UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

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Integrity of CAD/CAM onlays in ceramic and resin composite, associated or not with filler core – in vitro study

Integridade de restaurações CAD/CAM de cerâmica e resina composta tipo onlay, associadas ou não ao núcleo de preenchimento – Estudo in vitro

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Dissertação apresentada a Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Mestre em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Dentística.

Orientador: Prof. Dr. Sérgio Kiyoshi Ishikiriama

BAURU

2020

Queiroz, Camila Thais
Integrity of CAD/CAM onlays in ceramic and resin composite, associated or not with filler core – in vitro study / Camila Thais Queiroz – Bauru 2020.

61p, il, 31cm.

Dissertação (Mestrado) – Faculdade de Odontologia de Bauru. Universidade de São Paulo

Orientador: Prof. Dr. Sérgio Kiyoshi Ishikiriama

Comitê de Ética da FOB-USP
Protocolo: 18008718.8.0000.5417
Data: 16/07/2019

FOLHA DE APROVAÇÃO

DEDICATÓRIA

Dedico este trabalho à minha família, em especial aos meus pais, Nelson e Glaura que nunca mediram esforços para me ajudar a concretizar meus sonhos e continuam me apoiando e ajudando a enfrentar cada obstáculo para realizar minhas metas de vida.

AGRADECIMENTOS GERAIS

A **Deus e Nossa Senhora Aparecida,** por me guiar e renovar minha fé todos os dias.

A **minha família**, meus irmãos (Bruno e Dhiego), cunhadas (Glaucia e Aline), sobrinha (Lívia) que sempre me incentivaram e torceram para que eu concluísse mais essa etapa.

Especialmente ao meu pai, **Nelson Queiroz** e minha mãe **Glaura Thais Luisi Queiroz** que não medem esforços para realizar as minhas metas. Vocês são meu exemplo de vida, desde quando decidi cursar odontologia tive o apoio de vocês, mesmo sabendo que não iria ser fácil. Pai, você é meu super herói, um exemplo, me sinto privilegiada por estudar e trabalharmos juntos. Mãe, você é minha preciosidade, a melhor que eu poderia ter. Vocês são a minha base. Amo vocês.

Aos meus amigos que a vida me deu, que sempre estiveram ao meu lado. Obrigada pelo companheirismo e momentos de distração.

Em especial a minha amiga **Helize Ane Cursino**, que sempre esteve do meu lado em todas as situações da minha vida, uma amizade que começou na graduação e permanece até hoje. Minha irmã, muito obrigada. Amo você.

Ao meu namorado **Carlos Rodrigo Fonseca Chieppe** que me apoia todos os dias, e deixa meus dias mais felizes. Também, obrigada pela sua paciência. Te Amo.

A minha turma de mestrado 2017, **Camila L., Alyssa, Daniela, Genine, Juliana, Francielly, Mariele, Leandro, Naoki e Victor**. Muito obrigada meus amigos, foi maravilhoso conhece-los e passar esses anos com vocês, obrigada pelo companheirismo e ensinamentos.

Aos colegas de pós graduação, que sempre me incentivaram e me ajudaram de alguma forma, desde meu egresso como aluna especial do mestrado.

Em especial quero agradecer **Fernanda Sandes Lucena, Camila Libardi e Leandro Edgar Pacheco** que se tornaram amigos desde o começo dessa jornada, posso dizer que são anjos, por que foram essenciais na minha formação. Obrigada pelos ensinamentos, companheirismo e risadas. Vou levar vocês pro resto da vida no meu coração. Amo vocês.

Ao meu colega **Edgar Massunari Maenosono** que foi meu parceiro e essencial no desenvolvimento da minha pesquisa. Muito Obrigada, você é especial.

Aos professores do Departamento de Dentística FOB-USP: **Prof. Dr. Rafael Mondelli, Prof. Dr. José Mondelli, Profa. Dra. Linda Wang, Dra. Juliana Fraga Soares Bombonati, Profa. Dra. Ana Flávia Sanches Borges Profa. Dra. Maria Teresa Atta, Prof. Dr. Aquira Ishikiriama, Prof. Dr. Adilson Yoshio Furuse, Profa. Dra. Diana Gabriela Soares, Prof. Dr. Paulo Afonso Silveira Francisconi e Profa. Dra. Maria Fidela de Lima Navarro** que contribuíram para a minha formação profissional e pessoal. Sou fã de vocês. Muito Obrigada.

Ao meu orientador **Prof. Dr. Sérgio Kiyoshi Ishikiriama**, que me acolheu e foi essencial pelo meu crescimento profissional e pessoal. Muito obrigada professor, pelo seu ensinamento, incentivo, conselhos e paciência.

Aos funcionários do Departamento de Dentística FOB-USP: **Nelson, Rita, Audria**, **Natália**, **Charlene**, **Alcides, Elísio** e **Zuleica,** que sempre com muita alegria, carinho e paciência me ajudaram em todos esses anos. Muito obrigada.

AGRADECIMENTOS INSTITUCIONAIS

À **Faculdade de Odontologia de Bauru - Universidade de São Paulo (FOB-USP)**, por todo conhecimento que me proporcionou durante o mestrado, foi a realização de um sonho poder estudar nessa instituição.

À **Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES**) - Código de Financiamento 001 que financiou parte deste estudo (#134118/2017-0).

Ao **Prof. Dr. Vahan Agopyan,** digníssimo reitor da Universidade de São Paulo.

Ao **Prof. Dr. Carlos Ferreira dos Santos**, diretor da FOB-USP e exemplo de dedicação e profissionalismo.

À **Prof. Dra. Profa. Izabel Regina Fischer Rubira de Bullen**, presidente da Comissão de Pós-graduação da FOB-USP.

ABSTRACT

Integrity of CAD/CAM onlays in ceramic and resin composite, associated or not with filler core – in vitro study.

