yttrium of first generation (3Y-TZP) (Fig. 1). After model images definition, the abutments were manufactured with CAD/CAM system (Neodent Digital). The zirconia abutments were sinterized at 1500°C for 2 h.

Implant Volume Loss

The implant volume (mm^3) was evaluated before the abutment installation on the platform. A microtomograph device (SKYSCAN 1176: High-resolution in-vivo micro-ct; Bruker, Kartuizersweg, Belgium) was used for a better resolution and construction of the implant models. Images with a power of 90 Kv and a spatial resolution of 9 µm (maximum resolution allowed by the equipment) served to build the 3D implant models and to evaluate the quantitative analysis. The same analysis process for the volume of the implant before installation were used after the mechanical cycle.

Screw Loosening Torque

The values for the initial torque and the tightening torque of the prosthetic screw (Neotorque; Neodent) were applied with torque wrench with precision digital (TQ8800; Lutron, Taipei, Taiwan). The initial torque was the recommended by the manufacturer (32 N.cm) and the loosening torque measurement was performed 10 min after the initial torque. The screw was replaced and the torque processing repeated after each measurement cycle. In the same condition, the screw loosening torque was assessed after the mechanical cycling.

Vertical Misfit Measurement

The initial misfit level of each specimen was measured at the buccal, mesial, lingual, and distal points of the abutment-implant interface with linear optical microscope

Figure 1. Implant-supported abutments: Titanium (left) and zirconia (right).

(UHL VMM 100 BT; UK) with 1.0 µm accuracy equipped with digital camera (KC-512NT; Kodo BR Electronics, Sao Paulo, SP) and analyzer unit (QC 220-HH; Quadra-Check 200, Metronics Inc., Canada). The same researcher performed three evaluations on each point, and the average obtained was the value considered for each point. The average of the four points represents the final misfit value for each specimen. The misfit value after mechanical cycling was assessed with the same measurement method. All passive fits were evaluated at magnification of 120 times.

Mechanical Cycling

Specimens were submitted to the mechanical cycler (ER - 1100 Mechanical Fatigue Simulator; Erios, Sao Paulo, Brazil) with 1,000,000 cycles under compressive axial load (100 N/2 Hz frequency) exerted on the occlusal region of the crown immersed in distilled water.

Scanning Electron Microscopy

Before- and after-cycling qualitative analyzes were performed with scanning electron microscopy (JSM-5600LV; JEOL, Tokyo, Japan) to verify the possible changes or wear on implant platform.

Finite Element Analysis

A three-dimensional (3D) model composed by crown, prosthetic screw, implant and resin base was assembled. Three-dimensional geometries and assemblies were developed with computer-aided design (CAD) software (SolidWorks 2010, Concord, MA, USA). The 3D models were imported to computer-aided-engineering software (ANSYS Workbench 11; Ansys Inc., Pittsburg, PA, USA) for numerical analysis. Meshes composed with 10-nodes tetrahedrons, checked for element quality were refined in the interest areas.

All materials were linear elastic, isotropic, and homogeneous. The material properties were obtained from literature data for titanium (Elasticity modulus=110 GPa; Poisson's ratio=0.3) (14), epoxy resin (Elasticity modulus=1.29 GPa; Poisson's ratio=0.31) (15), zirconia (Elasticity modulus=210 GPa; Poisson's ratio=0.3) (16), and cancellous bone tissue (Elasticity modulus measured mechanically=10.4 GPa) (17).

A 100 N standard axial loading was applied to occlusal surface or at 45 degrees on the implant axis. Model movement was restricted at 6 degrees of freedom in the bottom region and lateral surface of the nodes of the acrylic resin cylinder base. Before axial occlusal loading, a pre-load of 20 N was applied at prosthetic screw neck (18,19). Similar von Mises stresses values were assigned for implant and prosthetic screw.

Statistical Analysis

Data were submitted to Kolmogorov-Smirnov and Shapiro-Wilk tests to identify data normality, and transformed in logarithmic scale when necessary to achieve normality. The influence of abutment type on the implant volume loss was verified with independent t-test. Two-way ANOVA for repeated measures and Tukey HSD test assessed the influence of abutment type and mechanical cycling on the misfit and loosening torque values. P value <0.05 was considered statistically significant (IBM SPSS Statistics for Windows, v.21.0, IBM Corp., Armonk, NY, USA).

