UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

EDGAR MASSUNARI MAENOSONO

Influence of thickness and restorative material on the physical-mechanical behavior of CAD/CAM minimally invasive occlusal veneers - in vitro study

Influência da espessura e material restaurador no comportamento físico-mecânico de facetas oclusais minimamente invasivas confeccionadas em CAD/CAM – 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.

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FOLHA DE APROVAÇÃO

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ABSTRACT

Influence of thickness and restorative material on the physical-mechanical behavior of CAD/CAM minimally invasive occlusal veneers - in vitro study

The occlusal veneers consist in a minimally invasive restorative approach that aims to restore the shape and function of the posterior teeth affected by tooth wear. The aim of this study was to evaluate the behavior of the occlusal veneers when subjected to thermal and mechanical cycling. Sixty specimens were divided into 04 groups (n=15), showing two variation factors divided into two levels: material – lithium dissilicate LD (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) and nano ceramic resins NCR (ESPE Lava Ultimate, 3M, São Paulo, Brazil); thickness - 0.6 and 1.2mm. The occlusal veneers were luted with dual-polymerizing luting agent (Variolink N, Ivoclar Vivadent, Schaan, Liechtenstein) (RelyX Ultimate 3M, São Paulo, Brazil) using the respective adhesive system in self-etch mode. The resin cement was light cured for 40 seconds each face, using a LED light cure equipment that irradiates 1,100 mW/cm^2 (BlueStar II, Microdont, São Paulo, Brazil). A response variable consists of veneer survival rates (crack formation, catastrophic cracks and debonding) when subjected to thermal cycling from 5 ° to 55 ° C for 1,000 cycles and simultaneous mechanical cycling performed at load intensities of 100, 200, 300, 400 and 450N for 20,000 cycles each. Data were submitted to the Kruskall Wallis test and Pairwise Comparison, adopting a significance level of 5%. NCRs presented a lower incidence of failures ($p < 0.05$) when compared to LD. As for thickness, 1.2 mm thick occlusal veneers withstand higher cycling loads. Within the constraints of this study, we can conclude that NCR occlusal veneers with 1.2mm thickness presented superior physical-mechanical behavior and lithium dissilicate occlusal veneers with thickness lower than 1.2mm are more likely to fail.

Key words: Tooth Wear. Dental Veneers. Fatigue. Ceramics. Composite Resins.

RESUMO

Influência da espessura e material restaurador no comportamento físico-mecânico de facetas oclusais minimamente invasivas confeccionadas em CAD/CAM – estudo in-vitro

Facetas oclusais consistem numa abordagem restauradora minimamente invasiva, que tem como objetivo reestabelecer forma e função de dentes posteriores severamente acometidos por desgaste dentário. O objetivo deste trabalho foi avaliar o comportamento das facetas oclusais minimamente invasivas quando submetidas à ciclagem térmica e mecânica. Sessenta espécimes foram divididos em 04 grupos (n=15), apresentando-se dois fatores de variação divididos em dois níveis: material - dissilicato de lítio LD (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) e resinas nano cerâmicas NCR (ESPE Lava Ultimate, 3M, São Paulo, Brasil); espessura - 0,6 e 1,2mm. As facetas oclusais foram cimentadas com cimento resinoso dual (Variolink N, Ivoclar Vivadent, Schaan, Liechtenstein)(RelyX Ultimate 3M, São Paulo, Brasil), utilizando o sistema adesivo de sua respectiva marca no modo autocondicionante. O cimento resinoso foi fotoativado por 40 segundos em cada face utilizando um equipamento fotopolimerizador LED com 1.100 mW/cm^2 (BlueStar II, Microdont, São Paulo, Brasil). A variável de resposta consistiu na taxa de sobrevivência (formação de trincas, trincas catastróficas e deslocamento da restauração) das facetas quando submetidas à ciclagem térmica de 5º a 55ºC por 1000 ciclos e concomitantemente ciclagem mecânica realizada com intensidades de carga de 100, 200, 300, 400 e 450N, por 20.000 ciclos cada. Os dados foram submetidos ao teste Kruskall Wallis e Comparação Pairwise, adotando-se nível de significância de 5%. As NCR apresentaram menor incidência de falhas ($p<0,05$) quando comparadas ao LD. Quanto à espessura, facetas oclusais com 1,2mm de espessura resistiram a cargas maiores de ciclagem. Dentro das limitações deste estudo, pode-se concluir que facetas oclusais confeccionadas com NCR, numa espessura de 1,2mm, apresentam comportamento físico-mecânico superior e facetas oclusais confeccionadas com dissilicato de lítio com espessura menores que 1,2mm estão sujeitas a um maior número de falhas.

