ARTIGO ORIGINAL

COMPARISON BETWEEN RETENTION OF ZIRCONIA CROWNS PRODUCED BY CAD CAM SYSTEM CEMENTED ON TIBASE AND CONVENTIONAL TITANIUM UCLAS

Comparação na retenção de coroas de zircônia produzidas por sistema CAD CAM cimentadas em TiBase e em UCLAS convencionais de titânio

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ABSTRACT

Introduction: Prostheses over implants in the digital flow have been used in a number of clinical contexts with efficacy both in terms of adaptability and durability. Objective: the present study aims to compare machined zirconia crowns (Ceramill Zolid FX Multilayer - AmannGirrbach), scanned with a bench scanner (Ceramil map 300) and cemented on TiBase, which is currently the traditional method for the retention of these types of crown, and on UCLA, which represents an option to the traditional technique. Methodology: Thirty zirconia crowns divided into two groups (n=15) according to prosthetic component, G1 cemented on TiBase and G2 cemented on titanium UCLA were cemented and submitted to tensile test. Cementing was conducted with dual resinous cement Allcem, FGM. Tests were conducted in a Universal Testing Machine EMIC with load cell of 2000 kgf and speed of 0.5 mm/min. Mann-Whitney test was used to analyze the results. Calculations were done using SPSS 23 (SPSS INC., Chicago, IL, USA) and BioEstat 5.0 (Fundação Mamirauá, Belém, PA, Brasil), with 5% of significance. Results: The analyses of data showed that the zirconia crowns cemented on UCLA presented better retention than those cemented on TiBase. Conclusion: According to results shown here, cementing of zirconia crowns on titanium UCLA present better retention than those cemented on TiBase.

Keywords: Dental Implants; Dental Implants Connection; TiBase.

RESUMO

Introdução: Próteses sobre implantes no fluxo digital têm sido utilizadas em diversos contextos clínicos com eficácia tanto em termos de adaptabilidade quanto de durabilidade. Objetivo: o presente estudo tem como objetivo comparar coroas de zircônia usinadas (Ceramill Zolid FX Multilayer - AmannGirrbach), escaneadas em scanner de bancada (Ceramil map 300) e cimentadas em TiBase, que atualmente é o método tradicional para retenção desses tipos de coroa, e em UCLA, que representa uma opção à técnica tradicional. Metodologia: Trinta coroas de zircônia divididas em dois grupos (n=15) de acordo com o componente protético, G1 cimentada em TiBase e G2 cimentada em titânio UCLA foram cimentadas e submetidas ao ensaio de tração. A cimentação foi realizada com cimento resinoso dual Allcem, FGM. Os ensaios foram realizados em Máquina Universal de Ensaios EMIC com célula de carga de 2000 kgf e velocidade de 0,5 mm/min. O teste de Mann-Whitney foi utilizado para análise dos resultados. Os cálculos foram feitos usando SPSS 23 (SPSS INC., Chicago, IL, EUA) e BioEstat 5.0 (Fundação Mamirauá, Belém, PA, Brasil), com 5% de significância. Resultados: As análises dos dados mostraram que as coroas de zircônia cimentadas em UCLA apresentaram melhor retenção do que aquelas cimentadas em TiBase. Conclusão: De acordo com os resultados aqui mostrados, a cimentação de coroas de zircônia em titânio UCLA apresenta melhor retenção do que aquelas cimentadas em TiBase.

Palavras-chave: Implantes Dentários; Conexão de Implantes Dentários; TiBase.

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INTRODUCTION

Titanium implants allow a wide range of rehabilitation options. The right choice and application of such implants can solve issues that up to recently were unrealistic [22].

The search for innovative, fast and standardized solutions is a part of the evolution process of any occupation and in Dentistry, it is no different. From the 1970's on, the first step toward digitalization was given by Professor François Duret, who described an optical molding method; however, one decade later an applicable system was developed by Mörmann [43,44].

After the introduction of CAD CAM systems in the late 1980's, digital Dentistry reached the status of a precise and practical technique in comparison with the conventional analog technique [1,78].