This in vitro study evaluated the integrity of indirect onlay restorations made of leucite-reinforced ceramic (IPS Empress CAD, Ivoclar Vivadent, Schaan, Liechtenstein) and nanoceramic composite resin (LAVA Ultimate, 3M ESPE, São Paulo, Brasil), with and without resin composite filler core (Tetric Ceram, IvoclarVivadent and FiltekZ350 XT, 3M ESPE). Sixty extracted third molars were prepared by planning the occlusal surface with total removal of enamel, until a standard 3mm high crown were obtained. The preparation was performed involving only the distal half of the remaining crown, which was worn with total removal of 2 mm in height of the crown, remaining 1 mm of enamel in the cervical region to make the chamfered end. After standardized preparation, the specimens were divided into four groups: (n=15): Group 1: Leucite-reinforced ceramic onlays without filler core (LC); Group 2: nanoceramic resin composite onlays without filler core (NRC); Group 3: leucite-reinforced ceramic onlays with previous filler core (LC-F) and Group 4: nanoceramic resin composite onlays with previous filler core (NRC-F). In groups 3 and 4 specimens, the filler cores were made with composite resin and over the resin filler core, a standardize preparation was made. All prepared specimens were scanned by a intraoral digital scanner and the ceramic and nanoceramics resin blocks were milled in CAD / CAM to obtain partial crowns that were cemented with Variolink N dual resin cement, (Ivoclar Vivadent, Schaan, Liechtenstein) for ceramics and RelyX Ultimate (3M, ESPE) for nanoceramic resin composite. The specimens were stored in distilled water in an oven at 37 °C throughout the process and at least 24 hours before testing .After cementation, the margins of all restorations were polished and subsequently, all samples were subjected to thermomechanical stress cycling from 5 ° to 55 ° C, simultaneously with compression cycling at different load intensities (100, 200, 300, 400, 450N) in each level 20,000 cycles were performed, totaling 100,000 cycles. At the end of the thermomechanical cycling, the onlays integrity was measured by the presence of cracks and catastrophic fractures, measured by scores. The scores were submitted to statistical analysis Friedman

repeated measures test with significance level of α=0,05, where no significance were found for both variation factors (“material” and the presence of “filler core”), since the survival rate between the groups were similar.

Keywords: Onlay. Leucite. Nanoceramic resin composite. Filler core. CAD/CAM.

RESUMO

Integridade de restaurações CAD/CAM de cerâmica e resina composta tipo onlay, associadas ou não ao núcleo de preenchimento – Estudo in vitro.

Este estudo in vitro avaliou a integridade de restaurações indiretas onlay feitas de cerâmica reforçada com leucita (IPS Empress CAD, IvoclarVivadent) e resinas nanocerâmicas (LAVA Ultimate, 3M ESPE), com e sem núcleo de resina composta. (Tetric Ceram, IvoclarVivadent e Filtek Z350 XT, 3M ESPE). Sessenta terceiros molares extraídos foram preparados planificando a superfície oclusal com remoção total do esmalte, até obter uma coroa padrão de 3 mm de altura. O preparo foi realizado envolvendo apenas a metade distal da coroa, que foi desgastada com remoção total de 2 mm de altura da coroa, permanecendo 1 mm de esmalte na região cervical para confeccionar o término chanfrado. Após o preparo padronizado, as amostras foram divididas em quatro grupos: Grupo 1: restaurações cerâmicas reforçada com leucita sem núcleo de preenchimento (LC); Grupo 2: restaurações resina nanocerâmica sem núcleo de preenchimento (NRC); Grupo 3: restaurações cerâmicas reforçadas com leucita com núcleo de preenchimento prévio (LC-F) e Grupo 4: restaurações resina nanocerâmica com núcleo de preenchimento prévio (NRC-F). Nas amostras do grupo 3 e 4, os núcleos de preenchimento foram feitos com resina composta e, sobre o núcleo de preenchimento, foi feita uma preparação padronizada. Todas as amostras preparadas foram digitalizadas por um scanner digital intraoral e os blocos de resina nanocerâmica e cerâmica foram fresados em CAD / CAM para obter coroas parciais que foram cimentadas com cimento resina Variolink N duplo (Ivoclar Vivadent, Schaan, Liechtenstein) para cerâmica e RelyXUltimate (3M, ESPE, São Paulo, Brasil) para resinas compostas de laboratório. As amostras foram armazenadas em água destilada em um forno a 37 ° C durante todo o processo e pelo menos 24 horas antes do teste. Após a cimentação, as margens de todas as restaurações foram polidas e, posteriormente, todas as amostras foram submetidas a ciclos termomecânicos de 5 ° a 55 ° C, simultaneamente com ciclos de compressão em diferentes intensidades de carga (100, 200, 300, 400, 450N) em cada nível foram realizados 20.000 ciclos, totalizando 100.000. Ao final do ciclo termomecânico, a integridade dos onlays foi medida pela presença de trincas e fraturas catastróficas, medidas por escores. Os escores foram

submetidos à análise estatística do teste de medidas repetidas de Friedman, com nível de significância de α = 0,05, onde não foram encontradas significâncias para os fatores de variação (“material” e presença de “núcleo de preenchimento”), uma vez que a taxa de sobrevivência entre os grupos foi semelhante.

Palavras-chave: Onlay. Leucita. Resina composta nanocerâmica. Núcleo de preenchimento. CAD/CAM.

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LIST OF ABBREVIATIONS AND ACRONYMS

CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CEJ	Cement Enamel Junction
Hz	Hertz
LC-F	Leucite with filler core
LC	Leucite without filler core
mm	Milimeter
N	Newton
NRC-F	Nanoceramic resin composite with filler core
NRC	Nanoceramic resin composite without filler core

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1 INTRODUCTION

1 INTRODUCTION

Onlay restorations are indicated for posterior teeth with large loss of coronary structure, usually involving more than one cusp or for teeth with extensive restorations that need replacement and can be made directly or indirectly with composite resin or some ceramic systems[1]. Among the direct-use materials available for restorative dentistry practice, composite resin can be considered the most versatile due to its aesthetic characteristics, ease of handling and adhesive properties. Currently there are also indirect composite resin systems that have conquered the dental market due to their technical ease, besides the additional polymerization methods, incorporation of inorganic particles, possibility of repair, reinforcement of remaining dental structure and conservative preparation[2].

In the early 1980s, with the primary objective of improving the physical-mechanical properties of the existing direct-use composite resins, they suggested first-generation indirect microparticulate resins (Dentacolor, Kulzer; Isosit N, Ivoclar; Visio-Gem, 3M ESPE), where through more efficient laboratory polymerization processes it was possible to improve some properties. This technological development has increased the possibilities of indicating this restorative material for anterior and posterior teeth with a high incidence of chewing efforts[3,4] .

