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Comparison of the Adhesive Strength of Universal Systems with and without MDP on Dentin by Microblading

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Abstract

In dentistry today, evaluating adhesive strength is crucial for successful treatment with universal adhesive systems. This article considers the adhesive resistance to dentin micro bleaching of two universal adhesive systems with and without MDP. For this purpose, third molars (n=40), divided into two groups, were used without occlusal enamel using a low-speed bioactive diamond disc with cooling up to 4mm above the amelocemental line. The universal adhesive system with MDP was applied for group 1 (n=20), and the universal adhesive system without MDP for group 2 (n=20). A standardized resin cylinder of 2mm in diameter and 4mm in height was made for both groups using a silicone mold, placing it on the occlusal surface. Each group was divided into two subgroups, where (n=10) were subjected to thermocycling and (n=10) were not subjected to thermocycling, to subsequently perform the micro-shearing test using the Shimadzu AGS-X Universal Testing Machine. The data were analyzed by ANOVA test, stating that the groups with MDP showed significantly higher micro-shear values than those without MDP. This indicates that the MDP group's mean shear load value of the resin cylinders is higher than that in the non-MDP group.

Keywords: MDP, Microshear, Thermocycling, Universal Adhesive.

Comparación de la resistencia adhesiva de sistemas universales con y sin MDP en dentina mediante microcizallamiento

Resumen

En la odontología actual, la evaluación de la fuerza adhesiva es crucial para el éxito del tratamiento con sistemas adhesivos universales. Este artículo evalúa la resistencia adhesiva al microblanqueamiento dentinario de dos sistemas adhesivos universales con y sin MDP. Para ello se utilizaron terceros molares (n=40), divididos en dos grupos, sin esmalte oclusal utilizando un disco de diamante bioactivo de baja velocidad con enfriamiento hasta 4mm por encima de la línea amelocementaria. Se aplicó el sistema adhesivo universal con MDP para el grupo 1 (n=20), y el sistema adhesivo universal sin MDP para el grupo 2 (n=20). Se elaboró un cilindro de resina estandarizado de 2 mm de diámetro y 4 mm de altura para ambos grupos utilizando un molde de silicona, colocándolo en la cara oclusal. Cada grupo se dividió en dos subgrupos, donde (n=10) fueron sometidos a termociclado y (n=10) no sometidos a termociclado, para posteriormente realizar el ensayo de microcizallamiento utilizando la Máquina Universal de Ensayos Shimadzu AGS-X. Los datos se analizaron mediante la prueba ANOVA, indicando que los grupos con MDP mostraron valores de microcizallamiento significativamente más altos que aquellos sin MDP. Esto muestra que el valor medio de la carga de cizallamiento de los cilindros de resina del grupo MDP es más alto que el del grupo sin MDP.

Palabras clave: MDP, Microcizallamiento, Termociclado, Adhesivo Universal.

Comparação da força adesiva de sistemas universais com e sem MDP sobre dentina por microblading

Resumo

Na odontologia moderna, a avaliação da força adesiva é crucial para o sucesso do tratamento com sistemas adesivos universais. Este artigo avalia a força adesiva para dentinar o microtreinamento de dois sistemas de adesivos universais com e sem MDP. Os terceiros molares (n=40), divididos em dois grupos, sem esmalte oclusal, foram utilizados para este fim usando um disco diamantado bioativo de baixa velocidade com resfriamento até 4mm acima da linha amelocemental. O sistema adesivo universal com MDP foi aplicado para o grupo 1 (n=20), e o sistema adesivo universal sem MDP para o grupo 2 (n=20). Um cilindro de resina padronizado de 2 mm de diâmetro e 4 mm de altura foi feito para ambos os grupos usando um molde de silicone e colocado no lado oclusal. Cada grupo foi dividido em dois subgrupos, onde (n=10) foram termociclados e (n=10) não foram termociclados, e então foram realizados testes de microcoração utilizando a Máquina Universal de Testes Shimadzu AGS-X. Os dados foram analisados pelo teste ANOVA, indicando que os grupos com MDP apresentaram valores significativamente mais altos de microcoração do que aqueles sem MDP. Isto mostra que o valor médio da carga de cisalhamento dos cilindros de resina no grupo MDP é maior do que o do grupo sem MDP.