Implant-supported prostheses on the digital flow have been widely studied and used in a number of clinical situations and have been shown effective both in terms of adaptability and durability [35].

Considering the development of the digital flow in Dentistry, one factor has been notably impacted – the abutments. TiBase (titanium base abutment) was developed to allow the digital transfer of the tridimensional positioning of the implant through scanning, enabling an agile and precise flow [68].

There are, however, some points not completely clarified and the most efficient way to attach this system is still under debate [20].

Although there are previous studies investigating TiBase abutments, literature still lacks studies on tensile tests where titanium UCLAs are used as abutments for the digital prostheses.

In face of the discussion posed above and guided by the belief that research should be conducted to seek scientific development and to help professionals in their choice for material and techniques, this study compares the retention of two different prosthetic components to be used in the digital flow: the commonly used TiBase components vs titanium UCLAs as prosthetic abutment connecting the dental implant and the prosthetic crown.

LITERATURE REVIEW

Prosthetic components

The manufacturing of fixed prostheses over implants involves connecting the titanium implant and the prosthetic abutment, which is also called connection or transmucosal pillar [9].

Succinctly, prosthetic components can be divided in three main groups according to composition: plastic, used in the casting process in the analog prostheses, metallic and ceramic, used in the digital flow [50].

Digital dentistry brought along some novelties and some restoration material replaced those used in the analog flow, majorly dependent on the casting process. Among those are zirconia, lithium disilicate, hybrid ceramics and resins containing ceramic particles [73].

Zirconia crowns cemented on metallic abutments are the standard choice for single crowns over implants produced in the digital flow. Durability and survival rates, above 94%, seem to base this choice [56].

During cementing, controlling the excess of cement and humidity is difficult to achieve. The possibility of cementing the crowns to the work model reduces the risk of gingival inflammation and improves the adhesive cementing quality [52].

Although results encourage the choice of zirconia cemented over metallic abutments, some processes need to be well understood to avoid technical complications that might lead to failure [62].

Cementing of zirconia to metal is a critical procedure. Both materials are highly opaque and present low adhesive capacity even when submitted to previous surface treatments, which may lead to the loss of retention over the years [4].

UCLA abutment

Developed by the University of California, in Los Angeles, it consists of a tube that might be metallic, plastic or plastic on a metallic base. Metallic UCLA abutments are commonly used in temporary applications, although they allow permanent cementing. The plastic and the plastic with a metallic base are used for casting and over-casting, respectively [9].

UCLA abutments are considered very versatile because they do not require an ample prosthetic space. As a disadvantage, UCLA abutments are screwed directly on the implant, which can create stresses that would be minimized if an intermediate were used [9].

TiBase

TiBase, also known as metallic link or titanium base, is an abutment used in the digital flow. Its base has a machined structure with the geometric characteristics of the implant or prosthetic connection. It can be attached to a scan body compatible with CAD/CAM systems allowing the scanning and transference of the implant positioning to the design and machining software. After manufactured, the prosthetic piece is cemented on TiBase, which is screwed to the mouth, thus completing the prosthetic restoration [18].

Scanning

In its basic concept, a scanner is a device capable of obtaining and digitalizing images, thus replacing the molding process [33,65].

3D scanners are somehow similar to photographic cameras; however, due to its conical field of view, the cameras cannot capture geometrical information. The scanners, on the other hand, are capable of capturing information on the landscape of the scanned object. Hence, to transform a real object into a digital one, the scanner analyses and converts the object into a combination of binary codes, and rebuild it as a polygonal mesh through a software [23].

CAD systems use a computer file called stl – abbreviation of Standart Triangle Language. This type of file rebuilds the scanned object through triangles. The larger the number of triangles and the smaller the gaps between them, the more precise the system will be [23].

The scanner used in the present study is Ceramill Map 300 of Amann Girbach. It is a bench device used in prosthetic laboratories that aim to transform a plaster mold created by the conventional molding method into a stl image, enabling for the use of CAD CAM technologies for dentists who lack the intraoral scanner in their practice.

CAD CAM process

Once the tridimensional image is generated through an independent scanner, whether intra or extraoral, the next steps are the design and production of the piece [66].