The development and evolution of CAD / CAM technology has led to a revolution in the ways in which restorative materials are produced, broadening its clinical indications. Composite resins also started to be used in CAD / CAM systems when, from the Z100 composite came the MZ100 system, which was currently replaced by the 3M ESPE LAVA Ultimate[5], aiming at obtaining some advantages over ceramics, such as the reduction of the cost associated with a stronger resinous material. Thus, with all this technological evolution, nowadays indirect technique composite resins can be used as more conservative and functional options in onlays, and their current indications for posterior teeth restorations are practically no different from ceramics[6].

Still among the aesthetic restorative materials, ceramics can be considered a great alternative to reproduce the structures of natural teeth. Although generally debatable, ceramics are still considered the material of choice when dealing with indirect restorations, and their routine use is increasingly frequent, despite the long history of these materials in dentistry.[7]

Among the numerous modifications that ceramic systems have undergone, the pursuit of improving mechanical properties without losing aesthetic and adhesive properties has always been a priority. Among the currently available reinforced ceramics, reinforced glass ceramics stand out, which combine an adequate flexural strength for use without metal, and maintain the adhesive property that allows more conservative biomechanical preparations to be performed.[8]

One of the most suitable materials for subsequent indirect restorations is leucite-reinforced ceramics. The IPS Empress system (Ivoclar Vivadent, Schaan, Liechtenstein) was developed at Zurich University, Zurich, Switzerland in 1983. But only in 1990 was it available for clinical use[7]. The IPS Empress system consists of a leucite-reinforced fused glass ceramic initially designed for full restorations, however, according to the manufacturer, it can currently be indicated for the manufacture of inlays, onlays, crowns and veneers.[9]

The growing demand for an aesthetic smile has stimulated the development of metal-free ceramics such as feldspar, formed by feldspar, quartz and kaolin, followed by other types such as lithium disilicate-reinforced pressure sensitive porcelain and infiltrated porcelain by glass, expanding the choice of ceramics for indirect restorations. These improvements in mechanical resistance were necessary, in addition to the aesthetic issue, because feldspar ceramics are known for their higher incidence of fractures in the body of the blocks, mainly associated with their low flexural strength.[4,8] However, it was these mechanical enhancements that allowed the ceramics to be machined and associated with CAD / CAM systems.

For clinical success, besides the indirect restorative material, many other factors are involved, especially the biomechanical preparation of the remnant.[10] This concern with the preparation of the dental element for indirect restoration has long been the object of numerous clinical and laboratory studies, especially when the adhesion process was incipient and retention depended mainly on mechanical retention, and available materials were less resistant and needed a uniform thickness to decrease the incidence of stress concentration and body fractures. Thus, in extensively destroyed teeth, the restorative protocol for confection of indirect onlay restorations involved a previous reconstruction of the dental remnant, which later allowed to perform a biomechanical preparation that should respect two main principles: uniform thickness of the indirect restorative material and mechanical retention.

Despite the evolution of ceramics that resulted in improvement of its mechanical properties and the knowledge of adhesion today, the biomechanical preparation whose principle should be associated with the restorative material, seems not to have accompanied this evolution. Thus, the classic biomechanical preparation of extensively destroyed teeth with previous reconstruction (filler core) continues to be advocated, despite all this evolution of indirect restorative materials and bonding systems. Therefore, there is a need to investigate whether the composite resin filler core is still necessary for the integrity of indirect restorations.

Therefore, the objective of this study was to comparatively evaluate the integrity of indirect onlay restorations made of leucite-reinforced ceramic (IPS Empress CAD, IvoclarVivadent, Schaan, Liechtenstein) and resin nanoceramic (LAVA Ultimate, 3M ESPE), with and without composite resin filler core after thermomechnical cycling test.

2 ARTICLE

2 ARTICLE

The article presented in this Dissertation was written according to the Operative Dentistry instructions and guidelines for article submission.

Integrity of CAD/CAM onlays in ceramic and resin composite, associated or not with filler core – in vitro study.

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Keywords: Onlay. Nanoceramic composite resin. Leucite. Filler core. CAD/CAM.

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Integrity of CAD/CAM onlays in ceramic and resin composite, associated or not with filler core – in vitro study.

Running title: Survival rate of CAD CAM onlay restorations with and without filler core after thermomechanical cycling.

Clinical Relevance: The filler core are previously indicated for dental reconstruction independent of the indirect restorative material. With the evolution of adhesive systems and indirect restorative materials, this technique may no longer be necessary.

SUMMARY

Objective: This study evaluated the integrity of CAD/CAM ceramic and nanoceramic resin composite onlay restorations, with and without composite resin filler core.**Methods and Materials:**This study presented 2 variation factors: resin composite filler core in two levels (with and without resin composite filler core); and CAD/CAM material in two levels (leucite-reinforced ceramic restorations (IPS Empress, IvoclarVivadent, Schaan, Liechtenstein) and nanoceramic resin composite (LAVA Ultimate, 3M ESPE, São Paulo, Brasil)). Sixty third molars were prepared and divided into 4 groups (n=15). Standardized specimen preparations were performed by flattening the occlusal surface for a total enamel removal to a standard crown of 3mm height. After this, the distal half of the remaining crown was prepared with total removal of additional 2mm crown height, remaining 1mm of enamel in the cervical region to make the chamfered end. In the filler core groups, the distal halves were restored with resin composite and a standardized preparation were also performed over the filler core. All prepared specimens were scanned by a intraoral digital scanner and ceramic and composite resin blocks were milled in CAD/CAM. The ceramics restorations were luted with Variolink N (IvoclarVivadent, Schaan, Liechtenstein) and nanoceramic resin composite luted withRelyx Ultimate (3M ESPE, São Paulo, Brasil). All samples were stored in distilled water in an oven at 37 ° C for 24 hours prior to testing. After cementation, the margins were polished and all samples were subjected to thermomechanical stress cycling from 5 ° to 55 ° C, simultaneously with compression cycling at different load intensities every 20,000 cycles (100, 200, 300, 400, 450N), totaling 100,000 cycles.At the end of the thermomechanical cycling, the survival rate was measured by the presence of fracture, cracks and/or displacement of the restoration The quantitative response variables were: restoration displacement, crack formation and fractures. The data were evaluated by Friedman's repeated measures test (α=0.05). **Results:** No statistical difference was found for both variation factors, since the survival rate between the all the groups was similar. **Conclusion:** It seems that the need of resin composite filler core before CAD/CAM adhesive restorations should be carefully evaluated for each clinical situation.

