UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

CAMILA PERFEITO EVANGELISTA DA SILVA

**Effect of CAD/CAM abutment height and cement type on the
retention of zirconia crowns**

**Efeito da altura do pilar CAD / CAM e tipo de cimento na retenção
de coroas de zircônia**

BAURU
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Orientadora: Profa. Dra. Simone Soares

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*“Aqueles que passam por nós, não vão sós, não nos deixam sós.
Deixam um pouco de si, levam um pouco de nós.”*

Antoine de Saint-Exupér

ABSTRACT

ABSTRACT

Effect of CAD/CAM abutment height and cement type on the retention of zirconia crowns

Aim: To evaluate the effect of different Ti-base abutment heights and cement type on the pullout retention of zirconia-based restorations.

Methods: Identical crowns were designed in a CAD software to fit two different Ti-base abutment heights, as follows (n=10/group): (i) 4-mm-height Ti-base abutment (Tall), and (ii) 2.5-mm-height Ti-base abutment (Short). Four cement types were selected: (i) Temporary cement (Provisional); (ii) Glass-ionomer cement (Meron); (iii) self-adhesive resin cement (U200), and (iv) conventional resin cement (Ultimate) with universal adhesive for treatment of titanium and zirconia substrates. Pull-out testing was performed in a universal testing machine. Data were statistically evaluated through two-way analysis of variance following post-hoc comparisons by Tukey test.

Results: Tall Ti-base abutments demonstrated similar retention to short abutments when data is collapsed over cement ($p>0.74$). Data evaluation as a function of cement type demonstrated the superiority of resin-based cements relative to provisional and glass-ionomer groups ($p<0.01$). Retentiveness data as a function of both factors demonstrated similar force to dislodgment between tall and short abutments for all within cement comparisons ($p>0.42$), except for U200 ($p=0.032$). Also, tall abutments cemented with Ultimate evidenced higher pull out values than U200 ($p=0.043$), and both were significantly more retentive than tall provisional and meron ($p<0.001$). No significant difference was observed between U200 and Ultimate cements for short abutments ($p=0.758$), and both presented statistically higher pull-out values than provisional and glass-ionomer ($p=0.001$).

Conclusions: While Ti-base abutment height have not influenced zirconia superstructure retentiveness, resin-based cements significantly evidenced higher retention than glass ionomer and temporary cements.

Key-words: CAD/CAM, Dental Implants, Abutment Design, Dental Cements, Zirconia.

RESUMO

RESUMO

Efeito da altura do pilar CAD / CAM e tipo de cimento na retenção de coroas de zircônia

Objetivo: Avaliar o efeito de diferentes alturas de interface de Titânio (Ti) e diferentes tipos de cimento na retenção de coroas de zircônia.

Métodos: Coroas idênticas foram projetadas em um software de CAD capaz de adaptar duas alturas diferentes do pilar de interface de Ti: cada grupo foi composto de 10 amostras conforme se segue: (i) interface de Ti de 4 mm de altura (alto) e (ii) interface de 2,5 mm de altura (curto). Foram selecionados quatro tipos de cimento: (i) cimento temporário (Provisional); (ii) Cimento de ionômero de vidro (Meron); (iii) cimento resinoso auto-adesivo (U200) e (iv) cimento resinoso convencional (Ultimate) com adesivo universal para tratamento de substratos de titânio e zircônia. O teste de tração foi realizado em uma máquina de ensaio universal. Os dados foram avaliados estatisticamente através de análise de variância a dois critérios, após comparações pós-hoc pelo teste de Tukey.

Resultados: As interfaces de Ti demonstraram retenção semelhante aos pilares curtos quando os dados foram colapsados sobre o cimento ($p > 0,74$). A avaliação dos dados em função do tipo de cimento demonstrou a superioridade dos cimentos à base de resina em relação aos grupos de cimentos temporário e de ionômero de vidro ($p < 0,01$). Os dados de retenção em função de ambos os fatores demonstraram força semelhante ao deslocamento, entre pilares altos e curtos, para todos dentro das comparações de cimento ($p > 0,42$), exceto para U200 ($p = 0,032$). Além disso, os pilares altos cimentados com Ultimate evidenciaram maiores valores de tração do que os cimentados com U200 ($p = 0,043$), e ambos foram significativamente mais retentivos do que o pilar alto cimentado com cimento Provisional e o Meron ($p < 0,001$). Não foi observada diferença significativa entre os cimentos U200 e Ultimate para pilares curtos ($p = 0,758$) e ambos apresentaram valores de tração estatisticamente mais elevados que os cimentos de ionômero de vidro e cimento temporário ($p = 0,001$).