The design process is known as CAD – computer aided design – a production process that correspond to CAM - computer aided manufacturing [66].

The prosthetic restoration can be generated by a 3D printing process or using a subtractive method where a milling machine cuts into a block to produce the object designed in the previous step [66].

The wide range of rehabilitation options encompassed by CAD CAM systems is due to the large variety of available material. Currently there are ceramic, resinous, acrylic, metallic materials, among others, all of which are to be used in the digital flow [7].

Zirconia

Zirconia is the most resistant ceramic used in dentistry, with high flexural strength and increased fracture toughness. This material was introduced in the 1990's and, with the conformation of block for machining through CAD CAM technology, it has become one of the most commonly used materials in rehabilitations over teeth and implants for single or multiples cases [31].

Zirconia or zirconium dioxide (ZrO^2) presents three crystal forms: monoclinic, cubic and tetragonal. The monoclinic phase is stable at room temperature, but its mechanical characteristics hinders its use as dental ceramic. Tetragonal phase presents the best mechanical properties, but it is stable only in very high temperatures: 1150-2370 °C. To allow its use at room temperature, other oxides based on Magnesium (Mg), Calcium (Ca), Yttrium (Y), Cerium (Ce) need to be added as stabilizers [31].

Yttrium oxide with its relatively fine grains has been shown as the most effective stabilizer oxide, providing high strength and toughness to zirconia 72.

Retention in Zirconia crowns

The fixation process of a cemented crown depends on the imbrication (mechanical retention) and adhesion (chemical bond). Therefore, when both bonding mechanisms are promoted, the chances of a successful restoration increase [64].

Mechanical factors such as convergence angle, mechanical friction and prosthetic component height influence the zirconia crown retention to the metallic components [63].

However, adhesion in zirconia structures is not as efficient as in feldspar and vitreous ceramics. This can be explained by the large amount of crystal content and the small vitreous matrix (below 1%), rendering hydrofluoric acid etching ineffective to create micro-retentions [11].

In an attempt to improve bonding between resinous cement and zirconia, several surface treatments have been described, including blasting, laser, silica coating, among others [77].

Surface treatments with aluminum oxide or silica blasting have shown good results to improve adhesion [71].

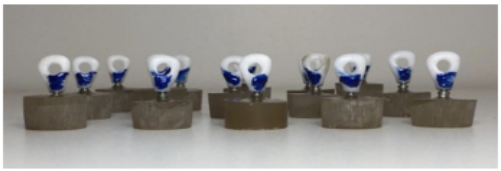
Overall, ceramic restorations should be cemented with resinous cements, ideally. They are capable of providing high retention and improving adaptation, because they seal small gaps created during blasting or corrosion, thus reducing marginal infiltration and reinforcing the ceramic [48].

METHODOLOGY

The present study has been approved by the Research Ethics Committee of Faculdade São Leopoldo Mandic under the protocol number 2023 – 0328 as a study that does not involve human participants, either in its totality or its parts, directly or indirectly, including management of data, information or biological material.

Using the software Ceramill Mind (Amann Girbach), 30 test specimens were designed, they were machined in a milling machine Ceramill Motion 2 (Amann Girbach) to simulate upper central incisor crowns with identical external geometry; perforations were created in the center of the crown, from vestibular to lingual, to attach the metallic hook for the tensile test (Lopes et al., 2019). Two groups were defined – the control group consisting of 15 Yttrium-stabilized polytetragonal zirconia specimens (Ceramil Zolid, Amann Girbach) cemented on TiBase (Consist Sistema de Implante LTDA) and the test group consisting of 15 zirconia specimens identical to the control group, but cemented on titanium UCLAs (Consist Sistema de Implante LTDA).

Figure 1 – Group 1: Zirconia crowns cemented on TiBase.



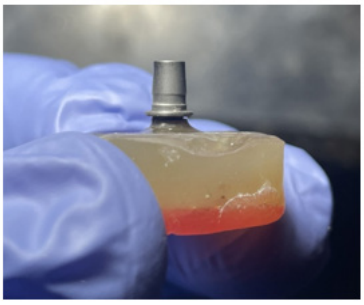
Source: own authorship.

