Dental Materials and Laboratory

Effect of Restoration Thickness on Fracture Resistance of Two CAD-CAM Polymeric Materials for Manufacturing Occlusal Veneers *

Efecto del espesor de la restauración en la resistencia a la fractura de dos materiales poliméricos CAD-CAM para fabricar de carillas oclusales

Efeito da espessura da restauração na resistência à fratura de dois materiais poliméricos CAD-CAM para fabricação de facetas oclusais

DOI : https://doi.org/10.11144/Javeriana.uo43.ertf
Submission Date: 18 November 2022
Acceptance Date: 25 August 2024
Publication Date: 22 December 2024

Carlos Arturo García Aycardi [a]
Pontificia Universidad Javeriana. Bogotá, Colombia
garcia.carlos@javeriana.edu.co
https://orcid.org/0009-0000-1854-8654

Gustavo Alberto Ramírez Fuentes [a]
Pontificia Universidad Javeriana. Bogotá, Colombia
ramirez.gustavo@javeriana.edu.co
https://orcid.org/0009-0005-4117-2831

Juan Carlos Vergel Rodríguez [a]
Pontificia Universidad Javeriana. Bogotá, Colombia
vergelj@javeriana.edu.co
https://orcid.org/0009-0009-9863-3677

Edgar Enrique García Hurtado [a]
Pontificia Universidad Javeriana. Bogotá, Colombia
edgar.garcia@javeriana.edu.co
https://orcid.org/0009-0007-6670-8035

Adriana Rodríguez Ciódaro [a]
Pontificia Universidad Javeriana. Bogotá, Colombia
aciodaro@gmail.com
https://orcid.org/0000-0002-6640-3975

Authors' Note: [a] **Correspondence:** Garcia.carlos@javeriana.edu.co; ramirez.gustavo@javeriana.edu.co; vergelj@javeriana.edu.co; edgar.garcia@javeriana.edu.co; aciodaro@gmail.com

ABSTRACT

Background: Modern dentistry focuses on preserving dental structures using treatments that provide strength and are minimally invasive. Occlusal veneers, thin restorations requiring simple preparations, represent conservative alternatives to full crowns. **Purpose**: To compare the effect of thickness on the fracture resistance of occlusal veneers made from two block polymeric materials. **Methods**: This experimental *in vitro* and *ex vivo* study used 60 healthy premolars extracted for orthodontic purposes, divided into six groups (N=10) based on the resin used: Crios® (Coltene) and Tetric CAD® (Ivoclar Vivadent), with three thicknesses (i.e., 0.4 mm, 0.6 mm, and 0.8 mm). A standardized dental preparation simulated advanced occlusal erosion. Veneers were fabricated using digital scans with an Omnicam® scanner (Dentsply Sirona), CAD-CAM design, and milling with a Cerec InLab MC X5® machine. They were then sandblasted and adhesively cemented with Relyx

U200®. Fracture resistance tests were conducted on a universal testing machine ($p < 0.05$). **Results**: Significant differences were observed in nine groups. Tetric CAD® at 0.8 mm showed the highest resistance (1790 N and 149.2 MPa), while Crios® at 0.4 mm showed the lowest resistance (1053.8 N and 87.8 MPa). All groups withstood average forces between 1000 N and 1800 N. **Conclusions**: Both Tetric CAD® and Brilliant Crios® are viable options for minimally invasive rehabilitation. At lower thicknesses (0.4 mm), Tetric CAD® performed better. Increasing thickness (0.8 mm) improved resistance but also raised the risk of fracture
Keywords: block resin; CAD-CAM; computer-aided design; dental materials; dentistry; occlusal veneers; prosthodontics; resistance; thickness

RESUMEN

Antecedentes: La odontología actual se centra en preservar la estructura dental, utilizando tratamientos que proporcionen solidez y sean mínimamente invasivos. Las carillas oclusales, restauraciones delgadas que requieren preparaciones simples, representan alternativas conservadoras a las coronas completas. **Objetivo**: Comparar el efecto del espesor de dos materiales poliméricos en bloque sobre la resistencia a la fractura de carillas oclusales. **Métodos**: En este estudio experimental *in vitro* y *ex vivo* se emplearon 60 premolares sanos extraídos por ortodoncia, divididos en 6 grupos (N=10) según la resina utilizada: Crios® (Coltene) y Tetric CAD® (Ivoclar Vivadent), y tres espesores (0,4 mm, 0,6 mm y 0,8 mm). Se estandarizó una preparación dental que simuló erosión oclusal avanzada. Las carillas se fabricaron mediante escaneos digitales con un scanner Omnicam® (Dentsply Sirona), diseño CAD-CAM y fresado con una máquina Cerec InLab MC X5®. Posteriormente, se arenaron y se cementaron adhesivamente con Relyx U200®. Las pruebas de resistencia a la fractura se realizaron en una máquina universal ($p < 0,05$). **Resultados**: Se observaron diferencias significativas en 9 grupos. Tetric CAD® a 0,8 mm presentó la mayor resistencia (1790 N y 149,2 MPa), mientras que Crios® a 0,4 mm mostró la menor resistencia (1053,8 N y 87,8 MPa). Todos los grupos resistieron fuerzas promedio entre 1000 N y 1800 N. **Conclusiones**: Tanto Tetric CAD® como Brilliant Crios® son opciones viables para rehabilitación mínimamente invasiva. A menor espesor (0,4 mm), Tetric CAD® mostró un mejor desempeño. Al aumentar el espesor (0,8 mm), incrementó la resistencia, pero también la probabilidad de fractura.
Palabras clave: carillas oclusales; CAD-CAM; diseño asistido por computador; espesor; materiales dentales; odontología; prostodoncia; resina en bloque; resistencia

RESUMO

Antecedentes: A odontologia atual tem como foco a preservação da estrutura dentária, utilizando tratamentos que proporcionem solidez e sejam minimamente invasivos. Facetas oclusais, restaurações finas que requerem preparos simples, representam alternativas conservadoras às coroas totais. **Objetivo**: Comparar o efeito da espessura de dois materiais de bloco poliméricos na resistência à fratura de facetas oclusais. **Métodos**: Neste estudo experimental *in vitro* e *ex vivo* foram utilizados 60 pré-molares hígidos extraídos por ortodontia, divididos em 6 grupos (N=10) de acordo com a resina utilizada: Crios® (Coltene) e Tetric CAD® (Ivoclar Vivadent), e três espessuras. (0,4 mm, 0,6 mm e 0,8 mm). Um preparo dentário que simulasse erosão oclusal avançada foi padronizado. As facetas foram confeccionadas por meio de escaneamento digital com scanner Omnicam® (Dentsply Sirona), desenho CAD-CAM e fresamento com máquina Cerec InLab MC X5®. Posteriormente, foram jateados e cimentados adesivamente com Relyx U200®. Os testes de resistência à fratura foram realizados em máquina universal ($p < 0,05$). **Resultados**: Diferenças significativas foram observadas em 9 grupos. Tetric CAD® em 0,8 mm apresentou a maior resistência (1790 N e 149,2 MPa), enquanto Crios® em 0,4 mm apresentou a menor resistência (1053,8 N e 87,8 MPa). Todos os grupos resistiram a forças médias entre 1.000 N e 1.800 N. **Conclusões**: Tanto o Tetric CAD® quanto o Brilliant Crios® são opções viáveis para reabilitação minimamente invasiva. Com uma espessura menor (0,4 mm), o Tetric CAD® apresentou melhor desempenho. Ao aumentar a espessura (0,8 mm), a resistência aumentou, mas também a probabilidade de fratura.
Palavras-chave: CAD-CAM; desenho assistido por computador; facetas oclusais; grossura; materiais dentários; odontologia; prótese dentária; resina em bloco; resistência

INTRODUCTION

Dental enamel, a hard, thin, and translucent layer of calcified substance that surrounds and protects dentin (1), is composed of a dense network of hydroxyapatite crystals and minerals such as calcium and phosphates. These components provide it with strength and hardness, protecting the underlying tissues from wear. This wear is defined as the progressive reduction in enamel thickness (2). Due to its function and location within the oral cavity, dental enamel is exposed to an environment that subjects it to various changes. These include mechanical forces, such as parafunctional habits (bruxism), and chemical substances, whether extrinsic (beverages or food) or intrinsic (gastric alterations). Over a lifetime, these factors alter its structure and thickness. This poses a problem because, unlike other tissues in the human body, dental enamel cannot regenerate. This makes it more susceptible to fissures, cavities, or cracks, potentially leading to tooth loss as a consequence of changes affecting this tissue (2).