Palavras-chave: Desgaste dos Dentes, Facetas Dentárias, Fadiga, Cerâmica, Resinas Compostas

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LIST DE ABBREVIATIONS AND ACRONYMS

CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
DSLR	Digital single-lens reflex
GERD	Gastroesophageal reflux disease
Hz	Hertz
LD	Lithium dissilicate
mm	millimeter
N	Newton
NCR	Nano Ceramic Resin

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1 INTRODUCTION

1 INTRODUCTION

Pathological tooth wear has been recognized as a growing problem in contemporaneous dentistry. Its causes are related to parafunctional habits and acid erosion. According to the systematic review published by Mesko et al., 2017, the prevalence of bruxism reaches 31% of adults. In a study conducted by Mafla et al., 2017, the authors observed a prevalence of dental erosion of around 57.3% in Colombian adolescents. Even more alarmingly, in a study by Gillborg et al., 2019, the authors observed that of a total of 831 individuals in Sweden, almost 80% had some sign of erosion.

Despite the higher prevalence, the treatment of tooth wear is still quite complex. It may involve restoration of all posterior teeth, which requires time and consequently high costs, and it often requires wear of the dental structure for onlay, overlay and crown preparations. In order to make more conservative preparations, the occlusal veneers, also known as "table tops" shown up. This restorative approach consists of a thin layer of restorative material positioned on the occlusal surface of the posterior teeth. Its purpose is to restore shape and function to teeth that have worn out and also to prevent the progression of tooth wear in an ultra-conservative way, and may also be used in clinical cases that need to increase vertical dimension of occlusion is necessary (GROTEN, 2007; BAHILLO et al., 2014).

The use of ultra-conservative restorative materials can be considered to be well established in the anterior teeth. Ultrathin occlusal veneers have shown very satisfactory clinical results (GROTEN 2007; BAHILLO, et al. 2014). However, it is important to note that the bite force that occurs in the posterior teeth are much higher, in the order of 300 to 600N (CALDERON et al. 2006; KOGAWA et al. 2006; TAKAKI P., VIEIRA M., BOMMARITO S. 2014). There is no consensus in the literature regarding the thickness and type of material that can withstand the chewing forces involved in the posterior region.

Dental ceramics have interesting properties for this type of restoration such as high wear resistance, higher acid resistance commonly associated with dental erosion and adhesion to the dental structure. Some studies indicate that dental ceramics have better properties when compared to composite resin restorations (FRON CHABOUIS H, SMAIL FAUGERON V, ATTAL JP 2013).

Another viable material option to make occlusal veneers is indirect composite resins. A higher degree of conversion, better mechanical properties were achieved due to the laboratory processing, mainly for indirect resins block for CAD/CAM, as their manufacture allows a higher amount of filler, less diluent, and are polymerized at high pressure and high temperature (MAINJOT et al. 2016).