Figure 2 – Group 2: Zirconia crowns cemented on UCLA.

Source: own authorship.

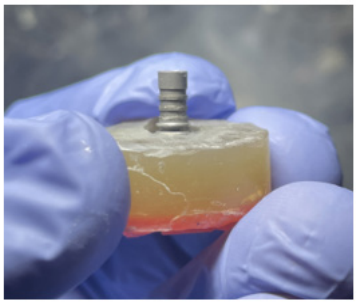
The test specimens were standardized using CM implant analogs with 11.5 º internal tilt (Consist Sistema de Implante LTDA). TiBase and titanium UCLA were applied on the analogs in the control and test groups, respectively. Both groups are fixed with lamination resin (Mazadur, Maza) to a PVC pipe (Tigre) to facilitate the attachment to the testing machine (EMIC) for the tensile test 22.

Figure 3 - TiBase fixed to acrylic.



Source: own authorship.

Figure 4 - UCLA fixed to acrylic.

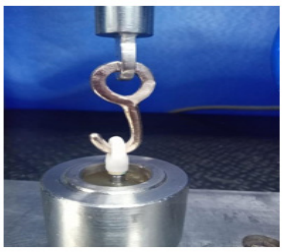


Source: own authorship.

The zirconia crowns of both groups were cemented with dual resinous cement Allcem, FGM (DENTSCARE LTDA)

The tensile test was conducted on a Universal Testing Machine EMIC with load cell of 2000 kgf and speed of 0.5mm/min at Faculdade São Leopoldo Mandic, in Campinas

Figure 5 – Tensile test.



Source: own authorship.

We applied the Mann-Whitney test to compare the maximum tensile load sustained by the test specimens with TiBase and UCLA intermediates because of the variance heterogeneity and non-gaussian distribution of results. Calculations were done on SPSS 23 (SPSS INC., Chicago, IL, USA) and BioEstat 5.0 (Fundação Mamirauá, Belém–PA, Brasil), with level of significance of 5%.

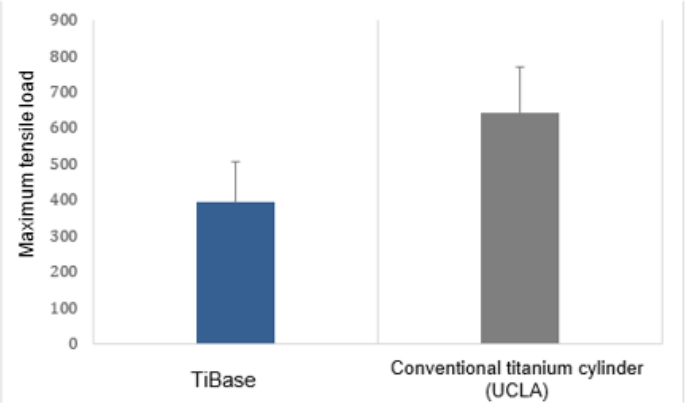
RESULTS

Table 1 – Average (standard deviations) and minimum and maximum values of maximum tensile load (N) of zirconia crowns machined and cemented on different intermediates.

Intermediate	Average (standard deviation)	Minimum and maximum values
Ti-Base	394.37 (113.09) B	293.38 and 771.98
Conventional titanium cylinder (UCLA)	642.14 (129.34) A	149.16 and 533.74

Caption: Ti-Base: n= 14; UCLA: n = 12.
Source: own authorship.
Averages followed by different uppercase letters indicate significant difference.

Graph 1 – Bar graph of maximum tensile load of zirconia crowns machined and cemented on different intermediates.



Caption: Ti-Base: n= 14; UCLA: n = 12. Vertical lines on each bar indicate standard deviation.
Different uppercase letters over the bars indicate significant difference between groups.
Source: own authorship.

DISCUSSION

The selection of prosthetic components for fixed prostheses over implants is an important step to ensure longevity. Professionals agree that the choice of the prosthetic components is based on multiple parameters [2,9,10,42,50,51,55,59,76].