Results

Implant Volume Loss

The independent t-test showed no significant difference when comparing the implant volume loss for the two groups (t=0.444; df=18; p=0.662). Mean (Standard deviation) for implant volume loss was 0.161 (0.20) mm3 for titanium, and 0.135 (0.16) mm3 for zirconia. The qualitative analysis performed with SEM showed no relevant differences for the implant platforms in relation to wear or damage of the structures (Fig. 2).

Screw Loosening Torque

ANOVA showed that the factors abutment material (p=0.398) and mechanical cycling (p=0.099) were not significant for screw loosening torque, although the factors interaction was significant (p<0.001). Zirconia showed a significantly higher screw loosening torque (24.8 N.cm) when compared to the titanium (17.9 N.cm) (p=0.001) for the before cycling time. After cycling, the zirconia abutment showed lower loosening torque (13.8 N.cm) when compared to titanium abutment (24.8 N.cm) (p<0.001).

Statistical differences were observed for screw loosening torque in both materials when the intra-group comparison was performed (Table 1). Zirconia showed significantly lower value for screw loosening torque after cycling when

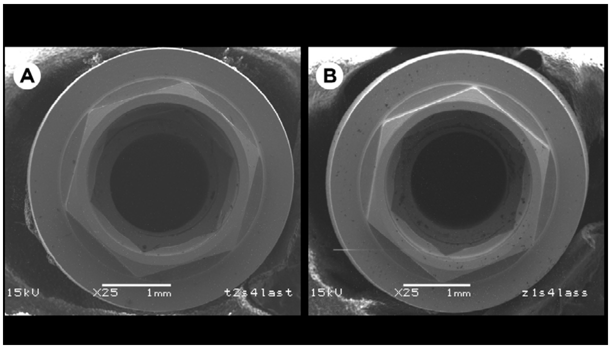

Figure 2. SEM micrographs for implant platform after mechanical cycling: (A) titanium and (B) zirconia.

compared to the initial torque (p<0.001). For the titanium, higher values of screw loosening torque were observed after cycling (p=0.004).

Vertical Misfit Measurement

ANOVA showed significant influence for the abutment material factor (p<0.001), but not for vertical misfit after mechanical cycling (p=0.209). Interaction between the factors was significant (p<0.001). Table 2 showed that titanium abutment presented lower misfit for before- (p<0.001) and after-cycling (p<0.001). When comparing the passivity for the same material before and after cycling, the titanium abutment showed reduced misfit after cyclic loading (p<0.001), while the zirconia abutment presented an increase in the same cycling conditions (p =0.034).

Finite Element Analysis

There was no relevant difference in the stress concentration for screws between the titanium and zirconia abutments when axial load (Fig. 3) or oblique load (Fig. 4) was applied. The axial load promoted greatest stress concentration at the junction between head and neck of the screw, whereas the oblique load concentrated stress on the central region of the screw.

Discussion

This study verified the mechanical behavior of custom titanium and zirconia abutments manufactured with the CAD/CAM system. According to the results, the first hypothesis that there would be no difference in the abutments passivity was not accepted. The titanium fit was better than the adaptation of the zirconia at the before and after cycling times, showing a significant improvement for titanium when compared to zirconia material (Table 1).

These results are in agreement with previous study showing that the abutment adaptation to the implant was close, the amount of contact larger for assembly with premachined abutment and laboratory modified premachined abutment than for those with cast abutments (18). However, all screw types displayed some decrease in preload with repeated tightening, regardless of abutment type and insertion torque (19).

In addition, the implant-titanium abutment connection showed significantly better fit than the implant-zirconia abutment configurations with gap values three to seven times larger than those for titanium abutment (20). Therefore, titanium CAD/CAM abutment showed similar adaptation with different prefabricated abutments for most of the systems evaluated, and design differences between the abutment connections affected the fit of internal components of the implant-abutment connections (10).