Palavras-chave: Palabras clave: MDP, Microcisalhamento, Termociclagem, Adesivo Universal.

1. Introduction

The evolution of adhesive systems has focused on simplifying protocols, reducing application time and steps, thus reducing the possibility of errors in the application of these substances, as well as stimulating the creation of simpler adhesive systems [1]. However, the diversity of the tissues involved during a restorative process, the location of the cavity preparation, and the incidence of mainly occlusal forces lead us to wonder if these materials will have acceptable behavior over time on the dentin substrate, which is the most unpredictable tissue due to its structural morphology, humidity and pathological factors that can affect the adhesion and subsequent failure of the restoration [2], [3]. To avoid this type of problem, universal adhesives present functional monomers such as MDP that help with the acid etching of the dentin substrate, promote the penetration of the monomers, aid in wettability and cause an adhesive interaction with the tooth. However, their main advantage is their ability to chemically bond to demineralized hydroxyapatite, allowing greater longevity and less postoperative sensitivity [4], [5].

During the last few years, a great variety of clinical techniques have emerged, due to the immeasurable progress of dental materials and esthetic demands, which has allowed new adhesive results, reducing the clinical failures that occur especially in dentin, due to its morphophysiological differences, in comparison with dental enamel, which makes it difficult to achieve adequate adhesion. Loguercio [6] mentions that adhesives evolved from presenting a hydrophobic character to a hydrophilic one, capable of interacting with the dentin substrate, which is moist. However, [7] mentions that this is not the only limiting factor, since it also depends on the adhesive technique, the operator's skill and the current state of the dentin, which can cause long-term degradation of the dentin-dentin interface and subsequent failure of the restorative treatment.

Functional monomers have been introduced in universal adhesives, which can be applied to the dentin structure without acid etching, avoiding excessive disorganization of the collagen fibers. MDP has excelled in maintaining adequate stability of the dentin-resin interface, being the most used monomer, and obtaining superior research results to other functional monomers [8]. Due to the importance of the data above, the choice of adhesive should be mediated under all the parameters above, so it is necessary to research to determine the bond indicated for each clinical situation. The evolution of adhesive systems has focused on simplifying protocols and decreasing the time and steps of application. This seeks to reduce the possibility of errors in applying these substances and stimulate the creation of simpler adhesive systems. However, the diversity of the tissues involved during a restorative process, the location of the cavity preparation, and the incidence of mainly occlusal forces lead us to wonder if these materials will have acceptable behavior over time on the dentin substrate, which is the most unpredictable tissue due to its structural morphology, humidity and pathological factors that can affect the adhesion and subsequent failure of the restoration [9], [10].

To avoid this type of problem, universal adhesives present functional monomers such as MDP that help with the acid etching of the dentin substrate, promote the penetration of the monomers, aid in wettability, and cause an adhesive interaction with the tooth [1]. However, their main advantage is their ability to chemically bond to demineralized hydroxyapatite, allowing for greater longevity and less postoperative sensitivity. Therefore, this research will enable us to compare the adhesive strength of two universal adhesive systems, one with MDP and the other without MDP, since at the time of making a direct or indirect restoration, the interaction of these adhesives with dental tissues, especially with dentin, is what generates a strong and durable bond over time, thanks to its chemical and mechanical bonding, so it is essential to obtain this data to identify the importance of this functional monomer to ensure the success of any treatment. In adhesion to dental tissues, universal adhesive systems containing MDP will present more excellent resistance to micro-shear than universal adhesive systems that do not have MDP [11].

This article consists of four sections, including the introduction in section 1. The methodology is presented in section 2, and the results in section 3.

2. Methodology

2.1. Type and design of research

An experimental study was carried out in vitro since the variables were subjected to manipulation under controlled conditions and comparative since it was determined whether there is a difference in the adhesive strength of a universal adhesive system with MDP and another without MDP, which was evaluated using micro-shear loads, in samples subjected to thermocycling and samples not subjected to thermocycling.