CAD CAM systems depend on specific metallic prosthetic components, usually titanium. Previous studies on durability and survival have shown that the use of TiBase for single zirconia crowns is reliable. [56]

The use of these abutments in the rehabilitator flow has created a hybrid type of prostheses that are screwed and cemented. Traditional cemented prostheses present better biomechanical properties in the long term [47]. However, the majority of dentists prefer screwed prostheses due to the easiness of maintenance 40 another aspect that disfavors the cemented technique and control on cement removal that may cause gingival irritation, the hybrid prostheses modal is very interesting, since it allows reversibility to a cemented system [54].

TiBase abutments present a titanium-titanium connection that provide good mechanical and biological properties: no gaps between implant and prosthetic abutment, possibility of milling a customized emergency profile in ceramic allowing maintenance of the gingival outline, thin cement layer used in the bonding between crown and prosthetic abutment performed outside of the mouth and with high degree of polishing, the sum of these aspects produce peri-implant health[17,38].

The mechanical resistance of titanium prosthetic abutments, in this case both TiBase and titanium UCLAs, are known for its higher toughness and resistance to fracture; because the process does not depend on casting, the metal is not submitted to high temperatures, offering great adaptability. The casting process is considered critical for totally calcinable components; previous studies show that the wax pattern is not perfectly reproduced in the cast metal [73].

The use of titanium UCLAs for the digital flow can be justified by its versatility and low cost. The UCLA component has the advantage of solving situations where the inter-occlusal and interproximal space are limited [34].

Another situation where UCLAs should be the material of choice is when the height of gingival tissue is insufficient. In this condition, the use of an intermediate can lead to the exposure of the metal belt, hindering aesthetics [25].

UCLAs are components that connect directly to the implant without intermediates; therefore, they are counter-indicated in cases of very deep peri-implant grooves. Handling of the implant platform in deep groove cases can induce apical migration of tissues [45].

In cases where implant positioning is highly tilted, UCLAs should be avoided in screwed prostheses because the emergence of the screw can affect anatomy and, as a consequence, the crown aesthetics. In these cases, cemented prostheses are recommended.

The literature and experience of professionals show that UCLAs can be used in a large number of clinical situations.

In the present study, a tensile test was proposed to assess the retention strength of zirconia crowns cemented with conventional resinous cement to two types of prosthetic components: TiBase and UCLA. Although there is no scientific consensus in terms of a safe minimum value for retention, comparing current and previous data can offer guidance to clinical decisions [36].

This study assesses the retention behavior of zirconia crowns cemented to titanium UCLA components to check if it can be used as an option to TiBase.

It has been discovered that the design, height and conicity affect the retention of zirconia crowns cemented to titanium abutments. Other studies note that the bigger the parallelism and height per width ratio, the bigger the retention, impacting directly the clinical scenarios where the prosthetic space is limited[6].

Other factors that may influence retention of the zirconia crowns to metallic components are type of cement and surface treatment [6,63].

Cements that were believed to play a key role on treatment success have been found as mere adjuvants. It is a consensus that resinous cements have more cementing strength; however, temporary cements show adequate strength for fixation, even in permanent applications[63].

Surface blasting also affects positively the retention of zirconia crowns because it provides roughness, increasing the cementing area through interlocking [28].

Although factors such as type of cement and surface treatment are very important in the clinical practice, in the present study, these variables were not taken into consideration because the focus was on the geometry of TiBase and UCLA abutments and their retentive capacities with the use of conventional resinous cement, which are the most recommended for zirconia crowns cementing to metallic abutments [79].

The present study reveals that the type of prosthetic component affects the results.

Although the crown tensile test does not perfectly simulate the buccal conditions, this is an efficient test to compare geometries, the main aspect of this study [63].

The diversity of implant brands and models makes the choice of rehabilitation system a task that requires a lot of knowledge. The present study focused on tensile tests of zirconia crowns cemented on TiBase and titanium UCLA. New studies are needed to analyze other aspects such as fatigue and aging, better simulating the buccal environment.

CONCLUSION

According to the results found in this study, the cementing of zirconia crowns to titanium UCLAs present better retention in comparison with TiBase abutments.

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Observação: os/(as) autores/(as) declaram não existir conflitos de interesses de qualquer natureza.