Conclusões: Embora a altura da interface de Ti não tenha influenciado a retenção das coroas de zircônia, os cimentos resinosos resultaram em maior retenção do que o ionômero de vidro e cimentos temporários.

Palavras-chave: CAD, Implantes dentários, Cimentos dentários.

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1 INTRODUCTION

1 INTRODUCTION

Implant dentistry is a well-established treatment option that has been demonstrating high success rates in long-term follow-up studies (KARO USSIS et al., 2004; HJALMARSSON; GHEISARIFAR; JEMT, 2016). When implant surgical protocols are strictly followed, metallic device osseointegration is expected to be uneventful. Despite the high success rates, biological and technical complications are frequently described for implant-supported reconstructions (PJETURSSON, et al., 2004; SCHWARZ, et al., 2012). Although still debated, it seems that the rate of such complications in internally connected implants are lower compared to external connections (GRACIS, et al., 2012). In a systematic review that analyzed more than 1,000 patients, only 61.3% of them were free of any complication after 5 years in function (PJETURSSON, et al., 2004). Abutment or occlusal screw loosening was the most common technical complication (12.7%), followed by crown loss of retention (5.5%), veneer fracture (4.5%), and screw and abutment fracture (0.35%). Consequently, current research in implantology have been focused on the improvement of prostheses longevity and retrievability (PAPASPYRIDAKOS, 2012).

Most implant rehabilitations comprise one or two-piece restorations where a crown can be cemented or screwed on the abutment (HEBEL; GAJJAR, 1997; LEE; OKAYASU; WANG, 2010). Substantial literature findings are categorical concerning to the advantages and disadvantages of both prosthesis retention systems (GOODACRE; KAN; RUNGCHARASSAENG, 1999; PJETURSSON, et al., 2004; WITTNEBEN, et al., 2017). While screw-retained restorations are known for their retrievability, cement-retained advantages include enhanced esthetic, easy handling, reduced laboratory technique sensitivity, ability to correct minor casting misfits between the superstructure and abutment, prevention of microorganism colonization of the inner part of the implant, and possibility of implant alignment correction. Nonetheless, loss of retention is the weakness of such system along with periodontal concerns relative to remnants of cement in the gingival sulcus (WITTNEBEN, 2017).

Considering the increased use of the digital workflow in restorative dentistry, the use of abutments with geometry stored in CAD/CAM systems for rapid restoration

fabrication, also known as Ti-Base abutments, has gained interest. The rationale behind its indication lies on the possibility of conventional or digital implant transfer for design of monolithic or bilayered restorations of any given material that will be cemented chairside and then screwed to the implant. Improved control of bonding procedures can be achieved specially during excess cement removal. This feature is advantageous since extraneous cement in the peri-implant tissue may lead to marginal bone loss. As a disadvantage, the screw access hole will still be visible which may impair excellent esthetic results (PAULETTO, LAHIFFE, WALTON, 1999; RODRIGUEZ, 2017).

Cementation protocols for Ti-base abutments have been scarcely explored (GEHRKE, 2014). There are several factors that may affect the final prostheses retention such as Ti-base height and texturization, cement type, superstructure fit, and surface treatment (KENT, KOKA, FROESCHLE, 1997; COVEY et al., 2000; SCHIESSL, 2013). When the prostheses material is zirconia, additional challenges are encountered for adequate bonding. Due to its high crystalline content and absence of a glass phase (GRACIS et al., 2015), zirconia demands different surface treatments, compared to other glass-matrix ceramics (INOKOSHI, et al., 2014), that should be carefully undertaken since loss of retention is an important issue affecting clinical success rates of zirconia prostheses (SAILER et al., 2016; PJETURSSON, et al., 2017). The use of temporary cements have been indicated as a safe alternative for implant-supported metalceramic crowns compared to conventional and resin-based cements (SCHWARZ et al., 2012). Also, the use of self-adhesive resin cements, indicated to bond all-ceramic crowns to titanium abutments, have been suggested as a straightforward alternative since the application of adhesive systems is not required. Self-adhesive cements comprise a single-step cement that contain a resin matrix packed with phosphoric groups that simultaneously react with the ceramic surfaces and have demonstrated satisfactory bond strength to zirconia (PASSOS, et al., 2010). However, the lack of an adhesive layer has been claimed to hamper bond strength (AB-GHANI, et al., 2015), suggesting that strategies, including the use of 10-methacryloyloxydecyl dihydrogenphosphate (MDP) based resin cements, may improve the bond between Ti-base abutments and zirconia crowns (PAPIA et al., 2014; OZCAN; BERNASCONI, 2011).