2.2. Participants

The sample size was established by convenience, considering that the minimum sample in vitro studies is 10, for which third molars (n=40) were used, divided into two groups, to which the universal adhesive system with MDP was applied for group 1 (n=20), and the universal adhesive system without MDP for group 2 (n=20). Each group was divided into two subgroups: (n=10) were subjected to thermocycling, and (n=10) were not.

2.3. Inclusion and Exclusion Criteria

Recently extracted third molars, healthy third molars, and third molars without fissures or fractures were considered for inclusion. Extracted third molars that had not been preserved in ideal conditions, third molars with coronary destruction, and third molars with restorations were excluded.

2.4. Data collection techniques and instruments

For the research, 40 recently extracted third molars donated by the surgical center of the Faculty of Dentistry of the Central University of Ecuador were used, with the patient's authorization through the application of an informed consent form attached to the respective medical records. The biological samples collected met the inclusion and exclusion criteria and were stored in a physiological saline solution until the time of the study.

2.5. Sample preparation

Each sample was cleaned with a 7/8 Gracey curette and stored in distilled water at 37ºC until submitted to the study. The occlusal enamel of each of the teeth was removed using a low-speed bioactive diamond disc with cooling up to 4mm above the amelocementary line. The exposed surfaces were polished with fine-grit water sandpaper to standardize the smear layer. Each sample was placed in self-curing acrylic specimens measuring 20 mm high by 20 mm long by 10 mm wide, up to the amelocemental limit, leaving the coronary portion free. Chlorhexidine 2% was applied to the exposed dentin surface to eliminate the metalloproteinases responsible for the degradation of the resin-dentin interface, and the feeling was dried with sterile paper swabs.

2.6. Classification of the samples

The third molars were divided into two groups of 20 each, and the adhesive was applied to each group according to the manufacturer's specifications, as follows:

2.6.1. Group 1: Adhesive with MDP

A micro brush was embedded with the adhesive, and two adhesive layers were applied to the slightly moist dentin surface. The first layer was applied by rigorously rubbing the adhesive with the micro brush for 10 seconds. In sequence, the second layer of adhesive was used for 10 seconds, and an air jet was applied to evaporate the solvent; finally, polymerization was performed with a GNATUS LED light lamp with a power of 1200mW/cm2 for 10 seconds.

2.6.2. Group 1: Adhesive without MDP

A drop of adhesive was dispensed on a micro brush and applied to the preparation, rubbing it gently for 10 seconds. The layer was thinned with air pressure for 10 seconds; finally, it was polymerized with a GNATUS brand LED light lamp with 1200mW/cm2 power for 10 seconds. The surface should look shiny.

The restoration of each group was carried out by making a resin cylinder of 2mm diameter x 4mm height, with micro-hybrid resin, in a silicone mold, with a titanium gutta-perch and compacted with an attacker with increments of 2 mm checked with a caliper and polymerized with a GNATUS LED light lamp with a power of 1200mW/cm2 for 40 seconds according to the manufacturer's instructions. Each group was divided into two subgroups of 10 each, which were subjected to thermocycling as follows:

- SUBGROUP A: Subjected to thermocycling.
- SUBGROUP B: Not subjected to thermocycling.

The corresponding groups were stored in distilled water at 37ºC for 24 hours, to be later subjected to temperatures of 55ºC and 5ºC, remaining 20 seconds at each temperature and 10 seconds to transfer from one temperature to another, considering this process as a cycle. Thus, the thermocycler subjected them to 500 cycles, equivalent to 6 months of artificial aging.

2.7. Preparation of samples to be subjected to micro-shearing tests

The specimens were taken to the Laboratory of Stress and Vibration Analysis of the National Polytechnic School to perform the micro-shear load tests in the Universal Testing Machine (SHIMADZU AGS-X) to determine the adhesive strength in each of the samples.

3. Results

Based on the 40 data provided by the Stress and Vibration Analysis Laboratory of the National Polytechnic School, they were divided into four groups with several ten samples each, as shown in Table 1.