Keywords: Onlay. Leucite. Nanoceramic resin composite. Filler core. CAD/CAM.

INTRODUCTION

The CAD / CAM technology has led to a revolution in the ways in which restorative materials are produced, broadening the clinical indications. Initially, only some ceramic materials had physical and mechanical characteristics to be machined in CAD / CAM systems, however, due to technological evolution, currently composite resins with specific characteristics have also been associated with CAD / CAM. One of these commercially available materials is the LAVA Ultimate (3M ESPE)[1] that presents some advantages over ceramic materials, such as the reduction of the cost associated with a more resistant resinous material. Thus, nowadays indirect composite resins can be used as more conservative and functional options in onlays, and their current indications for posterior teeth restorations are practically no different from ceramics[2,3].

Among the most suitable ceramic materials to produce indirect restorations are leucite-reinforced ceramics. The IPS Empress system (Ivoclar Vivadent) consists of a leucite-reinforced glass ceramic initially designed for full restorations and also, because of the technological evolution, can currently be associated with CAD/CAM systems to produce inlays, onlays, full crowns and veneers restorations.[4]

However, for clinical success, besides the indirect restorative material many other factors are involved, especially the biomechanical preparation of the remnant teeth structure.[5] This concern with the tooth remnant preparation for indirect restoration has long been the object of numerous clinical and laboratory studies, especially when the adhesion process was incipient and the restoration retention was depended mainly on mechanical/frictional retention between the luting agent and teeth's remnant structure or filler core. Besides the retention/adhesion factor, as the available materials in the past were less resistant, a uniform material thickness to decrease the concentration of stress spots and avoid catastrophic fractures was also preconized. Thus, in extensively destroyed teeth, the restorative protocol for indirect onlay restorations involved a previous direct or indirect reconstruction of the dental remnant, which later allowed to perform a biomechanical preparation that should respected two main principles: to achieve uniform thickness of the indirect restorative material and mechanical retention.[6]

Although the technological evolution of ceramic systems have resulted in improvement of its mechanical and physical properties and the knowledge of adhesion properties today, the biomechanical preparation of the remnant tooth structure whose principle should be associated with the restorative material properties, seems not to have accompanied this evolution. Thus, the classic biomechanical preparation of extensively destroyed teeth with previous reconstruction (filler core) continues to be advocated, despite all this evolution of indirect restorative materials and bonding systems. Therefore, there is a need to investigate whether the previous composite resin filler core is still necessary for the integrity of indirect restorations.

METHODS AND MATERIALS

This research project was submitted and approved by the Research Ethics Committee of the Bauru School of Dentistry (Protocol number 18008718.8.0000.5417), along with the informed consent.

Experimental Design

This study presented two variation factors: restorative material in two levels: leucite-reinforced ceramics (IPS Empress CAD, Ivoclar Vivadent, Schaan, Liechtenstein) and nanoceramic composite resin (LAVA Ultimate, 3M ESPE, São Paulo, Brasil);and biomechanical preparation in two levels: with or without composite resin filler core (Tetric Ceram, Ivoclar Vivadent, Schaan, Liechtenstein) for ceramic onlays and Z350 XT composite resin (3M, ESPE, São Paulo, Brasil) for nanoceramic resin composite onlays. The qualitative response variable was the onlays integrity after thermomechanical cycling, that was evaluated by the presence of cracks and catastrophic fractures, measured by scores.

Sample preparation

Sixty extracted healthy third molars were cleaned and stored in thymol solution (0.1%) at room temperature. These teeth were divided into four groups (n = 15): Group 1: Leucite-reinforced ceramic onlays without filler core (LC); Group 2: nanoceramic resin composite onlays without filler core (NRC); Group 3: leucite-reinforced ceramic onlays with previous filler core (LC-F) and Group 4: nanoceramic resin composite onlays with previous filler core (NRC-F).

The third molars were selected according to similar sized crowns. These teeth were included in self-curing acrylic resin(JET Clássico, Campo Limpo Paulista, Brazil) with aid of a PVC matrix, centered and with the occlusal face parallel to the ground, covering the root up to 3mm below the cementum enamel junction (CEJ). Using the diamond blade cutting machine (Isomet saw, METS-DCUT-W04-H012, Erios, São Paulo, Brazil), the occlusal enamel was totally removed until reaching 3mm coronally to the buccal CEJ (Figure 1), measured by a caliper. Standardized specimens preparations were performed with conical diamond tip (ref. 4137 and 4137F, KG Sorensen, Barueri, São Paulo, Brasil) involving the distal face. The final characteristics of the specimen preparations were: 2mm axial wall extension, finish line in enamel and 1 mm from CEJ, where the chamfered end was performed (Figure 1D).

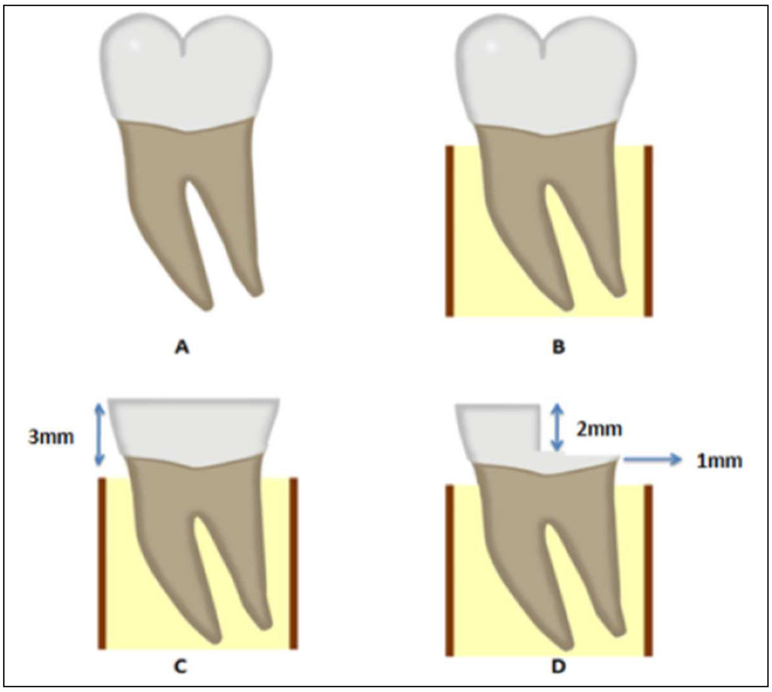

Figure 1: A: *Sound third molar; B: Specimen inserted in acrylic resin up to 3mm from CEJ; C: Wear of the occlusal face to the crown height of 3mm; D: Preparation of the distal face.*