Among the possible solutions to replace lost dental structure are various treatments, depending on the severity of the lesions. In cases of incipient lesions, where only the enamel or superficial dentin is affected, clinical monitoring and a non-invasive treatment can be chosen, such as sealing the dentin with an adhesive agent or performing conservative direct composite resin restorations (3). On the other hand, in severe lesions with minimal enamel remaining and deeper dentin involvement, occlusal veneers, also known as tabletops, represent an effective treatment option to reduce the tooth's susceptibility to caries and other pathologies related to the loss of these structures (2,4).

These occlusal veneers are small laminates made from various materials, such as ceramics, composite resins, and hybrid materials. They enable the indirect and minimally invasive restoration of lost dental structure on occlusal surfaces due to previously described physiological or pathological processes (2,4). Additionally, in cases of loss or the need to restore vertical dimension, the literature indicates that it is possible to recover it through the use of occlusal veneers, which are considered a minimally invasive treatment alternative (5).

In cases of severe wear, dental enamel is scarce, dentin is exposed, and adhesion may be compromised. The preservation of enamel enhances the adhesion of restorative materials to the dental substrate. For this reason, restoring advanced erosive lesions using adhesive techniques that allow minimal reduction of healthy dental structure, with non-retentive or preferably "no-preparation" designs, is considered the best alternative (5).

The selective wear or preparation required in the dental structure to properly adapt occlusal veneers depends on the amount and location of tissue loss, whether in the enamel or dentin. In many cases, simply regularizing the worn or affected dental surface is sufficient to ensure proper adhesion of the restorative material. Previously, in cases of significant tissue loss, more aggressive procedures were used, involving the removal of healthy dental structure in the periphery to ensure the retention of full-coverage restorations (4,5).

Currently, various materials are available for fabricating occlusal veneers, such as ceramic blocks, composite resins, and hybrid materials. These veneers can be manufactured either analogously or through digital systems known as computer-aided design/computer-aided manufacturing (CAD-CAM).

Ceramics are the most commonly used materials for fabricating occlusal veneers, having become a standard treatment option for dentists. For over 15 years, they have been the preferred material for replacing dental enamel, not only for their aesthetic qualities but also for their physical properties. In their design, thickness is a critical factor to ensure adequate resistance to the forces the veneer encounters during use. At present, a thickness of 1 mm to 1.5 mm is recommended; however, even with thinner veneers, as little as 0.3 mm, sufficient fracture resistance can be maintained due to the material's properties (4,6,7).

Presently, new CAD-CAM polymeric blocks with innovative physical properties are available, such as Tetric CAD® by Ivoclar Vivadent and Brilliant Crios® by Coltene. These materials have an elastic modulus similar to that of natural teeth, allowing them to better absorb and distribute the loads they endure. This enhances the longevity, stability, and mechanical behavior of dental restorations (8). In this context, the objective of this study was to compare the effect of thickness (0.4 mm, 0.6 mm, and 0.8 mm) of two polymeric materials on fracture resistance for the fabrication of occlusal veneers.

MATERIALS AND METHODS

With the approval of the Research and Ethics Committee of the Faculty of Dentistry at Pontificia Universidad Javeriana, an *ex vivo*, *in vitro* experimental study was conducted. Sixty recently extracted human maxillary premolars, free of caries and restorations, were obtained for orthodontic purposes with prior consent for organ donation from the donor patients. After extraction, the teeth were stored in distilled water at room temperature in a sealed container for preservation and cleaned with a chloramine-T solution. Subsequently, they were mounted in self-curing transparent acrylic resin cubes (Veracril®, New Stetic) measuring 2 cm in height and 2 cm in width, embedding the root up to the cementoenamel junction. Figures 1–6 illustrate the processes of preparation, design, cementation, and resistance testing.

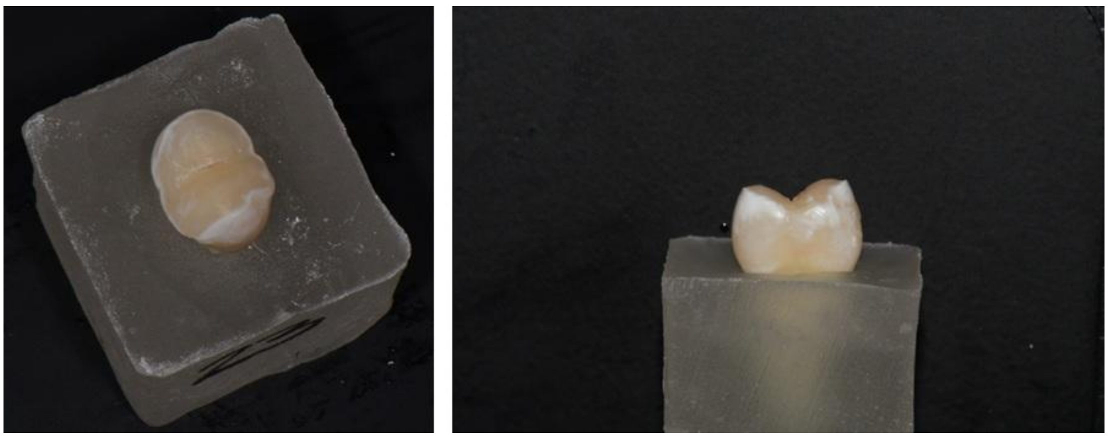

FIGURE 1
Teeth on Transparent Resin Cubes up to the Enamel-Cementum Line

Tooth Preparation

The coronal structure of the premolars was prepared on the occlusal surface to simulate advanced occlusal erosion. A 151-micron diamond bur (ref. #370) and a 40-micron fine-grain bur (ref. #8370) from Komet Brasseler® were used, positioned horizontally relative to the occlusal plane of the teeth. This procedure shaped and smoothed the surface, maintaining the inclination of the cusp slopes and achieving a depth of 1 mm. The result exposed dentin in the center and enamel at the periphery, clinically replicating severe wear. To ensure the preparation depth, the bur was marked at a distance of 1 mm. All angles were rounded, and the depth at the central groove matched the anatomical shape of the bur. A preparation parallelometer was used to standardize the preparations and ensure uniformity in the angles.

Each specimen was stored in distilled water until the design, milling, and cementation processes for the restorations required for testing began. Sixty specimens were randomly assigned to two block polymeric materials: Tetric CAD® (Ivoclar Vivadent), with n=30, and Brilliant Crios® (Coltene), also with n=30. Each group was further subdivided based on the thickness of the occlusal veneer: n=10 for 0.4 mm, n=10 for 0.6 mm, and n=10 for 0.8 mm in both materials. A digital impression of each specimen was taken using the Omnicam® scanner (Dentsply Sirona), and the occlusal veneer was subsequently designed.