Table 1. Sample identification.

Sample	LAEV Identification
Group A (Adhesive with MDP/without Thermocycling)	GA
Group B (Adhesive with MDP/with Thermocycling)	GB
Group C (Adhesive without MDP/without Thermocycling)	GC
Group D (Adhesive without MDP/with Thermocycled)	GD

According to report LAEV-M19.129, the shear strength was calculated according to the adhesive system used, considering the maximum load recorded. The area of incidence of the dental material (resin) was calculated in [MPa] units. The result is shown in Figure 1.

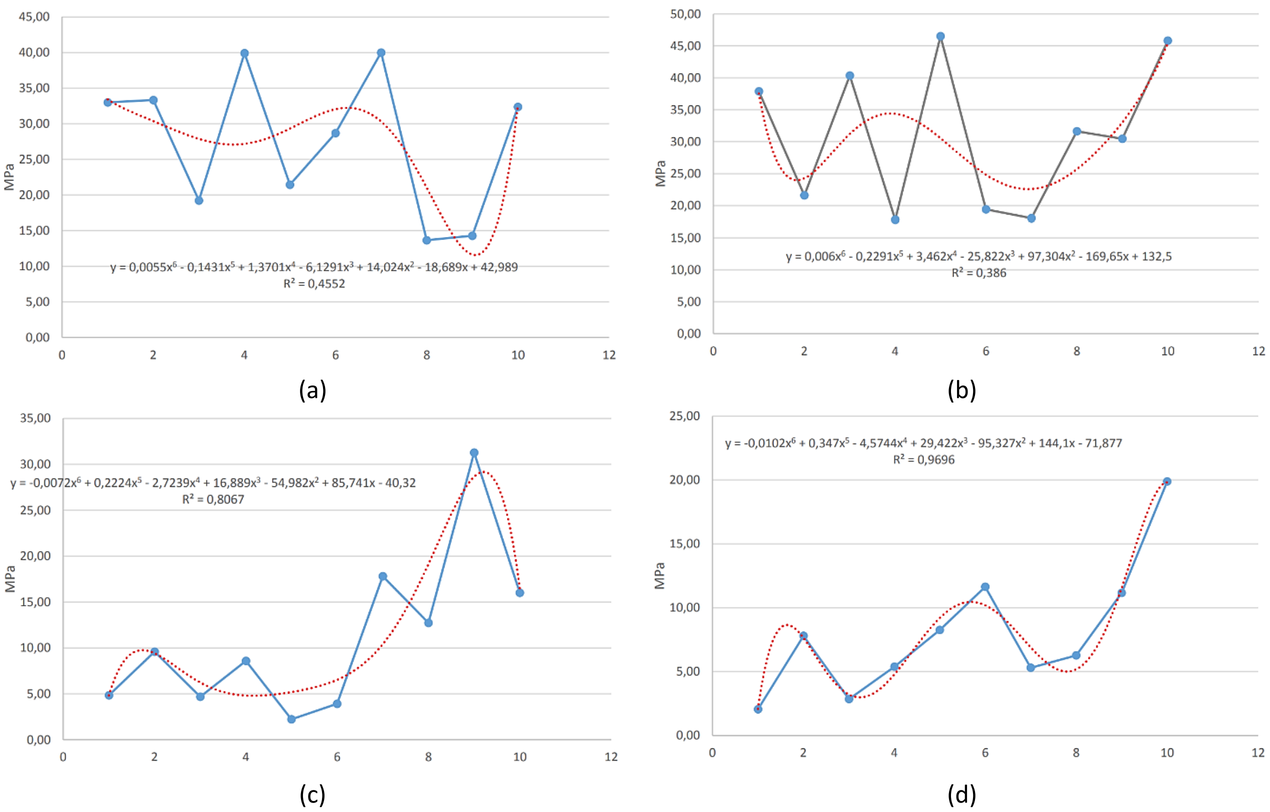

Figure 1. Distribution of shear strength data: a) group A; b) group B; c) group C; d) Group D.