The understanding of the relative retentiveness of Ti-base abutments to zirconia crowns using different cements should improve clinician's ability to choose a particular cementation protocol. Accordingly, this study sought to evaluate the effect of different Ti-base abutment heights and cement type on the pullout retention of zirconia-based restorations. The postulated null hypotheses were: (i) that Ti-base abutment height would not influence pullout retention values and (ii) cement type would not influence pullout retention values.

2 ARTICLE

2 ARTICLE

The article presented in this Dissertation was written according to International Journal of Prosthodontics instructions and guidelines for article submission (Annex)

EFFECT OF CAD/CAM ABUTMENT HEIGHT AND CEMENT TYPE ON THE RETENTION OF ZIRCONIA CROWNS

ABSTRACT

Aim: To evaluate Ti-base abutment height and cement type on the retentiveness of zirconia-based restorations.

Methods: 4mm- (Tall) and 2.5mm-height (Short) abutments along with temporary (Provisional), glass-ionomer (Meron), self-adhesive (U200) and conventional resin cement (Ultimate) were evaluated using pull-out testing (n=10crowns/group).

Results: Tall and short abutments demonstrated similar retention for all within cement comparisons, except U200 ($p=0.032$). Resin cements exhibited superior retentiveness than others ($p<0.01$). While no significant difference between resin cements for short abutments, Ultimate evidenced higher retention than U200 for tall abutments ($p=0.043$).

Conclusions: Ti-base height has not influenced crown retentiveness; however, resin-based cements were significantly more retentive.

Key-words: CAD/CAM, Dental Implants, Abutment Design, Dental Cements, Zirconia.

INTRODUCTION

Considering the increased use of the digital workflow in restorative dentistry, the indication of abutments with geometry stored in CAD/CAM systems for rapid restoration fabrication, known as Ti-Base abutments, has gained interest. Such abutments allow conventional or digital implant transfer for designing monolithic or bilayered restorations that will be cemented chairside and then screwed to the implant. Therefore, control of bonding procedures and retrievability comprise their main advantages.

Additionally, prostheses retention can be influenced by different parameters, such as abutment height and texturization, cement type, superstructure fit, and surface treatment, which have been scarcely explored for Ti-Base abutments.^{1, 2} This study evaluated the effect of Ti-base abutment height and cement type on the pull-out retention of zirconia-based restorations.

MATERIALS AND METHODS

Identical crowns were designed to fit two different Ti-base heights (Emfils, Itu, SP, Brazil), n=10/group: (i) 4mm (Tall) and (ii) 2.5mm height (Short) (Figure 1). Ti-base abutments and their corresponding internal conical connection implants (Novo Colosso, Emfils, Itu, SP, Brazil) were embedded in acrylic resin (Jet, Clássico Artigos Odontológicos, São Paulo, SP, Brazil).

Four cement types were assessed: (i) Temporary (Provisional) (Temp-Bond, Kerr Orange, CA, EUA); (ii) Glass-ionomer (Meron) (Meron, Voco, Cuxhaven, Germany); (iii) self-adhesive resin cement (U200) (RelyX U200, 3M Oral Care, St. Paul, MN, USA), and (iv) conventional resin cement (Ultimate) (RelyX Ultimate, 3M)

with universal adhesive (Scotchbond Universal, 3M). Abutments were torqued (32 N.cm) and cemented as per manufacturer's recommendations.

Pull-out testing was performed in a universal testing machine (Kratos, Sao Paulo, SP, Brazil) at a cross-head speed of 1mm/min until crown displacement and load drop. The force was recorded and statistically evaluated through two-way analysis of variance following post-hoc comparisons by Tukey test ($\alpha=.05$).

RESULTS

Standard 4mm-height abutments (Tall) demonstrated similar retention to 2.5mm (Short) when data are collapsed over cement type ($p>0.74$) (Figure 2A). On the other hand, resin-based cements (U200 and Ultimate) presented significantly higher pullout values relative to provisional and glass-ionomer cements ($p<0.01$), without significant difference between U200 and Ultimate and between provisional and glass-ionomer (data collapsed over Ti-Base height) ($p>0.34$) (Figure 2B).