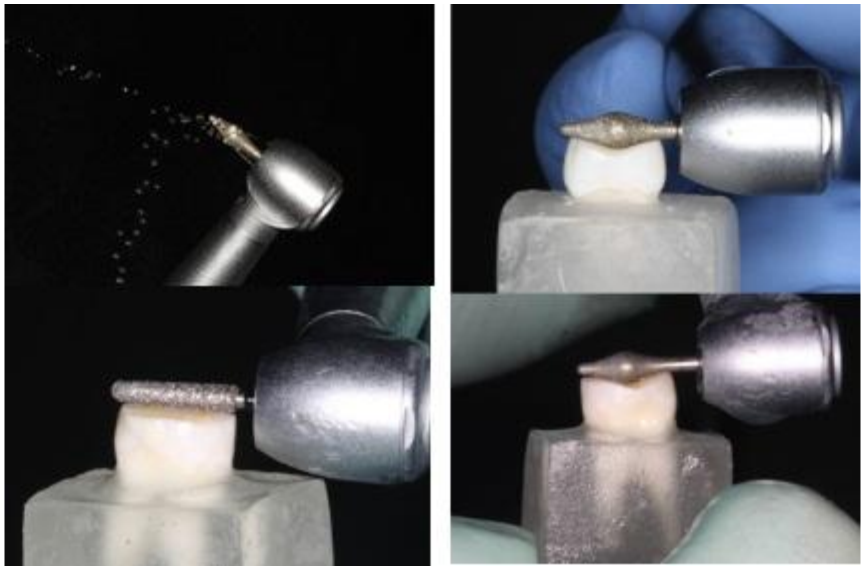

FIGURE 2
Tooth Preparation with Komet Burs on the Occlusal Surface Imitating Occlusal Erosion

Restoration Design and Manufacturing

The occlusal veneers were digitally designed using the Inlab 18® software with thicknesses of 0.4 mm, 0.6 mm, and 0.8 mm, and fabricated using the five-axis Cerec InLab MC X5® machine (Dentsply Sirona). The restorations were milled and cleaned following the specific protocols provided by each manufacturer for the selected materials. The fit and seating of each restoration on its respective specimen were evaluated under a stereomicroscope before proceeding with cementation.

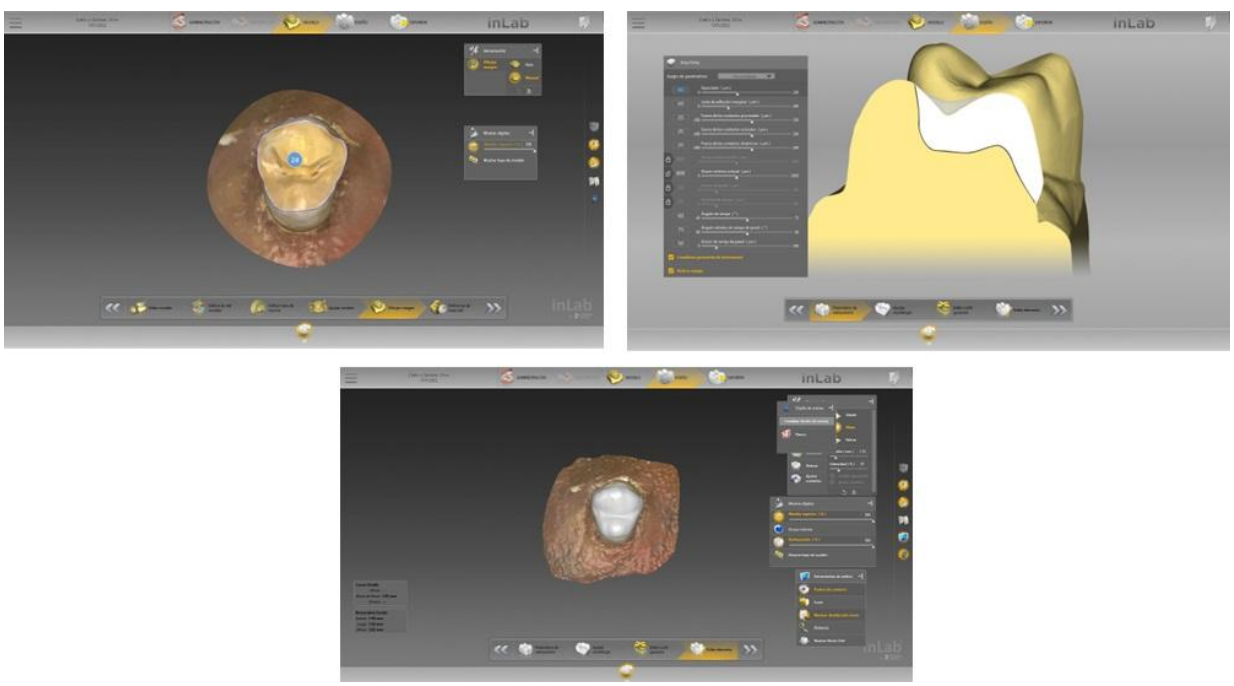

FIGURE 3
Design of Occlusal Veneers in Inlab 18® Software

Cementation of the Restoration

The conditioning of the tooth surface involved etching the enamel with 37 % orthophosphoric acid for 15 seconds, followed by careful rinsing and drying without desiccation. For the restorations, the protocol included sandblasting with 50-micron aluminum oxide at 2 bars of pressure, drying with oil-free air, and applying a seventh-generation adhesive (Single Bond Universal®, 3M). This adhesive was left to sit for 1 minute before being air-thinned.

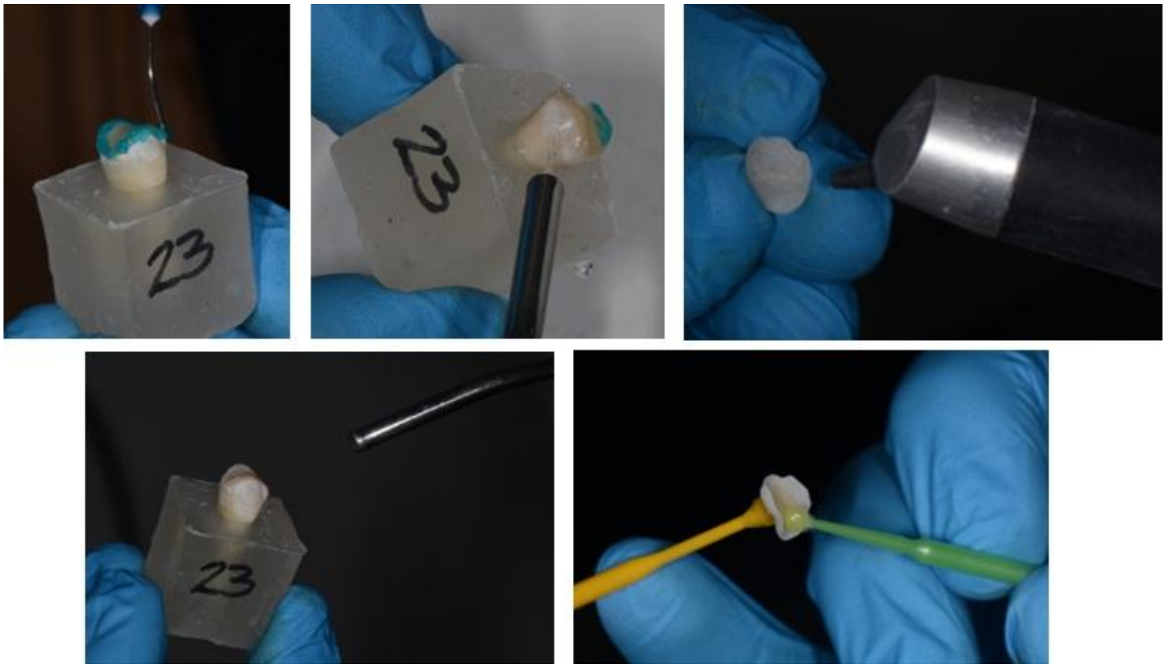

FIGURE 4
Cementation Protocol for Tooth and Restoration

The final cementation was performed by applying the self-adhesive resin-based cement Relyx-U200® (3M ESPE) to the restoration. It was seated with 5 kg of digital pressure for 5 minutes. Excess material was then removed, and the restoration was light-cured at a distance of 5 mm for 20 seconds on each mesial, distal, buccal, and lingual surface using the Bluephase N® lamp (Ivoclar Vivadent) with a power of 1200 mW/cm². After cementation, the samples were stored in a water bath at 37 °C until three days before testing.