Zirconia abutment showed value of fracture strength lesser as conventional titanium abutment; but it promoted good adjustment in the interface with dental implant,

Table 1. Screw loosening values (N.cm) and (Standard deviation) before and after cycling for titanium and zirconia abutments

Abutment	Before cycling	After cycling
Titanium	17.9 (5.1) bB	24.8 (2.8) aA
Zirconia	25.9 (2.5) aA	13.8 (7.6) bB

Different lowercase letters in row and different capital letters in columns indicate significant statistical differences (p<0.05, Tukey HSD test)

Table 2. Misfit average values (μm) and (Standard deviation) for titanium and zirconia abutments for the before and after cycling times

Abutment	Before cycling	After cycling
Titanium	11.1 (4.0) aB	8.0 (8.0) bB
Zirconia	25.3 (2.0) bA	27.0 (9.0) aA

Different lowercase letters in row and different capital letters in columns indicate significant statistical differences (p<0.05, Tukey HSD test). For data normality, the passivity values in log10 scale.

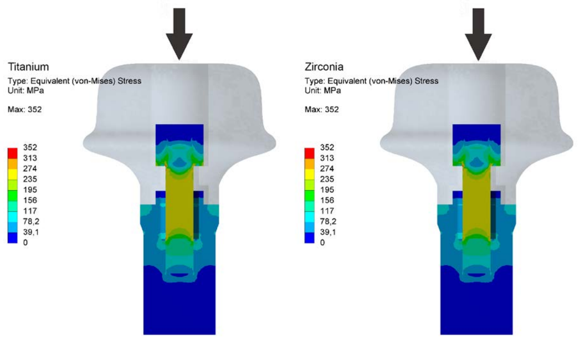

Figure 3. von Mises stress distribution in screws for titanium and zirconia abutments after axial load.

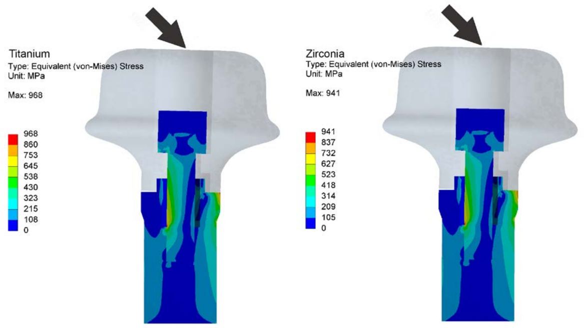

Figure 4. von Mises stress distribution in screw for titanium and zirconia abutments after oblique load.

excellent biocompatibility and good aesthetical appearance (21). On the other hand, the copy-milled zirconia abutment did not fit as accurately as prefabricated titanium abutment. However, the less precise fit of customized zirconia abutment did not negatively affect their ability to maintain the applied torque (11).

The comparison of the abutment misfit in each material in relation to cycling time showed significant statistical difference for the titanium with lower misfit after mechanical cycle. Significant statistical difference occurred also for the zirconia; however, the misfit level was greater in both evaluation times when compared to titanium (Table 2). This fact allows assuming that the higher elasticity modulus of the zirconia would negatively affect the implant passivity during the mechanical load application on the screw.

Probably, the better fit obtained for the titanium is due to greater malleability of the metallic alloy when compared to zirconia rigidity. Consequently, the zirconia rigidity would promote greater misfit level, decreasing the force value employed in the initial torque. This assumption would also related to other variables of the study, by example, the initial torque applied and the torque maintenance resulting in lower misfit after application of the screw load.

On the other hand, titanium implants showed higher wear at the interface after cyclic loading when connected to one-piece zirconia abutments compared to titanium abutments. However, the clinical relevance was not clear, since the damages in the internal implant connection could result in prosthetic failures or the need for implant removal (13).

The different CAD/CAM systems used in the manufacture of the abutment could also influence these mechanical differences. However, the CAD/CAM abutments appear to have a fit comparable to the prefabricated abutments for most of the different evaluated systems. On the other hand, the design differences of the abutment connections affected the adjustment level of the internal components between abutment and implant (10).