In groups 3 and 4 (with composite resin filler core), a steel band matrix was used to make the composite resin filler core in the distal missing face. Two horizontal increments of 1mm were used until the cavity was completely filled, and the reference was the non-prepared mesial face (Figure 2A). Subsequently, controlled and standardized preparation of the composite resin core was performed with aid of a steel device for cavity preparation standardization. In this device the handpiece was fixed in a holder with the diamond tip in the vertical position. The axial wear of the core was performed by contacting the specimen, already included in the acrylic resin base, with the diamond tip penetrating half its diameter into the external contour of the resin core establishing the beveled cervical finish line around the entire core. It was possible to standardize the axial wall angulation of the core according to the shape of the diamond tip (Figure 2B).

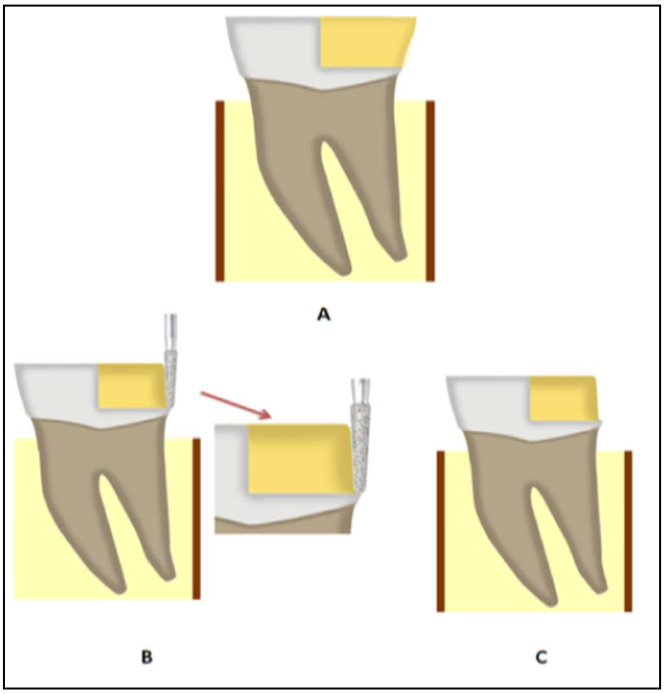

Figure 2: A: *Composite resin filler core in the distal half of the tooth; B: Wear with conical diamond tip, determining the core axial wall angulation and finishing line in enamel; C: Standard preparation completed.*

Restorative procedures

All specimens were of scanned by a digital intraoral device (Trios Cart, 3 Shape, Copenhagen, Denmark), and the indirect onlay restorations were designed by In Lab software. For both materials the anatomy of a lower second molar was chosen, the occlusal thickness was standardized at 1.5mm and the free face contour followed the anatomical shape of the unprepared face. Restorations of ceramic and nanoceramic resin composite were made by milling the blocks in the CAD/CAM lathe (CEREC MC XL, Sironal, New York, US) (Figure 3).

Figure 3: *Schematic illustration of CAD / CAM machined parts with and without filler core.*

Cementation procedure

Selective acid etching of specimen’s enamel was performed with 37% phosphoric acid, water rinsed and air dried, followed by the application of the universal adhesive system (Tetric N-Bond Universal, IvoclarVivadent, Schaan, Liechtenstein) for ceramic onlay groups, and other universal adhesive system (Singlebond Universal, 3M ESPE, São Paulo, Brazil) for nanoceramic resin composite groups according to manufacturer's instructions. Adhesives light curing was performed by 30 seconds with a LED curing unit with 1100 mW/cm^2 (BlueStar II, Microdont, São Paulo, Brazil).

Leucite-reinforced ceramic restorations were conditioned with 10% hydrofluoric acid (Condac porcelana, FGM, Joinville, Brazil)for 60 seconds, water rinsed and air dried, silane coupling agent application also for 60 seconds (Monobond N, IvoclarVivadent, Schaan, Liechtenstein), followed by application of universal adhesive system (Tetric N-Bond Universal), in selfetch mode in dentin.. Then the cementation was performed with dual-curing resin cement (VariolinkN, Ivoclar, Vivadent, Schaan, Lieschtenstein), and light cured for 40 seconds at each side.. To standardized the cementation line, a 50N weight was applied by 60 seconds over the occlusal surface prior light curing.

For the nanoceramic resin composite restorations the adhesive system (Singlebond Universal, 3M, São Paulo, Brazil) was applied, in self-ecth mode in dentin. Then the restoration adhesively luted with dual-polymerizing luting agent (Relyx Ultimate, 3M, São Paulo, Brazil) and light cured for 40 seconds at each side. The same force (50N) was applied over the restoration for 60 seconds before lighting curing.

The cement light curing for all groups was performed for 40 seconds at each face using the same LED equipment (BlueStar II, Microdont, São Paulo, Brazil) used for light curing irradiates 1100 mW/cm^2(Figure 4).

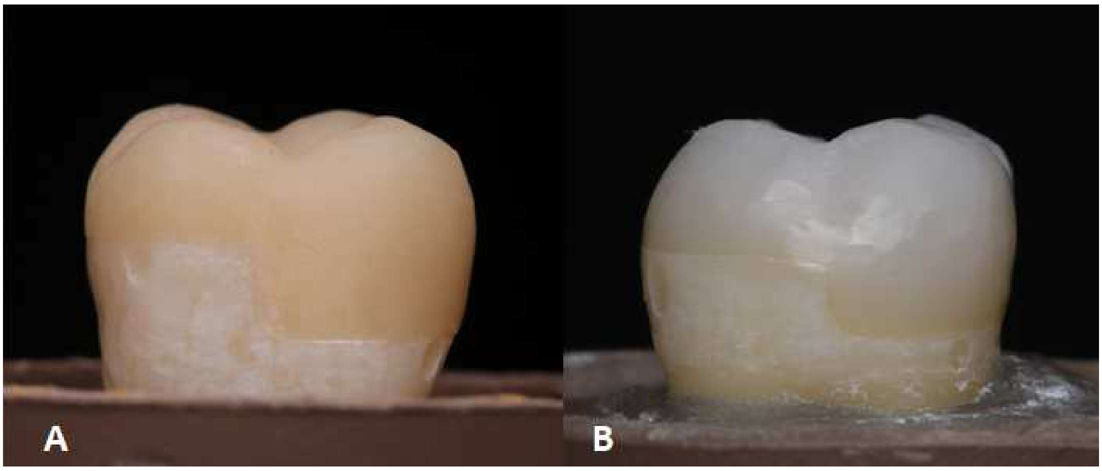

Figure 4: *Appearance after cementation of leucite reinforced ceramic (A) and nanoceramic resin composite (B) restorations.*