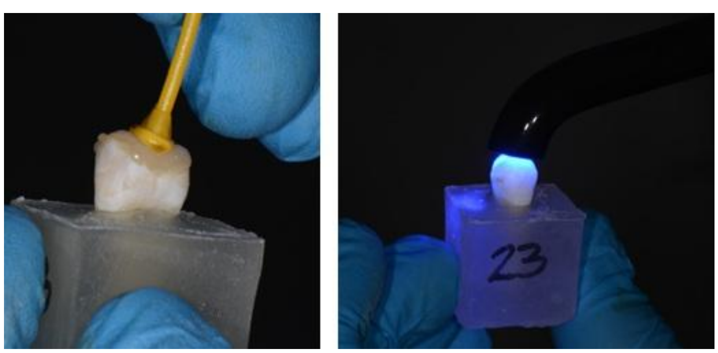

FIGURE 5
Cementation with RelyxU200® and Polymerization

Resistance Test

The fracture resistance of the samples was measured using compressive forces applied with a universal testing machine (MRC® ref. UTM-65), which allowed for control of both time and applied force. The samples were positioned vertically, and the load was applied individually using a 6 mm diameter stainless steel spherical tip on the occlusal surface, simulating an antagonistic cusp. In all six groups, fracture resistance was recorded by observing failures such as a fracture line in the veneer, restoration fracture, or simultaneous fracture of the tooth and restoration. The force values at fracture were expressed in Newtons, and the material's resistance was reported in megapascals.

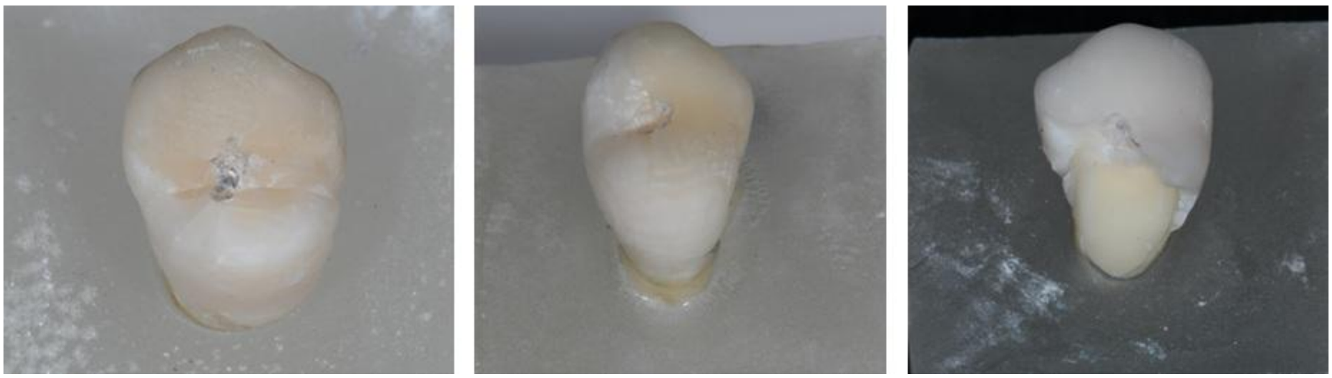

FIGURE 6
Fracture Line on Veneer, Fracture of Restoration, and Fracture of Tooth and Restoration Simultaneously

Data were collected and a descriptive and exploratory statistical analysis was performed using the ANOVA technique to determine whether there were significant differences in the average fracture resistance of the occlusal veneers, measured in MPa, based on the material used (Crios® and Tetric CAD®) and the thickness (0.4 mm, 0.6 mm, and 0.8 mm), generating six groups for comparison. The viability of the ANOVA was verified through residual analysis of the linear model and normality tests such as QQ plot, Shapiro-Wilk, and Kolmogorov-Smirnov. A p-value lower than 0.05 (95% confidence) was considered significant. Additionally, the Chi-square independence test was used to evaluate the association between the type of failure, the material, and the thickness of the veneers.

RESULTS

Considering the results on the type of failure, Brilliant Crios® exhibited similar behavior between thicknesses of 0.4 mm and 0.8 mm. The only significant difference was a 10 % increase in the probability of restoration and tooth fracture when comparing these thicknesses, while the probability of restoration-only fracture decreased, and the percentage of restoration fractures with a crack line in the tooth remained constant. On the other hand, at a thickness of 0.6 mm, cases of restoration and tooth fractures doubled, whereas cases of restoration fractures with a crack line in the tooth decreased significantly. Despite these findings, no clear pattern was identified to indicate consistent differences between the types of failure (Figure 7).

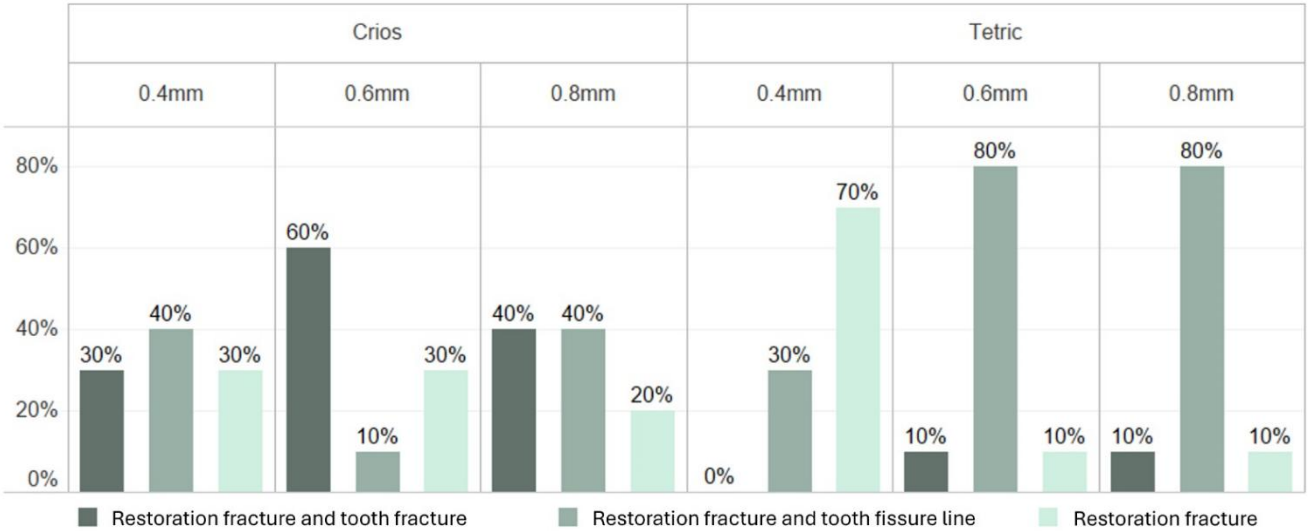

FIGURE 7
Frequency of Failure Types for each Material and Thickness

For the Tetric CAD® material, failures showed similar proportions at thicknesses of 0.6 mm and 0.8 mm, with a high prevalence of restoration fracture accompanied by a crack line in the tooth. Overall, the frequency of restoration and tooth fractures was exceptionally low across all thicknesses, in contrast to Brilliant Crios®. At a thickness of 0.4 mm, a significant increase in the probability of restoration fracture was observed, along with a decrease in the probability of restoration fracture with a crack line in the tooth, indicating a different behavior compared to the other thicknesses (Figure 7).