Evaluation of pullout data as a function of both factors, Ti-Base height and cement, demonstrated similar force to dislodgment between tall and short abutments for all within cement comparisons ($p>0.42$), except for U200 ($p=0.032$) where short abutments were more retentive. While tall abutments cemented with Ultimate evidenced higher pullout values compared to U200 ($p=0.043$), no significant difference was observed between U200 and Ultimate cements used in short abutments ($p=0.758$).

DISCUSSION

The current study evaluated the effect of different Ti-base abutment height and cement type on the pull-out retention of zirconia-based restorations. Overall, similar retentiveness between tall to short abutments was demonstrated, except for U200 when both factors were analyzed with short abutments outperforming tall. Such result is in contrast to previous literature findings which postulate that the higher the abutment's axial walls or the height to width ratio the better the effect on the uniaxial testing values due to higher contact area.³

Furthermore, resin-based cements presented significantly higher force to dislodgment relative to provisional and glass-ionomer groups, without significant difference between both resin cements and also between provisional and glass-ionomer cement (collapsed data). This rank order corroborates with previous studies that evaluated pullout retentiveness of metal abutments using different cements ^{1, 2}. On one hand, the higher pull-out values of resin-based cements and absence of significant difference between them lies on their improved adhesion to zirconia due to phosphate groups content and similar composition (methyl methacrylate monomers)⁴. On the other hand, the notably lower retention for glass-ionomer and provisional cements are based on the absence or weak bond to zirconia due to lack of any bonding agent⁵.

There is no determination based on what constitutes a minimum pullout value that provides long retentiveness to an implant supported rehabilitation so that the patient would not have to return for prostheses recementation at an unexpected time. Then, the current study provided a scenario of bonding behavior of various cements

and abutment designs that may be used as a guide until clinical studies are conducted.

CONCLUSION

While Ti-base abutment height have not influenced zirconia superstructure retentiveness, resin-based cements significantly evidenced higher retention than glass ionomer and temporary cements.

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LEGENDS FOR ILLUSTRATIONS

Figure 1. Schematic with dimensions for the A) tall (4 mm height) and B) short (2.5 mm height) Ti-base abutments. C) Proximal view of the .stl file with projections that were designed with a round perforation of 2 mm (depicted in figure D) to provide the attachment of stainless steel wires for pull-out testing. E) Occlusal view shows the projections located at the cusp regions to allow occlusal access for abutment screw torqueing after cementation.

Figure 2. Pull Out retention values as a function of mean and 95% confidence interval. A) Ti-base abutment height have not influenced pullout retention values. B) Resin-based cements evidenced significant higher retentiveness than provisional and meron. C) Tall and short abutments presented similar force to dislodgment for all within cement comparisons, except U200; and, resin-based tall and short abutments demonstrated higher retentiveness than their provisional and meron counterparts. Different symbols indicate significant difference between groups.

Fig 1

Fig 2

3 DISCUSSION

3 DISCUSSION

One of the critical factors for implant supported restorations success is the connection integrity between the prosthetic superstructure and implant (BREEDING, et al., 1992). Such integrity is provided as a function of implant-prostheses retention using screw and/or cement. The advantages and disadvantages of restoring dental implants with a screw- or cement-retained superstructure are well documented (GOODACRE; KAN; RUNGCHARASSAENG, 1999; PJETURSSON, et al., 2004; SCHIESSL, 2013), but less frequently documented is the use of hybrid restorations which are both cemented and screwed. Nonetheless, besides the evident biomechanical advantages of cement-retained prostheses, most clinicians still opt for screw-retained due to the retrievability inherent to such assemblies (MICHALAKIS; HIRAYAMA; GAREFIS, 2003). It is worth to mention that the concern in supported prostheses cementation lies on ranking various cements to establish a guide for clinicians since retrievability and longevity in cement-retained prosthesis with provisional cements has been previously reported (KIM, et al., 2006; WORN, et al., 2015). Also, not only the adhesive bond strength is important to cementation longevity but also mechanical factors, such as frictional resistance (COVEY, et al., 2000; SCHIESSL, et al., 2013). Then, final prostheses retention depends on cement type, abutment height and texture, fit of the superstructure and prosthesis material composition (KENT; KOKA; FROESCHLE, 1997; COVEY, et al., 2000; SCHIESSL, et al., 2013).