Fatigue Test: Thermomechanical Cycling

The specimens underwent thermal and mechanical cycling (Thermomechanical Cyclist, Biopdi, São Carlos, Brazil) using a 6mm ceramic spherical tip positioned in the central occlusal surface of the onlays and it always in contact with the specimen. The mechanical cycling was performed with 20.000 cycles at each load intensity (100, 200, 300,400, 450N), totaling 100.000 cycles at a frequency of 2Hz. While the dynamic mechanic cycling was performed, all the specimens were submitted to simultaneous thermal cycling with baths varying from 5 ° to 55 °C for 20 seconds each, totalizing 1.000 cycles.

Specimen Evaluation

After the end of the thermomechanical cycling,the specimens were evaluated at every 20,000 cycles with aid of a light curing device (VALO, Ultradent, South Jordan, USA) that was laterally positioned on the onlay, to verify crack formation that was not possible to be visualized by naked eye. Cracks and fractures were evaluated by scores: Score 0: absence of cracks (survival rate = 100.00%); Score 1: presence of initial cracks (small cracks or cracks visualized only with transilumination (survival rate = 66.66%)); Score 2: presence of bigger cracks visualized by naked eye (survival rate = 33.33%) and Score 3: catastrophic fractures of the onlay/tooth (survival rate = 0.00%).

Statistical analysis

The statistical analysis was performed through by SigmaPlot program (Systat Software, Inc, San Jose, CA, USA). The data was analyzed by a non-parametric Friedman's repeated measures test with significance level of $\alpha=0.05$.

RESULTS

The statistical analysis showed no significant difference for the two factors studied ($p=1.000$). Both materials exhibited similar integrity rate, and the presence or absence of the resin composite filler core. No cracks or catastrophic failure could be seen in any specimen after the termomechanical cycling. Although not measured, all samples had a wear point where the edentor was positioned to perform the cyclic load.It was possible to visualize by naked eye that restorations made with nanoceramic resin composite presented more wear than those with ceramics.

The results were submitted to statistical analysis by Friedman Repeated measures analysis of variance on ranks test.

Table 1:*Average of scores after each load stage and statistical analysis*.

Group	100N	200N	300N	400N	450N	Median
LC	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
LC-F	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
NRC	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]
NRC-F	0[a]	0[a]	0[a]	0[a]	0[a]	0[a]

Lowercase letters showed that there is not a statistically significant difference (p = 1,000).

Table 2. *Survival rate for evaluated by groups (in %)*

Group (n=15)	100N	200N	300N	400N	450N	Median
LC	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
LC-F	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
NRC	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]
NRC-F	100[a]	100[a]	100[a]	100[a]	100[a]	100[a]

Lowercase letters showed that there is not a statistically significant difference (p = 1,000).

DISCUSSION

In order for a restorative material to exhibit its best properties, proper biomechanical preparation of the remaining dental structure has always been recommended.[5,7] However, some ceramic systems and indirect resin composites currently have the retention and resistance properties that theoretically contradict the principles governing the wear of classical biomechanical preparation, hitherto recommended.

The loads used in this study were based on previous studies that evaluated the maximum bite force of different age groups. According to Kogawa et al. (2006)[8], the maximum bite force found was around 338 N, which agrees with other studies. Takaki et al. (2014)[9] reported that the average bite force of male participants was higher than that of female participants, with a difference of 31.01 N (male: 285.01 N; female: 253.99 N). Thus, in the present study, different intensities of cyclic occlusal load (100, 200, 300, 400 and 450N) were used, whose maximum bite force values reported in the literature are contained in the load ranges used.

During the test, although not quantified, it was possible to observe a visual difference between the materials, where nanoceramic resin restorations showed noticeably greater wear when compared to Leucita restorations. These results agree with the literature that compared the wear suffered by ceramic and resinous materials, with greater wear associated with resinous materials. A 10-year randomized, split-mouth study comparing indirect composite resin veneers and ceramic veneers showed that in addition to a lower survival rate (75%), indirect composite resin also showed greater material degradation, with fractures, chipping and initial wear often associated.[10,11] In the present study, besides the resin content of nanoceramic groups, the thermocycling should be exacerbated the wear, since polymeric materials are more affected by thermal variation than ceramic materials that are more stable in this aspect.[12]

In the present study it was found that the restorative material factor was not significant. All indirect nanoceramic resin or leucite-reinforced ceramic onlays survived the test, showing no failures, cracks or displacement of the restorative material/teeth. These results also agree with other studies. According to Shembish et al. (2015)[13], all leucite-reinforced glass-ceramic crowns began to fail during stress fatigue at a load level greater than 450 N and none of these restorations survived over 650N. Meanwhile, the restorations of nanoceramic composites survived the load of 1700N, with no catastrophic failures.

Thus it seems that the structural failures in leucite-reinforced ceramics occur in the range between 450N and 650N, and in a much higher force in nanoceramic composites, which was not reached in the present study, however the objective was not to test the maximum load supported by both indirect materials, but to verify their integrity under the maximum forces reached during chewing, and both resisted well.

Another factor analyzed in this study was the presence or absence of the composite resin core buildup. According to the results it was possible to verify that the presence of the core buildup was also not significant for the integrity of the restorations with both materials. According to Mamoun J. (2017)[14], the core build-up has the function of “force transmission” medium, where instead the occlusal force being concentrated on one stress plane, the force is distributed among multiples planes where the core is well adhered. However, in the present study, even in the absence of it, the forces were not sufficient to cause structural damage in both materials that presented greater thickness when compared to groups with core build-ups. On the other hand, in the presence of the core buildup, the onlays had their thickness reduced, and even so the intrinsic strength of both materials was sufficient to avoid cracking and fracturing, although some of the stress may have been transmitted to the core build-up.