Resistance-related Findings

Overall, the force measured in Newtons was higher on average when using Tetric CAD®, as the means exceeded those of Brilliant Crios® across all thicknesses. Regardless of the material, the 0.8 mm thickness showed the highest average resistance at 149.2 MPa. Comparative analysis of the three thicknesses for both materials, using the Tukey test to evaluate the material-thickness interaction, revealed a statistically significant difference (p = 0.008). This difference is mainly attributed to the 0.8 mm thickness of Brilliant Crios®, whose resistance (109.1 MPa) was significantly lower compared to Tetric CAD® (149.2 MPa) (p = 2.47 E-08). At lower thicknesses, such as 0.4 mm, Brilliant Crios® also exhibited lower fracture resistance (87.8 MPa) compared to Tetric CAD® (121.3 MPa), and this difference was statistically significant (p = 0.000002) (Table 1).

TABLE 1

Average Force en each Experimental Group in Newtons and Resistance to Fracture Expressed in MPa

Material/Espesor	Promedio de Fuerza en N	Desv. Est. Fuerza en N	Promedio de resistencia en Megapascales	Desv. Est. Resistencia en MPa
CRIOS (COLTENE)	**1182,0**	**154,7**	**98,5**	**12,9**
0.4MM	1053,8	107,0	87,8	8,9
0.6MM	1182,9	116,9	98,6	9,7
0.8MM	1309,3	125,4	109,1	10,4
TETRIC CAD (IVOCLAR)	**1539,3**	**249,9**	**128,3**	**20,8**
0.4MM	1455,9	223,4	121,3	18,6
0.6MM	1371,3	177,0	114,3	14,8
0.8MM	1790,9	102,9	149,2	8,6
Total general	**1360,7**	**273,7**	**113,4**	**22,8**

Figure 8 presents the behavior of resistance values in MPa for each combination of the evaluated factors, allowing for the observation of differences in fracture resistance based on the material and thickness analyzed.

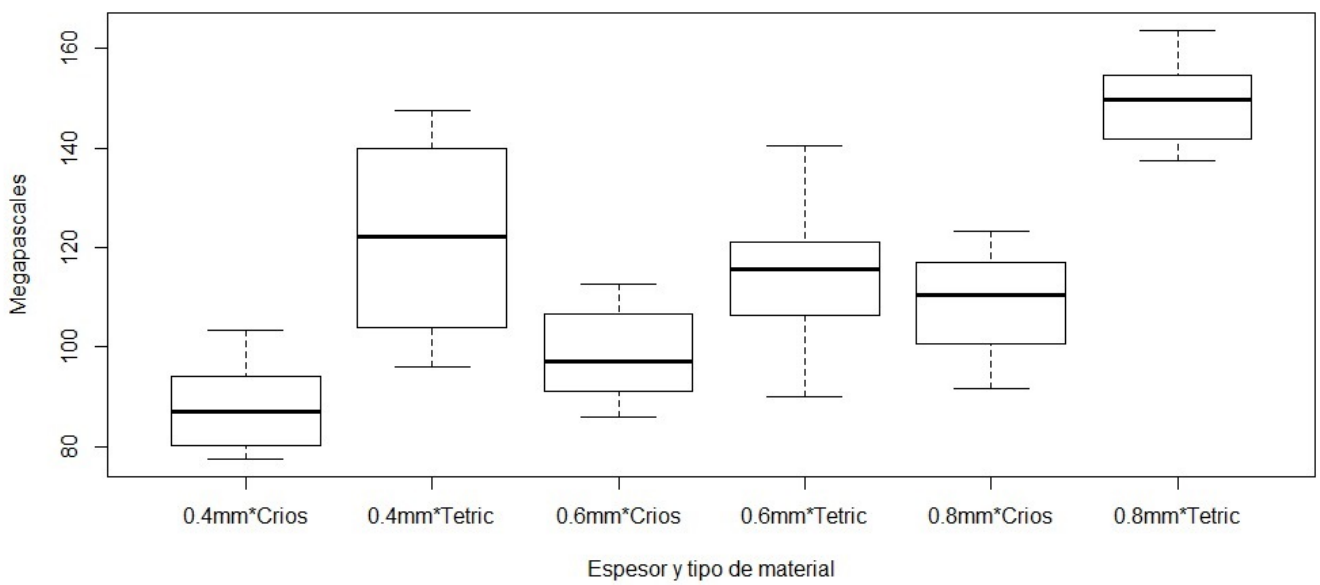

FIGURE 8

Median Fracture Resistance of each Experimental Group Expressed in MPa

At all thickness levels, the resistance measurements of the samples with Tetric CAD® consistently exceed those of Brilliant Crios®, particularly at thicknesses of 0.4 mm and 0.8 mm. This suggests that statistically significant differences in fracture resistance exist depending on both the material used and its thickness (Figure 8).

On the other hand, the resistance in the Brilliant Crios® samples shows a trend of improvement with increasing thickness, whereas in Tetric CAD®, the median resistance in MPa remains relatively constant between thicknesses of 0.4 mm and 0.6 mm but is notably higher in the 0.8 mm group. It is important to highlight that, except for the 0.4 mm Tetric CAD® samples, the other groups exhibited a relatively small standard deviation, indicating greater consistency in the results (Figure 8).

To confirm the findings of the descriptive analysis, a two-factor analysis of variance ANOVA was performed. The results are presented below (Table 2).

TABLE 2
Significant Differences (p <0.05)

Fuente de variación	Grados de libertad	Suma de cuadrados	Cuadrado medio	F calculado	P-valor
Material	1	13301	13301	86,616	8,16E-13
Espesor	2	7511	3755	24,455	2,74E-08
Material*Espesor	2	1597	799	5,201	0,0086
Residuals	54	8292	154		

Based on the results of the ANOVA test, the following hypothesis was proposed:

$H_0^{(1)}$: All pressure means $\mu_{i,j}$ are equal, where $i = 1, 2$ corresponds to the materials and $j = 1, 2, 3$ refers to the thicknesses.

$H_1^{(1)}$: There is at least one mean $\mu_{i,j}$ that differs from the others.

With a 95% confidence level, sufficient statistical evidence was found to reject the null hypothesis $H_0^{(1)}$. The analysis showed that the *p*-value for the interaction between materials and thicknesses was 0.0086, which is lower than the significance level of 0.05. Therefore, it is inferred that the resistance measured in MPa exhibits significant differences depending on the combination of material and thickness used (Table 2).

After evaluating this hypothesis, the following can be established:

$H_0^{(2)}$: All pressure means μ_i are equal, where i = 1,2 corresponds to the materials.

$H_1^{(2)}$: The means μ_i are different.

With 95 % confidence, it can be inferred that there is a difference in pressure resistance (MPa) depending on the material used, as the *p*-value for this factor was virtually zero (8.16E-13). This occurs regardless of the thickness level with which it is combined (Table 2).

Finally, the significance of thickness can be evaluated individually; for this purpose, the following hypothesis was proposed:

$H_0^{(3)}$: All pressure means μ_j are equal, where $j = 1, 2, 3$ corresponds to the thickness.