There were statistically significant difference concerning the cycling time, with better value for zirconia in the pre-cycling time, and greater value for the titanium in the post-cycling time (Table 2). Since the maintenance of the initial torque was different for the titanium in relation to the zirconia the second hypothesis was not confirmed.

These findings highlight the assumption that the material stiffness influences the passivity maintenance and pre-torque load level. These findings highlight the assumption that the material stiffness influences the passivity maintenance and pre-torque load level. Thus, screw preload maintaining is an important factor to maintain the fixation of implant-supported rehabilitations for long term. Another interesting factor shown in previous study was that there is always a loss of the initial torque value, whatever the evaluation condition. The wet condition showed higher torque and better preload values, suggesting that the abutment screw must be lubricated with saliva to avoid further loosening (1), whereas the zirconia and titanium abutments exhibited similar survival times, and same technical, biological and esthetical outcomes after three years in use (22).

Over the years, implants with external connections screwed or cemented for single prosthetic rehabilitations were frequently analyzed by different methods in relation to the stability level of the screw torque (13,23,24). The screw loosening occurs by reduction or complete loss of the initial torque, which depends of several factors including improper torque, lack of adaptation, large rotational freedom, and failure in the screw when re-tightened, favoring the wear and the friction between the components (24).

In addition, the aging by thermo cycling and chewing simulation with static load applied at 30 degrees angle to the palatal face showed that bending moment for different types of zirconia abutments changes with different implant-abutment connections when compared to titanium abutments with internal connection (25).

Due to the lack of a clear conclusion in the literature about possible damage caused by titanium or zirconia abutments in implants of external connections, the present study also verified a reduction in the volume of the implant platform. The third hypothesis was confirmed since there was no statistically significant difference between the abutment materials in relation to implant volume loss. Although the levels of hardness and stiffness showed higher values for the zirconia, it is possible to assume that the functional load was not sufficient to promote different wear patterns in relation to volume loss of the implant.

Although the abutment materials are different in the current study, the axial force was similarly exerted in both abutment types, and distributed on the screws and implant platforms in similar mode. Since the concentration of stress at screws was not different between abutments, the fourth hypothesis was accepted. This fact appears to confirm the result similarity in relation to stress supported by the screws under axial force (Fig. 3).

However, the oblique load promoted greater deformation on the titanium abutment probably due to lesser elastic modulus, increasing the stress transfer to the prosthetic screw (larger tension on the screw neck) and smaller increase for the von Misses maximum stress value on the prosthetic screw body (Fig. 4). By analogy, previous study showed that stiffer frameworks promoted higher stress concentration; however, these frameworks caused lower tension on the porcelain veneer, retention screw, and peri-implant bone tissue (23).

The results of the current study suggest that titanium abutment used with external hexagon implant placed in posterior region might cause less biomechanical problem related to the screw loosening or fracture when compared to zirconia abutment, since its mechanical properties are considered superior to those of zirconia. However, it is claimed that the zirconia material can be used especially as abutment (26). In addition, internal tapered connection implants assessed with strain gauges showed that the screw-retained or cement-retained do not always exhibit different levels of stress (27).

Future clinical long-term follow-ups are necessary to confirm the current in vitro results. The effect of the connection and abutment on the fatigue strength and assembly change is important for the maintaining of the interface, which wear is not always similar between titanium and zirconia materials (28). In addition, the type of abutment material and the connection design may affected the fit and the sealing capability of the different abutments (29).

Possible study limitations were considered, such as lack of simulation of the mandibular dynamics and absence of prosthetic crown, variables that should be subjected to further investigations.