According to Tukey's method, the check begins by verifying no extreme outliers, which refers to the difference between the first quartile (Q1) and the third quartile (Q3), called the interquartile range, which different circumstances can obtain. This can be seen in the box-and-whisker plot described in Figure 2. The shear strength data for each group were entered into a database in the IBM SPSS software version 22 to perform the descriptive and inferential statistics calculations.

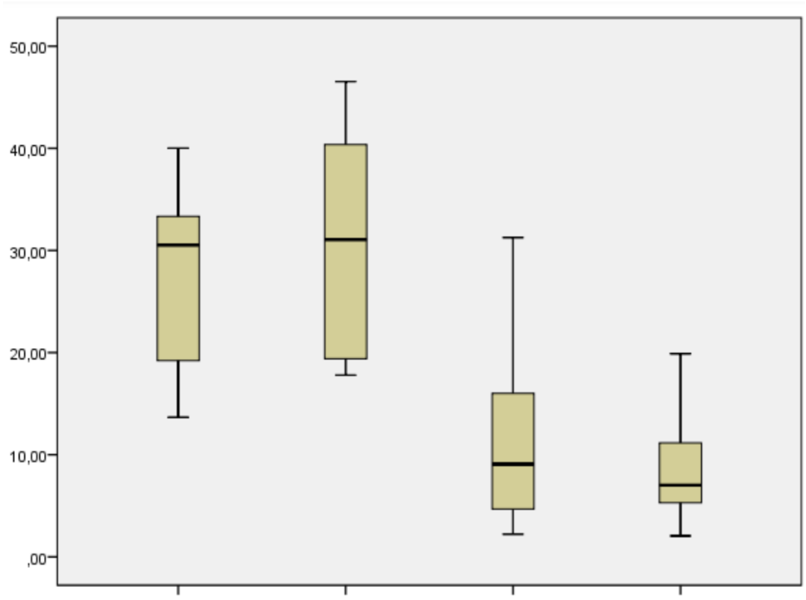

Figure 2. Shear strength in each group from left to right (A, B, C, D).

3.1. Normality and homogeneity test

Before performing the ANOVA statistical test, a normality test should be performed. The SHAPIRO-WILK test is chosen because it is effective when the sample size is less than or equal to 30. From the normality test, all groups A-B-C-D come from a population with normal distribution since they exceed the imposed significance level of 0.05, as shown in Figure 3.

The homogeneity of variances test is performed, that is to say, if the variances are equal or not, this will give the way to observe the significance in the post hoc tests, where it is analyzed between which groups the means are similar or not, assuming equal variances - TUKEY and if equal variances are not added - Games-Howell. Since the value is 0.052>0.05, equal variances are considered for post hoc tests by Tukey.

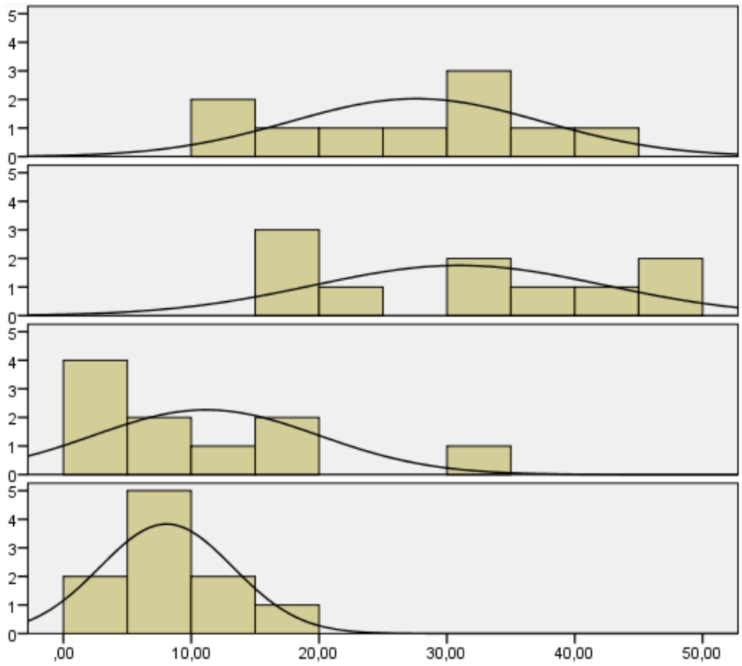

Figure 3. Histogram of data Group A-B-C-D showing the normality of the data.