$H_1^{(3)}$: There is at least one mean μ_j that differs from the others, where j corresponds to the thickness levels.

With a 95 % confidence level, the statistical significance of the thickness factor is confirmed. Similar to the material factor, the obtained *p*-value was extremely low (2.74E-08), allowing the conclusion that, regardless of whether Tetric CAD® or Brilliant Crios® is used, thickness alone generates significant differences in resistance measured in MPa (Table 2).

Given the results obtained, Tukey tests were conducted to individually analyze the factors of material and thickness. The objective was to identify the specific levels of each factor that generate significant differences in pressure resistance (MPa) (Table 3).

TABLE 3
Significant Difference (p <0.005) Between Groups by Thickness

Factor	Grupos	Diferencia	Inferior 95%	Superior 95%	P-valor
Material	Tetric - Crios	29,78	23,36	36,19	0,0000
Espesor	0.6mm - 0.4mm	1,86	-7,59	11,30	0,8838
	0.8mm - 0.4mm	24,61	15,16	34,05	0,0000
	0.8mm - 0.6mm	22,75	13,31	32,19	0,0000

As in the descriptive analysis, it was confirmed that pressure resistance (MPa) is higher when using Tetric CAD®, as the Tetric-Crios contrast showed a positive difference. Additionally, the associated *p*-value was small, aligning with the results obtained in the ANOVA analysis (Table 3).

In the analysis of the second factor, no significant differences were identified between the thicknesses of 0.6 mm and 0.4 mm, as reflected by a high *p*-value of 0.8838. However, contrasts involving the 0.8 mm thickness were significant, indicating that this level accounts for the observed differences in this factor (Table 3).

The mean plot for the two factors is presented below, validating the conclusions obtained. This graph clearly illustrates how differences in pressure resistance (MPa) are influenced by the interaction between the material used and the applied thickness (Figure 9).

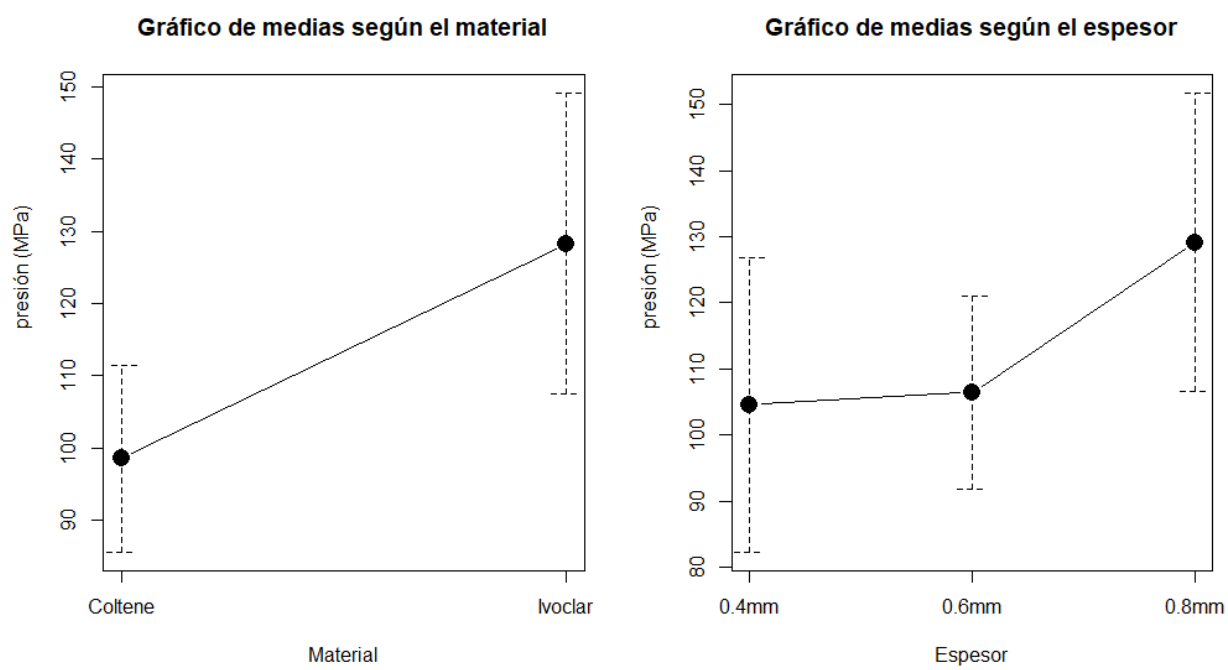

FIGURE 9
Average Fracture Resistance of Materials in all Thicknesses Studied

The Tukey test was reapplied to determine which combinations of factors (material and thickness) exhibit significantly different resistance compared to the others. This analysis identified the specific interactions between the factor levels that significantly influence pressure resistance (MPa). The detailed results of these comparisons are presented in Table 4.

TABLE 4
Levels of Significance when Comparing Thickness and Material

Grupos	Diferencia	Inferior 95%	Superior 95%	P - Valor
0.6mm*Crios - 0.4mm*Crios	10,76	-5,61	27,14	0,388423
0.8mm*Crios - 0.4mm*Crios	21,30	4,92	37,67	0,004150
0.4mm*Tetric - 0.4mm*Crios	33,51	17,14	49,88	0,000002
0.6mm*Tetric - 0.4mm*Crios	26,46	10,09	42,83	0,000198
0.8mm*Tetric - 0.4mm*Crios	61,43	45,05	77,80	4,89E-13
0.8mm*Crios - 0.6mm*Crios	10,53	-5,84	26,91	0,413028
0.4mm*Tetric - 0.6mm*Crios	22,74	6,37	39,12	0,001833
0.6mm*Tetric - 0.6mm*Crios	15,69	-0,68	32,07	0,067463
0.8mm*Tetric - 0.6mm*Crios	50,66	34,29	67,04	2,26E-11
0.4mm*Tetric - 0.8mm*Crios	12,21	-4,16	28,58	0,253142
0.6mm*Tetric - 0.8mm*Crios	5,16	-11,21	21,54	0,936572
0.8mm*Tetric - 0.8mm*Crios	40,13	23,76	56,50	2,47E-08
0.6mm*Tetric - 0.4mm*Tetric	-7,05	-23,42	9,32	0,798684
0.8mm*Tetric - 0.4mm*Tetric	27,92	11,55	44,29	0,000079
0.8mm*Tetric - 0.6mm*Tetric	34,97	18,60	51,34	7,93E-07

Of the 15 contrasts evaluated, 9 showed significant differences, highlighting that all contrasts involving the Tetric CAD® – 0.8 mm treatment were significant. The mean for this combination was the highest, with an average pressure resistance of 149.2 MPa. This leads to the conclusion that Tetric CAD® – 0.8 mm is the material with the highest resistance. Additionally, treatments with Tetric CAD® generally outperformed those with Crios®, except at a thickness of 0.6 mm, where no significant differences were observed between the materials.

On the other hand, in Crios®, differences were observed only between the thicknesses of 0.8 mm and 0.4 mm. In contrast, in Tetric CAD®, differences were identified between the thicknesses of 0.8 mm and 0.6 mm, as well as between 0.8 mm and 0.4 mm (Table 4).

The following graph presents the correlation between the previously mentioned results and the means, considering the material-thickness interaction. This supports the findings obtained (Figure 10).