However, not much is known about the clinical longevity of this treatment, because the thickness of the material associated with parafunctional habits may reduce the survival of these occlusal veneers. Magne et al. (2010) performed isometric mechanical cycling of occlusal veneers made of leucite-reinforced ceramics, lithium dissilicate ceramics (IPS Empress CAD and IPS e.max CAD) and composite resin (Paradigm MZ100), each with 1.2mm thick. These specimens were mechanically cycled at various load intensities (400, 600, 800, 1,000, 1,200, and 1,400N). After mechanical cycling the specimens were evaluated by translumination, microscopy and photography, looking for cracks larger than 2mm in the surface that would indicate failure. Composite resin specimens had 100% survival, lithium dissilicate ceramics 30% and leucite-reinforced ceramics an 0% survival rate.

Schlichting et al. (2011) also performed isometric mechanical cycling of occlusal veneers made of leucite-reinforced ceramics, lithium dissilicate ceramics (IPS Empress CAD and IPS e.max CAD) and composite resin (Paradigm MZ100 and experimental resin) each with 0.6 mm thick. These specimens were mechanically cycled at various load intensities (400, 600, 800, 1,000, 1,200, and 1,400N). The specimens were evaluated by translumination, microscopy and photography, looking for cracks larger than 2mm in the surface which would determine the failure of the restoration. Experimental composite resin specimens had 100% survival, commercial composite resin 60%, lithium dissilicate ceramics 0% and leucite-reinforced ceramics 0% survival.

Sasse et al. (2015) compared different thicknesses of minimally invasive occlusal veneers and luted on different substrates (strictly enamel; enamel and dentin; enamel, dentin and composite resin). Strictly enamel luted restorations had significantly lower fracture resistance than the other groups. The work suggests that the minimally invasive ceramic occlusal veneer is a good restorative procedure for worn or misplaced teeth, but the study also suggests that it should be used at least a thickness of 0.7 to 1.0mm.

Heck et al. (2019) evaluated occlusal veneers made of different materials: IPS Empress CAD, IPS e.max CAD and LAVA Ultimate. The restorations had a thickness of 0.3mm in the region of pits and fissures, and 0.5mm in the region of the cusps. 64 teeth were prepared so that there was only enamel at the edge of the preparation, and only dentin on the occlusal surface. The specimens were mechanically cycled 1,000,000 cycles at a 50N load, and another 1,000,000 cycles at 100N were performed on lithium dissilicate specimens. All lithium dissilicate restorations survived mechanical cycling, 10 leucite-reinforced glass ceramic restorations fractured, 8 in the 10,000 cycle range and 2 in the 100,000 cycle range, and only one nano ceramic resin restoration fractured in the 100,000 cycle range. Based on these results the group concludes that IPS Empress CAD occlusal veneers have a higher probability to fracture compared to LAVA Ultimate and IPS e.max CAD occlusal veneers.

Maeder et al. (2019) evaluated the loading-bearing of 0.5 and 1.0mm occlusal veneers with various materials: zirconia (Vita YZ HT (ZIR)); lithium dissilicate (IPS e.max Press (LDC)); nano ceramic resin (Vita Enamic (E), Lava Ultimate (LU)). The average force required to start cracking was 1,350N for 0.5-ZIR, 850N for 0.5-LDC, 1,100N for 0.5-E, 1,950N for 0.5-LU, 2,100N for 1.0-ZIR, 1,750N for 1.0 -LDC, 2,000N for 1.0-E and 2,300N for 1.0-LU. And the average load required for the restoration fracture was 2,493N for 0.5-ZIR, 1,165N for 0.5-LDC, 2,275N for 0.5-E, 2,265N for 0.5-LU, 2,489N for 1.0-ZIR, 1,864N to 1.0-LDC, 2.485N to 1.0-E and 2.479N to 1.0-LU. Based on these results, it was concluded that these materials have the properties necessary to be used as occlusal veneers.