According to the results of the study, the following conclusions can be drawn:

1. The passivity of the custom titanium abutments adapted to external connections was higher than for zirconia, with lower misfit in the before- and after- cycling times;

2. Titanium abutments showed better results than zirconia in maintaining of the screw torque in the after-cycling time;

3. There was no statistically significant difference for implant volume reduction in relation to the different abutment materials;

4. The screw stress magnitude was not influenced by the abutment material.

Resumo

O objetivo neste estudo foi verificar o efeito da diminuição de volume do implante, desajuste vertical entre o pilar e plataforma protética, torque de afrouxamento do parafuso protético e distribuição da tensão no parafuso em pilares de titânio e zircônia. Dez pilares personalizados de cada material foram fresados e conectados aos implantes de titânio. A diminuição de volume do implante foi avaliada com microtomografia, o desajuste vertical com microscopia óptica e o torque de afrouxamento do parafuso protético com chave de torque digital. Todas as análises experimentais foram realizadas antes e após aplicação do ciclo mecânico (1.000.000 ciclos, 100 N/2 Hz). Modelos virtuais das estruturas foram criados para análise por elementos finitos e a tensão no parafuso obtida com valores de von Mises. Os dados foram analisados usando teste t independente, análise de varância dois fatores para medidas repetidas e teste de Tukey HSD (α=0,05). Não houve diferença significativa na diminuição de volume do implante para os dois materiais do pilar (p= 0,662). Os pilares de titânio proporcionaram maiores valores de torque de afrouxamento após o ciclo mecânico (p<0,001). O menor desajuste marginal foi obtido com os pilares de titânio antes e após o ciclo mecânico (p<0,001). A distribuição da tensão no parafuso foi similar entre os materiais. Em conclusão, os pilares personalizados de titânio reduziram o desajuste marginal e aumentaram a manutenção do torque dos parafusos protéticos quando comparados aos pilares de zircônia.

References

1. Nigro F, Sendyk CL, Francischone JR. CE, Francischone CE. Removal torque of zirconia abutments screws under dry and wet conditions. Braz Dent J 2010;21:225-228.
2. Fabris V, Reginato VF, Smaniotto C, Bacchi A, Consani RLX. Treatment of resorbed mandibles with titanium plate and immediate implant-supported prosthesis - Case series. Braz Dent J 2019;30:244-251.
3. Magne P, Magne M, Jovanovic SA. An esthetic solution for single-implant restorations – type III porcelain veneer bonded to a screw-retained custom abutment: a clinical report. J Prosthet Dent 2008;99:2-7.
4. Obermeier M, Ristow O, Erdelt K, Beuer F. Mechanical performance of cement- and screw- retained all-ceramic single crowns on dental implants. Clin Oral Investig 2018;22:981-991.
5. Bidra AS, Rungruaganunt P. Clinical outcomes of implant abutments in the anterior region: a systematic review. J Esthet Restor Dent 2013;25:159-176.
6. Sikora CL, Alfaro MF, Yuan JC, Barao VA, Sukotjo C, Mathew MT. Wear and corrosion interactions at the titanium/zirconia interface: Dental Implant Application. J Prosthodont 2018;27:842-852.
7. Boudrias P, Shoghikian E, Morin E, Hutnik P. Esthetic option for the implant-supported single-tooth restoration - treatment sequence with a ceramic abutment. J Can Dent Assoc 2001;67:508-514.
8. Pauletto N, Lahiffe BJ, Walton JN. Complications associated with excess cement around crowns on osseointegrated implants: a clinical report. Int J Oral Maxillofac Implants 1999;14: 865-868.
9. Park JI, Lee Y, Lee JH, Kim YL, Bae JM, Cho HW. Comparison of fracture resistance and fit accuracy of customized zirconia abutments with prefabricated zirconia abutments in internal hexagon implants. Clin Implant Dent Relat Res 2013;15:769-778.
10. Hamilton A, Judge RB, Palamara JE, Evans C. Evaluation of the fit of CAD/CAM abutments. Int J Prosthodont 2013;26:370-380.
11. Alikhasi M, Monzavi A, Bassir SH, Naini RB, Khosronedjad N, Keshavarz S. A comparison of precision of fit, rotational freedom, and torque loss with copy-milled zirconia and prefabricated titanium abutments. Int J Oral Maxillofac Implants 2013;28: 996-1002.
12. Foong JKW, Judge RB, Palamara JE, Swain MV. Fracture resistance of titanium and zirconia abutments: An in vitro study. J Prosthet Dent 2013;109:304-312.
13. Stimmelmayr M, Edelhoff D, Güth JF, Erdelt K, Happe A, Beuer F. Wear at the titanium-titanium and the titanium-zirconia implant-abutment interface: a comparative in vitro study. Dent Mater 2012;28:1215-1220.
14. Çaglar M, Bal BT, Karakoca S, Aydin C, Yilmaz H, Sarisoy S. Three-dimensional finite element analysis of titanium and yttrium-stabilized zirconium dioxide abutments and implants. Int J Oral Maxillofac Implants 2011;26:961-969.
15. Materials' Library, SolidWorks 2010, Concord, MA, USA.
16. Ma L, Guess PC, Zhang Y. Load-bearing properties of minimal-invasive monolithic lithium disilicate and zirconia occlusal onlays: finite element and theoretical analyses. Dent Mater 2013;29:742-751.
17. Rho JY, Ashman RB, Charles H.Turner CH. Young's modulus of trabecular and cortical bone material: Ultrasonic and microtensile measurements. J Biomechanics. 1993;26:111-119.
18. Byrne D, Houston F, Cleary R, Claffey N. The fit of cast and premachined implant abutments. J Prosthet Dent 1998;80:184-192
19. Byrne D, Jacobs S, O'Connell B. Preloads generated with repeated tightening in three types of screws used in dental implant assemblies. J Prosthodont 2006;15:164-171.