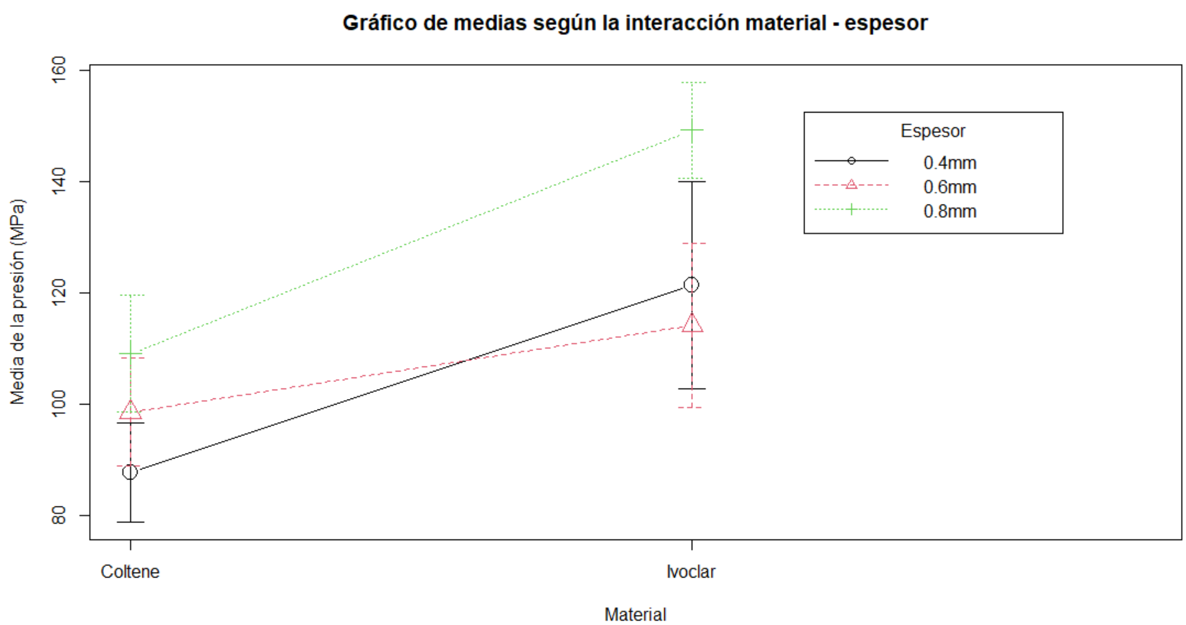

FIGURE 10
Mean Comparison According to the Material-Thickness Comparison

Normality

The QQ plot and a histogram of the residuals are presented below. In the QQ plot, all points align with the straight line and fall within the confidence bands. In the histogram, a symmetric distribution centered at 0 is observed. Both graphs indicate that the assumption of normality in the residuals is satisfied (Figure 11).

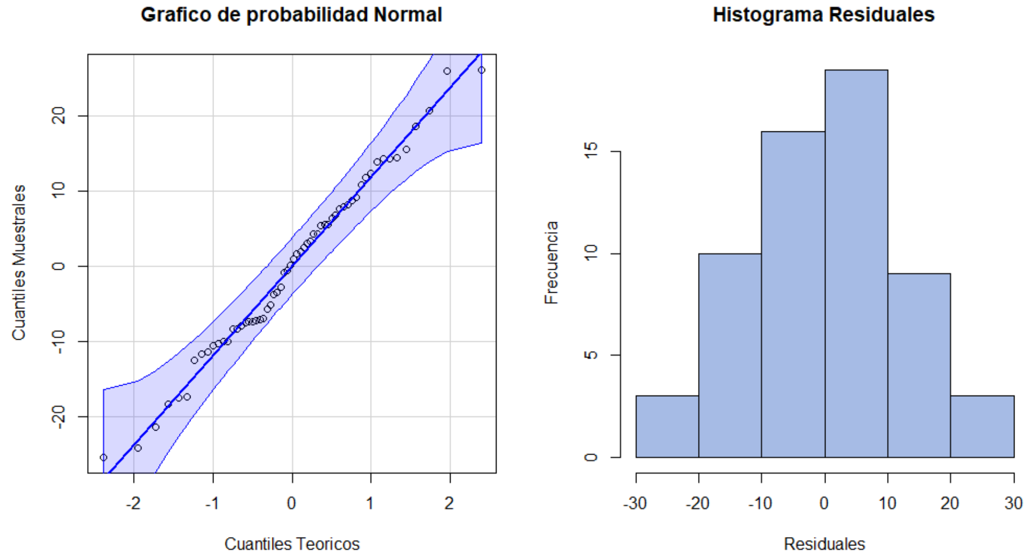

FIGURE 11
Normality Analysis

The QQ plot and a histogram of the residuals are presented below. In the QQ plot, all points align with the straight line and fall within the confidence bands. In the histogram, a symmetric distribution centered at 0 is observed. Both graphs indicate that the assumption of normality in the residuals is satisfied (Figure 11).

DISCUSSION

The traditional restorative approach with full-coverage crowns involves substantial removal of healthy enamel. In contrast, ceramic occlusal veneers with conservative dental preparation have recently emerged as an effective treatment for rehabilitating cases of severe dental erosion. This approach is based on the principles applied to porcelain or resin veneers for anterior laminates, which led to the development of so-called posterior "occlusal veneers," characterized by their thin, non-retentive overlay design. These restorations can be compared to gold onlays or overlays, as they are extracoronal and require simpler, more intuitive preparations tailored to the interocclusal space and anatomical considerations. For resin restorations, a recommended thickness is between 1.0 mm and 1.5 mm (9).

Currently, there is a wide variety of materials with unique characteristics, such as glass-ceramics and polymeric materials. Among the latter, CAD-CAM polymer blocks like Tetric CAD® and Brilliant Crios® stand out. These materials exhibit new physical properties that may offer improved physical-mechanical performance due to their elastic modulus, which is similar to that of natural teeth. Additionally, they can efficiently absorb and distribute applied loads, contributing to enhanced longevity, stability, and mechanical behavior of these dental materials (8).

The thickness of polymeric and ceramic block materials significantly influences fracture resistance. Various studies have evaluated the behavior of occlusal veneers made from ceramics compared to polymeric materials or composite resin blocks. Notably, the 2010 study by Magne, *et al.* (9) examined the compressive strength of occlusal veneers with a thickness of 1.2 mm. IPS Empress CAD® ceramic veneers failed under an average load of 900 N. In contrast, the crack-free survival rates at 1400 N were 30% in the IPS e.max CAD® group and 100% in the MZ100® polymer group. These results suggest that MZ100® polymer demonstrated superior fatigue resistance compared to IPS EmpressCAD® and IPS e.max CAD® ceramics.

Schlichting, *et al.* (2011) (8) compared occlusal veneers made from ceramics and polymeric materials. In the first group, restorations made of leucite-reinforced ceramic (IPS Empress CAD®) failed under an average load of 500 N, while lithium disilicate ceramic (IPS e.max CAD®) restorations failed at an average load of 800 N. None of the samples withstood 1000 N. In contrast, in the polymeric materials or composite resins group (MZ100®), initial failure occurred at 800 N, with a survival rate of 60 % at 1400 N. The tests indicated that polymeric materials (MZ100®) exhibited greater fatigue resistance compared to ceramics (IPS Empress CAD® and IPS e.max CAD®), all with a standard thickness of 0.6 mm (10).

Johnson, *et al.* (13) studied the behavior of two polymeric materials under different loads. They found that the average maximum fracture loads for the groups of the first polymeric material (Paradigm MZ100®) were 1620 N, 1830 N, and 2027 N for thicknesses of 0.3 mm, 0.6 mm, and 1 mm, respectively. In the groups of the second polymeric material (Lava Ultimate®), fractures occurred at slightly higher loads of 2078 N, 2141 N, and 2115 N at the same thicknesses.