These results are in accordance with others that also verified that core build-up as a function of macro-mechanical retention is insignificant to the clinical performance when large all-ceramic CAD/CAM restorations are adhesively luted. Roggendorf et al. (2012)[7], analyzed the 7-year clinical performance of all-ceramic CAD/CAM restorations placed within deeply destroyed teeth, and among the all groups that included different clinical situations, groups with different macro-mechanical retention where compared and revealed that even in the absence of retention, the restorations performed satisfactorily. Some authors stated that the adhesive luting of some ceramics to dentine can substitute the macro-mechanical retention, jeopardizing one of the principles that guide the biomechanical preparation: achieve frictional retention to the indirect restoration.[15]

Thus, the biomechanical preparation of the remaining structure, in extensively destroyed teeth, should follow the technological evolution of dental materials, and some concepts should be rethought and not linked to dental materials from the past.

CONCLUSION

Leucite glass reinforced ceramic and nanoceramic composite resin presented similar integrity rate after the fatigue test, and the preparation of a previous composite resin core build-up in extensively destroyed teeth for indirect onlays restorations seems not be necessary.

Acknowledgments

We thank 3M/ESPE and Ivoclar/Vivadent for providing materials for this research. This paper is in fulfillment of the requirements for the MsC degree in Applied Dental Science for Camila Thais Queiroz, USP, SP, Brazil. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES - #001) and Conselho Nacional de Desenvolvimento Científico e Tecnológico - Brazil (CNPQ) (#134118/2017-0).

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3 Discussion

3 DISCUSSION

The technological evolution that dentistry is currently experiencing has brought many changes, not only in the physical-mechanical properties of different restorative materials, but also in the way they are produced and processed. Among the aspects that improved considerably, the intrinsic resistance of the resin-based and ceramic materials stands out, which allowed a considerable increase in the clinical indication of these materials that currently can be used in any region of the oral cavity.

The increase in the intrinsic strength of restorative materials also allowed new modeling and processing to be used to obtain indirect restorations and prosthetic pieces, combining greater strength with a faster and more accurate manufacturing method. Thus, the machining of parts that has always been used in the industry in general, in different areas of knowledge, is now being used in dentistry in search of more resistant restorations and much faster and optimized process due to the association of computer/software and milling machines[5,11, 12]. However, the short and long-term success of indirect restorations when in oral cavity does not depend only on the restorative material properties. In order for a restorative material to exhibit its best properties, proper biomechanical preparation of the remaining dental structure has always been recommended[10,13]. The recommended biomechanical preparation has always been based on two principles: promote resistance to the restorative material through a uniform thickness to avoid stress concentration, and to promote retention to the restorative material through frictional retention.

When the dental substrate is extensively destroyed, with the absence of some reinforcement structures, direct or indirect reconstruction of the tooth prior to biomechanical preparation is recommended, aiming that retention and resistance principles can be controlled, because in a reconstructed tooth, wall wear and tear can be performed as if it is a sound tooth. Again, due to technological evolution, some ceramic systems and indirect resin composites currently have the retention and resistance properties that theoretically contradict the principles governing the wear of classical biomechanical preparation, hitherto recommended.

The literature reports the development of different adhesive techniques for porcelain restorations. An additional chemical bond is produced when the internal part of ceramic is treated with hydrofluoric acid and a silane-based agent, and an increase in bond strength is reported when this combination is performed compared to another surface treatment methods[14,15].

As adhesive techniques were developed with satisfactory results in some types of ceramics, and the intrinsic strength also increased considerably, theoretically eliminating the need for prior reconstruction to achieve an uniform restoration thickness and favor frictional retention, the present study investigated the integrity of onlays made in two materials recommended for this, and also if the resin core buildup prior to preparation influences the mechanical behavior of these restorations.

The test chosen for this study, according to the literature, evaluates the survival rate of indirect restorations of different materials under thermomechanical cycling[16,17]. The dynamic fatigue test represents a clinically relevant approach to investigate the failure mechanism of the tested restorations and allow the approximate calculation of survival rates.

The loads used in this study were based on previous studies that evaluated the maximum bite force of different age groups. According to Kogawa et al. (2006)[18], the maximum bite force found was around 338 N, which agrees with other studies. Takaki et al. (2014)[19] reported that the average bite force of male participants was higher than that of female participants, with a difference of 31.01 N (male: 285.01 N; female: 253.99). N). Although men have a bite force slightly higher than 12% compared to women, the difference was not statistically significant. Thus, in the present study, different intensities of cyclic occlusal load (100, 200, 300, 400 and 450N) were used, whose maximum bite force values reported in the literature are contained in the load ranges used.

In addition, the bite force decreases with time and with the number of chewing strokes. Due to laboratory test data, it seems reasonable to increase the load during simulation. Studies with humans who chewed different food items revealed that the vertical bite force on molars ranges from 20 to 140 N - depending on the consistency of the food items[20,21]. Thus, in the present study intensities load slower than the maximum force was also applied, covering situations where food interposition occurs during chewing. Higher intensity forces were not applied due to the limitation of the thermomechanical cycling machine, whose maximum supported load intensity is 450N.

Regardless of the load tested, the number of cycles for each load intensity tested was 20,000 cycles, totaling 100,000 cycles for each specimen. According to some studies, this total amount of cycles would be equivalent to 6 months of clinical life[16,17], however, according to Borba et al. (2013)[22], the use of different load intensities, as in the present study, allows to expand the clinical simulation time.

The indenting tip that was used in the present study to apply the different cyclic loads was made of ceramic, because according to Kelly (1999)[17], it has a hardness similar to dental enamel. The tip remained in constant contact with the center of the occlusal face of the restorations during force cycling, simulating a clinical tightening situation. Even with this constant contact, although not quantified, it was possible to observe a visual difference between the materials, where nanoceramic resin restorations showed noticeably greater wear when compared to Leucita restorations. These results agree with the literature that compared the wear suffered by ceramic and resinous materials, with greater wear associated with resinous materials. A 10-year randomized, split-mouth study comparing indirect composite resin veneers and ceramic veneers showed that out of 34 direct resin (Stenia) restorations, 6 had adhesive failures and fractures, while the 24 restorations in ceramic material had no type of failure. In addition to a lower survival rate (75%), indirect composite resin also showed greater material degradation, with fractures, chipping and initial wear often associated[23,24]. In the present study, besides the resin content of nanoceramic groups, the thermocycling should be exacerbated the wear, since polymeric materials are more affected by thermal variation than ceramic materials that are more stable in this aspect[25].