3.2. One Factor ANOVA

There are significant differences between the means of all the groups. To observe which groups this difference exists, we will check with the POST HOC tests; in this case, we will use the TUKEY test. There is no significant difference between the shear stress means between group A and B; therefore, the shear stress means are equal; the same between C and D. Between A and C, it was evidenced that A has more significant shear stress, while between A and D, there is more substantial stress in D. Between B and C more significant stress was found in group B, as well as between B and D. All this can be better appreciated in Table 2.

Table 2. Significance test with ANOVA - POST HOC - TUKEY.

Group I	Group J	Difference between means (I-J)	Standard error	Sig.	95% confidence interval	
					Lower limit	Upper limit
GA	GB	-3.36300	4.06553	.841	-14.3124	7.5864
	GC	16.42900*	4.06553	.001	5.4796	27.3784
	GD	19.53900*	4.06553	.000	8.5896	30.4884
GB	GA	3.36300	4.06553	.841	-7.5864	14.3124
	GC	19.79200*	4.06553	.000	8.8426	30.7414
	GD	22.90200*	4.06553	.000	11.9526	33.8514
GC	GA	-16.42900*	4.06553	.001	-27.3784	-5.4796
	GB	-19.79200*	4.06553	.000	-30.7414	-8.8426
	GD	3.11000	4.06553	.870	-7.8394	14.0594
GD	GA	-19.53900*	4.06553	.000	-30.4884	-8.5896
	GB	-22.90200*	4.06553	.000	-33.8514	-11.9526
	GC	-3.11000	4.06553	.870	-14.0594	7.8394

As can be seen, some values of significance are lower and others higher than 0.05, which is the assumed error value, with a 95% confidence level. It is concluded that the highest shear strength values were those of Group A (Adhesive with MDP / without Thermocycling) and Group B (Adhesive with MDP / with Thermocycling). This can be seen from the graph between averages described in Figure 4 and Figure 5.

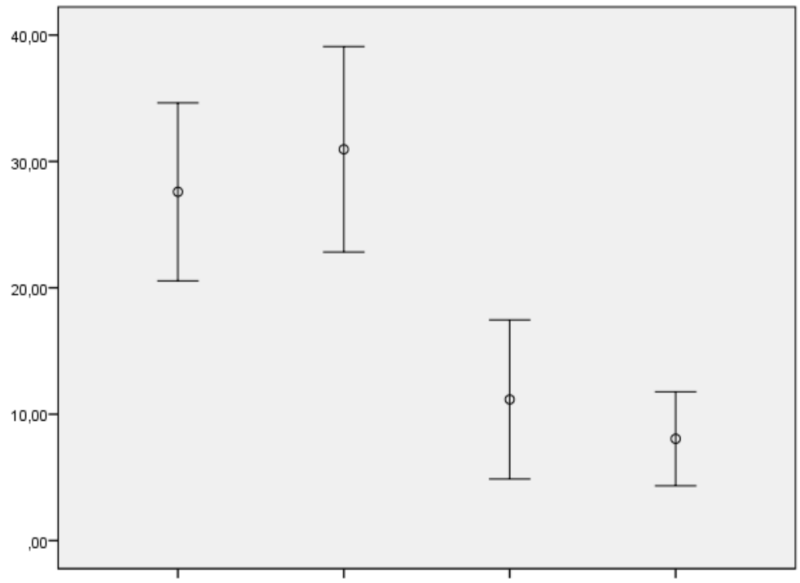

Figure 4. 95% CI shear strength in each group from left to right (A, B, C, D).