Ti-base abutments are a somewhat novel concept that can be indicated not only for conventionally cemented rehabilitations but also as a link between implant and a monolithic customized crown or a high-strength customized ceramic abutment joint to a cement-retained crown (screwed three-piece restorations). The main advantages of such concept, as previously explained, comprise the absence of ceramic material inside the implant connection, reproduction of a tailored emergence profile, and last but not the least, the opportunity of performing the bonding procedure before crown placement. Such sequence of procedures support a final bond area polishing that decrease soft tissue reaction regarding remnants of cement (PAULETTO; LAHIFFE; WALTON, 1999; RODRIGUEZ et al., 2017). Nonetheless,

literature findings are scarce in addressing the influence of Ti-base height and cement type regarding to abutment-to-crown retention (GEHRKE, et al., 2017).

The abutment geometry, mainly taper degree and height, has been previously shown to affect the retentiveness of implant supported rehabilitations (KENT, KOKA FROESCHLE, 1997; BERNAL; OKAMURA; MUNOZ, 2003). In the present study, taper degree was standardized by the manufacturer, and the force to dislodgment for 4.0 mm (tall) and 2.5 mm (short) Ti-base abutments were compared. Both abutment cone heights demonstrated similar retentive force (data collapsed over cement). Even when data were evaluated as a function of both factors, similar force to dislodgment between tall to short abutments for all within cement comparisons was evidenced, except for U200. Consequently, the first postulated null hypothesis that Ti-base abutment height would not influence pull-out retention values was accepted. This result is in contrast to previous literature findings that have shown that the higher the abutment's axial walls or the height to width ratio the better the effect on the uniaxial testing values due to higher contact area (KENT, KOKA FROESCHLE, 1997; BERNAL; OKAMURA; MUNOZ, 2003). In one investigation, an approximately 1.5-mm-height increase in the axial wall of standard abutments (3.6 mm) evidenced twice retention strength values (KENT, KOKA FROESCHLE, 1997).

Previous studies have demonstrated that provisional cements can satisfactorily work for conventional cement-retained implant supported crowns (KIM, et al., 2006; WORNİ, et al., 2015). Consequently, the second postulated null hypothesis of the current study consisted on the assumption that cement type would not influence pull-out retention values, even for Ti-base abutments that possess a screw access. Nonetheless, the results demonstrated that resin-based cements presented significantly higher force to dislodgment relative to provisional and glass-ionomer groups, without significant difference between both resin cements and also between provisional and glass-ionomer cement (data collapsed over Ti-Base height). The same behavior was evidenced when data were evaluated as a function of both factors with resin-based cements demonstrating similar force to dislodgment between tall to short abutments and both significantly more retentive than tall and short provisional and Meron cements. This rank order corroborates with previous studies that evaluated pullout retention values for metal abutments with different cements (SCHIESSL, et al., 2013; GARG; PUJARI; KHARE, 2014).

The absence of significant difference between both resin-based cement lies behind their similar composition (methyl methacrylate monomers) (PASSOS, et al., 2010). The lack of an adhesive layer between zirconia superstructure and resin-based cements has been previously shown to hamper bond strength (AB-GHANI, et al., 2015), however, the retention is proposed to be improved with use of chemical surface treatments such as the addition of phosphate groups in the cement system (HILL; LOTT, 2011; PAPIA, et al., 2014). Both cements tested in the current study presented phosphate groups; self-adhesive U200 cement presents such monomers in its composition and Ultimate, even as a conventional cement, is recommended to be used with an adhesive system that also present MDP in its composition. On the other hand, the notably lower pullout retention values for glass-ionomer and provisional cements are based on the absence or weak bond to zirconia due to lack of any bonding agent, as previously reported (ROHR, et al., 2017).

Although time-consuming, the pullout test is an efficient alternative to determine the retentive force of abutment joint to zirconia restorations. Such a test is influenced by several factors such as the degree of fit, height of the planned restoration, taper angle and luting agent (HEINTZE, 2010). Consequently, the general coincidence with literature findings allows us to conclude that the rank ordering of the cements in the current study is valid. Actually, there is no determination based on what constitutes a minimum pullout value that provides long retentiveness to an implant supported rehabilitation so that the patient would not have to return for prostheses recementation at an unexpected time. Then, the current and previous studies provide a scenario of the bonding behavior of various cements and abutment designs that may be used as a guide until clinical studies are conducted (SHEETS; WILCOX; WILWERDING, 2008).

4 CONCLUSION

4 CONCLUSION

While Ti-base abutment height have not influenced zirconia superstructure retentiveness, resin-based cements significantly evidenced higher retention than glass ionomer and temporary cements.

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ANNEX

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