Many reinforcement particles and different strategies have been used to increase the strength of both resin and ceramic dental materials. In the case of ceramics, the most commonly used inorganic reinforcements today are: leucite, lithium dissilicate, aluminum oxide and zirconium oxide. The differences lie in the strength acquired by the reinforced material, in addition to the adhesive and aesthetic properties[26]. In the case of indirect resins, the filler particles do not differ much from direct resins, but laboratory polymerization methods guarantee improvement of the physical-mechanical properties. Nanoceramics, such as LAVA Ultimate (3M ESPE), used in this study, are composed of silane and zirconia nanostructures treated with a silane agent to promote chemical bonds between the nanoceramic surface to the resin matrix[27]. This material has shown better results in vitro for fatigue testing compared to various total ceramic materials due to the presence of a polymeric matrix and the difference in elastic properties.

For the onlay restorations analyzed in the present study, leucite-reinforced ceramics and nanoceramic resin, both manufactured by CAD/CAM, were tested. At the end of the thermomechanical cycling, it was found that the restorative material factor was not significant. All indirect nanoceramic resin or leucite-reinforced ceramic restorations survived the test, showing no failures, cracks or displacement of the restorative material. Surface wear was observed for both materials, causing no damage to the restorations. These results agree with other studies. According to Shembish et al. (2015)[28], all leucite-reinforced glass-ceramic crowns began to fail during stress fatigue at a load level greater than 450 N and none of these restorations survived 650N. The survival rate of leucite-reinforced ceramics was 90% for 1.250.000 cycles at 200N, which is equivalent to approximately 5 years of clinical survival. Meanwhile, the restorations of nanoceramic composites survived the load of 1700N, with no catastrophic failures[16].

According to information provided by the manufacturer, LAVA Ultimate nanoceramics have higher flexural strength (approximately 200 MPA) than feldspar and leucite-reinforced ceramic CAD/CAM blocks, and similar values were found in in vitro studies[28,29,30]found that CAD/CAM composite resin crowns showed higher fracture resistance to fatigue testing than a leucite-reinforced ceramic. All leucite-reinforced glass ceramics broken at an indentation force of 650N, while no catastrophic failures occurred for the composite resin group.

Thus it seems that the structural failures in leucite-reinforced ceramics occur in the range between 450N and 650N, and in a much higher force in nanoceramic composites, which was not reached in the present study, however the objective was not to test the maximum load supported by both indirect materials, but to verify their integrity under the maximum forces reached during chewing, and both resisted well.

These laboratory results are in line with studies that evaluated clinical behavior. A systematic review by Heintze et al, 2008[31] included seven clinical studies involving 1487 total crowns of IPS Empress CAD (Leucite-reinforced) and concluded that the risk of failure of these crowns was 16 out of 1,000 crowns. This indicates that IPS Empress CAD crowns have good clinical performance, with the main reported cause of clinical failure being ceramic chip fractures.

Another factor analyzed in this study was the presence or absence of the composite resin core buildup. According to the results it was possible to verify that the presence of the core builds upwas not significant for the integrity of the restorations with both materials. According to Mamoun J., 2017[32], the core build-up has the function of “force transmission” medium, where instead the occlusal force being concentrated on one stress plane, the force is distributed among multiples planes where the core is well adhered. However, in the present study, even in the absence of it, the forces were not sufficient to cause structural damage in both materials that presented greater thickness when compared to groups with core build-ups. On the other hand, in the presence of the core buildup, the crowns had their thickness reduced, and even so the intrinsic strength of both materials was sufficient to avoid cracking and fracturing, although some of the stress may have been transmitted to the core build-up.

These results are in accordance with others that also verified that core build-up as a function of macro-mechanical retention is insignificant to the clinical performance when large all-ceramic CAD/CAM restorations are adhesively luted. Roggendorf et al., 2012[13], analyzed the 7-year clinical performance of all-ceramic CAD/CAM restorations placed within deeply destroyed teeth, and among the all groups that complained different clinical situations, groups with different macro-mechanical retention where compared and revealed that even in the absence of retention, the restorations performed satisfactorily. Some authors stated that the adhesive luting of some ceramics to dentine can substitute the macro-mechanical retention, jeopardizing one of the principles that guide the biomechanical preparation: achieve frictional retention to the indirect restoration[33].

Both materials resisted the occlusal forces used in this study, and in terms of integrity, both can be indicated for indirect onlay restorations in extensively destroyed teeth. Previous resin core build-up reconstruction of extensive destructed teeth for onlay restorations appears to be unnecessary for both materials tested, as the adhesive and strength properties were sufficient to prevent fracture or displacement. The biomechanical preparation of the remaining structure, in extensively destroyed teeth, should follow the technological evolution of dental materials, and some concepts should be rethought and not linked to dental materials from the past.

4 CONCLUSION

4 CONCLUSION

According to the findings of this in vitro study, the preparation of a previous composite resin filler cores in extensively destroyed teeth for indirect onlays restorations seems not be necessary, independent of the material used. Both Leucite glass reinforced ceramic and nanoceramic composite resin presented similar integrity rate after the fatigue test.

5 FINAL CONSIDERATIONS

5 FINAL CONSIDERATIONS

Considering that the results obtained in this research are in accordance with the literature, more research must be carried out in relation to the tested materials and applied methods.

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APPENDIX

APPENDIX

APÊNCIDE A - DECLARAÇÃO DE USO EXCLUSIVO DE ARTIGO EM DISSERTAÇÃO/TESE

DECLARATION OF EXCLUSIVE USE OF THE ARTICLE IN DISSERTATION/THESIS

We hereby declare that we are aware of the article (Integrity of CAD/CAM onlays in ceramic and resin composite, associated or not with filler core – in vitro study) will be included in (Dissertation/Thesis) of the student (Camila Thais Queiroz) and may not be used in other works of Graduate Programs at the Bauru School of Dentistry, University of São Paulo.

Bauru, th, 2020.

Camila Thais Queiroz ______________________________
Author Signature

Sérgio Kiyoshi Ishikiriama ______________________________
Author Signature