This study evaluated and compared the effect of thickness (0.4 mm, 0.6 mm, 0.8 mm) of two CAD-CAM polymeric materials on fracture resistance for the fabrication of occlusal veneers (Brilliant Crios® and Tetric CAD®). The results suggest that restorations with greater thickness exhibited significantly superior mechanical properties compared to those with lower thickness in both materials under the study conditions. Fracture resistance was measured by applying compressive forces to the samples using a universal testing machine to assess the mechanical properties of the polymeric materials.

Fracture resistance tests are essential for estimating the anticipated lifespan of restorations with a low likelihood of failure. Fracture resistance is commonly used to characterize the ability of brittle materials to withstand failure. On the other hand, fracture toughness is defined as a material's ability to resist crack propagation. Therefore, the most brittle material is the one with the lowest fracture toughness (12).

Therefore, it is important to understand that the behavior of these polymeric materials depends on their elastic modulus and their ability to absorb and distribute generated forces. For Brilliant Crios®, the elastic modulus is 10.3 GPa, while for Tetric CAD®, it is 10.2 GPa. Both values are not only low but also similar to the elastic modulus of dentin.

Understanding the behavior of materials under maximum masticatory forces is essential for comparing their maximum resistance results and evaluating their clinical use. The average force during mastication and swallowing in humans ranges between 3 N and 72 N, while maximum masticatory forces in the posterior region can reach between 200 and 540 N (13,14). This study demonstrates that the fracture resistance of the evaluated materials exceeds the physiological forces of mastication. Therefore, it can be concluded that both materials are capable of withstanding intraoral loading conditions, with resistance values ranging between 800 N and 1600 N.

A factor that could influence the results of this study is the type of dental preparation. In this case, the preparation was performed without including retentions, inclinations, or sharp angles, using a butt joint on the buccal and palatal cusps of the premolars. This joint was achieved using the Komet Brasseler® bur (ref. #370) to improve seating and force distribution, yielding favorable results in the fracture resistance of the evaluated materials and thicknesses. In contrast, the studies by Magne, *et al.* (2010) (7) and Schlichting, *et al.* (2011) (8) employed dental preparations that simulated dental erosion, preserving cusp height and inclination with unrounded edges. Meanwhile, the study by Sasse, *et al.*

(2015) featured a dental preparation with a 150° angle between the cusps, creating a cusp inclination while maintaining the circumferential contour in enamel (9,10,15).

CONCLUSIONS

Within the limitations of this *in vitro* and *ex vivo* study, the fracture resistance of occlusal veneers exceeded the forces generated by the human masticatory system. Fracture resistance is significantly influenced by both the material and thickness of the occlusal veneer, with Tetric CAD® demonstrating higher resistance values compared to Brilliant Crios®, particularly at greater thicknesses.

Fracture resistance differs significantly depending on the specific material-thickness combination, with certain combinations demonstrating superior performance in terms of mechanical properties.

Fracture resistance (MPa) is significantly influenced by the thickness of the occlusal veneer, regardless of the material used.

Brilliant Crios®, at thicknesses of 0.4 mm, 0.6 mm, and 0.8 mm, demonstrated the lowest resistance, failing at a lower MPa compared to the other material.

Tetric CAD®, at thicknesses of 0.4 mm, 0.6 mm, and 0.8 mm, demonstrated the highest resistance, failing at a higher MPa compared to the other material.

For Tetric CAD®, the thinner the veneer, the lower the probability of simultaneous fracture of the tooth and veneer. In contrast, this probability appeared to increase as the veneer thickness increased.

As for Brilliant Crios®, in a thickness of 0.4 mm, it significantly increased the probability of restoration fracture and decreased the probability of restoration fracture and tooth crack line.

References

1. The Glossary of Prosthodontic Terms: Ninth Edition. J Prosthet Dent. 2017 May; 117(5S): e1-e105. http://doi.org/10.1016/j.prosdent.2016.12.001
2. Lacruz RS, Habelitz S, Wright JT, Paine ML. Dental enamel formation and implications for oral health and disease. Physiol Rev. 2017 Jul 1; 97(3): 939-993. http://doi.org/10.1152/physrev.00030.2016
3. Bartlett DW. The role of erosion in tooth wear: aetiology, prevention and management. Int Dent J. 2005; 55(4 Suppl 1): 277-284. http://doi.org/10.1111/j.1875-595x.2005.tb00065.x
4. Edelhoff D, Liebermann A, Beuer F, Stimmelmayr M, Güth JF. Minimally invasive treatment options in fixed prosthodontics. Quintessence Int. 2016 Mar; 47(3): 207-216. http://doi.org/10.3290/j.qi.a35115
5. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 1. Eur J Esthet Dent. 2008 Spring; 3(1): 30-44
6. Al-Akhali M, Chaar MS, Elsayed A, Samran A, Kern M. Fracture resistance of ceramic and polymer-based occlusal veneer restorations. J Mech Behav Biomed Mater. 2017 Oct; 74: 245-250. http://doi.org/10.1016/j.jmbbm.2017.06.013
7. Magne P, Schlichting LH, Maia HP, Baratieri LN. In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. J Prosthet Dent. 2010 Sep; 104(3): 149-157. http://doi.org/10.1016/S0022-3913(10)60111-4
8. Schlichting LH, Maia HP, Baratieri LN, Magne P. Novel-design ultra-thin CAD/CAM composite resin and ceramic occlusal veneers for the treatment of severe dental erosion. J Prosthet Dent. 2011 Apr; 105(4): 217-226. http://doi.org/10.1016/S0022-3913(11)60035-8
9. Albelasy EH, Hamama HH, Tsoi JKH, Mahmoud SH. Fracture resistance of CAD/CAM occlusal veneers: A systematic review of laboratory studies. J Mech Behav Biomed Mater. 2020 Oct; 110: 103948. https://doi.org/10.1016/j.jmbbm.2020.103948
10. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 2. Eur J Esthet Dent. 2008 Summer;3(2):128-146
11. Vailati F, Belser UC. Full-mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part 3. Eur J Esthet Dent. 2008 Summer;3(2): 236-57.
12. Egbert JS, Johnsonb AC, Tantbirojnc D, Versluis A. Fracture strength of ultrathin occlusal veneer restorations made from CAD/CAM composite or hybrid ceramic materials. Oral Sci Int. 2015 May 31; 12(2): 53-58. https://doi.org/10.1016/S1348-8643(15)00017-8
13. Johnson AC, Versluis A, Tantbirojn D, Ahuja S. Fracture strength of CAD/CAM composite and composite-ceramic occlusal veneers. J Prosthodont Res. 2014 Apr;58(2):107-14. http://doi.org/10.1016/j.jpor.2014.01.001

14. Lauvahutanon S, Takahashi H, Shiozawa M, Iwasaki N, Asakawa Y, Oki M, Finger WJ, Arksornnukit M. Mechanical properties of composite resin blocks for CAD/CAM. Dent Mater J. 2014; 33(5): 705- https://doi.org/10. 10.4012/dmj.2014-208
15. Güngör MB, Nemli SK, Bal BT, Ünver S, Doğan A. Effect of surface treatments on shear bond strength of resin composite bonded to CAD/CAM resin-ceramic hybrid materials. J Adv Prosthodont. 2016 Aug; 8(4): 259-266. https://doi.org/10.4047/jap.2016.8.4.259

* Original research.

How to cite this article: García Aycardi CA, Ramírez Fuentes GA, Vergel Rodríguez JC, García Hurtado EE, Rodríguez Ciódaro A. Effect of Restoration Thickness on Fracture Resistance of Two CAD-CAM Polymeric Materials for Manufacturing Occlusal Veneers. Univ Odontol. 2024; 43. https://doi.org/10.11144/Javeriana.uo43.ertf