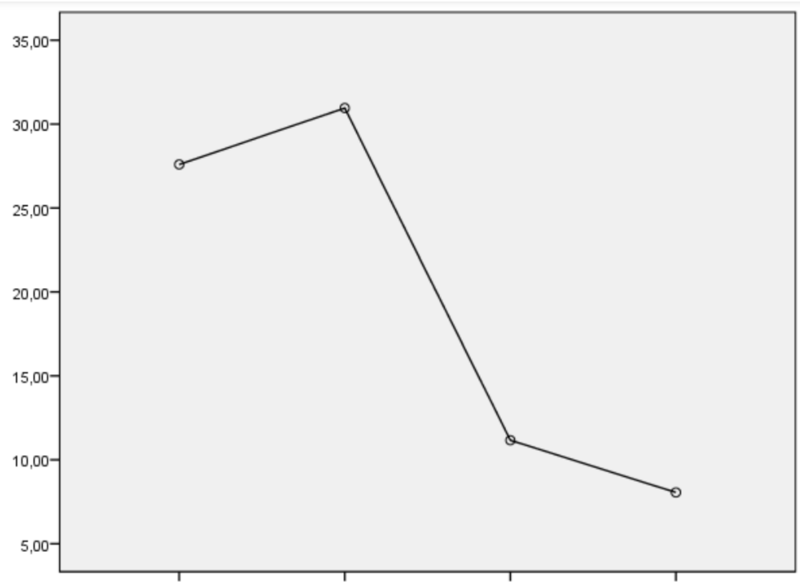

Figure 5. Mean shear strength in each group from left to right (A, B, C, D).

4. Discussion

In this study, a resin cylinder was built up on the exposed dentin surface of teeth. An adhesive with MDP was applied to one group that underwent thermocycling (Group B) and another that did not experience thermocycling (Group A). In addition, an adhesive without MDP was also applied to another group that was a thermocycler (Group D) and another that was not a thermocycler (Group C). Each sample was subjected to shear loading, and it was obtained that there is a statistically significant difference between groups A-B and C-D. Consequently, the research hypothesis is accepted, and the null hypothesis is rejected.

The bond strength of an adhesive to dentin depends on its composition, which can provide more excellent resistance and less microleakage, as is the case with universal adhesives that allow chemical bonding to dentin by incorporating functional monomers. MDP is the primary monomer present in most universal adhesive systems and is considered the Gold Standard for its effectiveness in durability and chemical interaction with dental tissues. However, pharmaceutical companies have experimented with other functional monomers with similar characteristics to MDP [9].

This study aimed to evaluate the shear bond strength of resin cylinders bonded with two types of adhesives, one with MDP and the other without MDP. Previous studies have assessed the adhesive force in dentin treated with 5.25% sodium hypochlorite by micro tensile testing, obtaining similar results between adhesives with different functional monomers. Other studies have evaluated various functional monomers, such as GPDM, using tensile testing for better immediate results. In addition, it has been determined that the self-etching technique is easier to use and reduces clinical failures in dentin. Due to its humidity, it presents difficulties in its handling, especially in the acid wash, causing the drying of the dentin and deterioration of the adhesive forces. Therefore, in this study, the self-etching technique was used [8].

5. Conclusions

This study showed that the bond strength of an adhesive to dentin is highly dependent on its composition, particularly the presence of functional monomers such as MDP. It was found that the adhesive with MDP presented a higher shear loading resistance than the adhesive without MDP in both thermocycling and nonthermocycled samples. The results of this study are consistent with previous studies that have found MDP to be an effective functional monomer in forming a chemical bond with dentin. However, other studies have suggested that other functional monomers, such as GPDM, may be equally or even more effective than MDP in certain situations.

It is essential to keep in mind that the choice of adhesive type and application technique will depend on the specific clinical case, as different adhesives may have distinct advantages and disadvantages depending on the conditions of the dentin and the treatment it is subjected to. Generally, universal adhesives with functional monomers, such as MDP, are an effective option to achieve strong adhesion to dentin and improve the durability of dental restorations.

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Institutional Review Board Statement

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Informed Consent Statement

Not applicable.

Conflicts of Interest

The authors declare no conflict of interest.

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