20. Baldassarri M, Hjerppe J, Romeo D, Fickl S, Thompson VP, Stappert CF. Marginal accuracy of three implant-ceramic abutment configurations. Int J Oral Maxillofac Implants 2012;27:537-543.
21. Gomes AL, Montero J. Zirconia implant abutments: a review. Med Oral Patol Oral Cir Bucal 2011;16:e50-e55.
22. Zembic A, Sailer I, Jung RE, Hämmerle CH. Randomized controlled clinical trial of customized zirconia and titanium implant abutments for single-tooth implants in canine and posterior regions: 3-year results. Clin Oral Implants Res 2009;20:802-808.
23. Carvalho BAC, Vedovatto E, Carvalho PSP, Mazaro JVQ, Falcón-Antenucci RM. Effect of mechanical cycling on screw torque in external hexagon implants with and without platform switching. Braz Dent J 2015;26:284-287.
24. Bacchi A, Consani RLX, Mesquita MF, dos Santos MBF. Effect of framework material and vertical misfit on stress distribution in fixed implant-supported partial prosthesis under load application: 3D finite element analysis. Acta Odontol Scand 2013;71:1243-1249.
25. Truninger TC, Stawarczyk B, Leutert CR, Sailer TR, Hämmerle CH, Sailer I. Bending moments of zirconia and titanium abutments with internal and external implant-abutment connections after aging and chewing simulation. Clin Oral Implants Res 2012;23:12-18.
26. Hanawa T. Zirconia versus titanium in dentistry: A review. Dent Mater J 2020;39:24-36.
27. Lee MY, Heo SJ, Park EJ, Park JM. Comparative study on stress distribution around internal tapered connection implants according to fit of cement- and screw-retained prostheses. J Adv Prosthodont 2013; 5:312-318.
28. Sen N, Us YO. Fatigue survival and failure resistance of titanium versus zirconia implant abutments with various connection designs. J Prosthet Dent 2019;122:315.e1-315.e7.
29. Sen N, Sermet IB, Gürler N. Sealing capability and marginal fit of titanium versus zirconia abutments with different connection designs. J Adv Prosthodont 2019;11:105-111.

Received January 8, 2020
Accepted June 23, 2020

Errata

https://doi.org/10.1590/0103-64402020errata2

For article published as cited below:

Barbosa JR, Sales Antônio et al . Implant Volume Loss, Misfit, Screw Loosening, and Stress In Custom Titanium and Zirconia Abutments. Braz. Dent. J., Ribeirão Preto , v. 31, n. 4, p. 374-379, Aug. 2020 Available from <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-64402020000400374&lng=en&nrm=iso>. access on 03 Oct. 2020. Epub Sep 04, 2020. https://doi.org/10.1590/0103-6440202003643.

Where is read author: Yara Teresinha Silva-Souza

The author should be read as follows: Yara Teresinha Corrêa Silva-Sousa