Ioannidis et al. (2019) evaluated the loading-bearing of 0.5 and 1.0mm occlusal veneers made of various materials: zirconia (Vita YZ HT (ZIR)); lithium dissilicate (IPS e.max Press (LDC)); nano ceramic resin (Vita Enamic (E), Lava Ultimate (LU)) The average load required for the restoration fracture was 1,692N for 0.5-LDC, 2,390N for 0.5-E, 2,200N for 0.5-LU, 2,299N for 1.0 -ZIR, 1,537N for 1.0-LDC, 2,124N for 1.0-E and 2,489N for 1.0-LU The group did not get results for

0.5mm zirconia because of the difficulty of milling ultrathin specimen restorations. Based on these results, it was concluded that these materials have properties necessary for use as occlusal veneers.

Considering that further studies are still needed to better understand the physical-mechanical behavior of restorative materials indicated for occlusal veneers, as the materials are constantly evolving to improve their properties, especially those used in CAD/CAM systems, the aim of this work was to evaluate the physical-mechanical properties and survival rate of occlusal veneers made of nano ceramic resin and lithium dissilicate ceramic, milled in CAD/CAM at 1.2mm and 0.6mm thickness when submitted to thermomechanical cycling with different load intensities.

4 Final Considerations

4 FINAL CONSIDERATIONS

The NCR occlusal veneers presented satisfactory properties to endure the thermomechanical cycling and show a higher survival rate when compared to LDC occlusal veneers even in thin thickness. Further studies are needed to support the use of occlusal veneers as restorative approach to patients that presents parafunctional habits.

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APPENDIXES

APPENDIXES

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 (Influence of thickness and restorative material on the physical-mechanical behavior of CAD/CAM minimally invasive occlusal veneers - in vitro study) will be included in (Dissertation/Thesis) of the student (Edgar Massunari Maenosono) and may not be used in other works of Graduate Programs at the Bauru School of Dentistry, University of São Paulo.

Bauru, November 1st, 2019.

Edgar Massunari Maenosono
Author

____
Signature

Sérgio Kiyoshi Ishikiriama
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Survival rate of specimens in different load stages

Material	100N	200N	300N	400N	450N
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	-	-	-	-	-
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
NCR 1.2mm	1	1	1	1	1
	100%	100%	100%	100%	100%
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	1	1
NCR 0.6mm	1	1	1	7	-
NCR 0.6mm	1	1	1	6	-
NCR 0.6mm	1	1	1	1	1

	100%	100%	100%	86,66%	86,66%
LDC 1.2mm	1	1	1	1	1
LDC 1.2mm	1	1	1	2	3
LDC 1.2mm	1	1	3	3	3
LDC 1.2mm	1	1	1	1	4
LDC 1.2mm	1	2	3	3	4
LDC 1.2mm	1	1	3	4	4
LDC 1.2mm	1	1	3	4	4
LDC 1.2mm	1	1	1	3	4
LDC 1.2mm	1	1	2	2	2
LDC 1.2mm	1	1	1	4	4
LDC 1.2mm	1	1	3	3	4
LDC 1.2mm	1	1	3	4	4
LDC 1.2mm	1	1	3	4	4
LDC 1.2mm	1	1	3	4	4
LDC 1.2mm	1	1	3	4	5
	100%	100%	100%	53,33%	26,66%
LDC 0.6mm	1	2	2	2	2
LDC 0.6mm	1	2	2	2	5
LDC 0.6mm	3	4	4	4	4
LDC 0.6mm	2	3	4	4	4
LDC 0.6mm	2	3	3	3	4
LDC 0.6mm	3	4	4	4	4
LDC 0.6mm	-	-	-	-	-
LDC 0.6mm	2	3	3	3	4
LDC 0.6mm	2	3	3	3	4
LDC 0.6mm	2	2	2	3	3
LDC 0.6mm	2	3	4	4	4
LDC 0.6mm	3	4	4	4	4
LDC 0.6mm	2	3	3	4	4
LDC 0.6mm	4	4	4	5	-
LDC 0.6mm	4	4	4	4	4
	85,71%	64,28%	50%	42,85%	14,28%

1 – no crack; 2 – subsurface crack; 3 – visible crack; 4 – fracture; 5 – fracture + debonding; 6 – debonding; 7 – tooth fracture