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ORIGINAL

Compressive Strength of Bulkfill Resin Light Cured with Different Powers Led Light

Resistencia a la compresión de resina de relleno en bloque fotopolimerizada con diferentes potencias de luz LED

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ABSTRACT

Introduction: Bulk Fill resins are used as materials to replace tooth structure, being important to identify the resistance of these to different LED light lamps with their powers, so that they are able to withstand masticatory forces.
Objective: to analyze the resistance of Bulk Fill resins, with light curing of LED light lamps of different powers, subjected to compressive forces.
Method: the research was an observational, cross-sectional, quantitative experimental design. The study population consisted of 30 cylindrical samples divided into three groups of 10 Bulk Fill resins light cured with 3M, Woodpecker and Valo lamps, placed in an acrylic matrix with an ISO 4049 measurement (6mmx6mm). The data obtained were subsequently analyzed and recorded in the SPSS V25 program.
Results: The data obtained indicate that Group A 3M Lamp 1550 MW presented a compressive strength of 3496,3 N; Group B Woodpecker Lamp 1350 MW of 3496,3 N; Group C Valo Lamp 1250 MW of 2084,1 N. Group A was the one that presented a compressive strength of 3496,3 N; Group B Woodpecker Lamp 1350 MW of 3496,3 N; Group C Valo Lamp 1250 MW of 2084,1 N. Group A presented the highest compressive strength to the rest of the photocured resins at different powers.
Conclusions: when comparing the compressive strengths of the Bulk Fill resins, which were subjected to three different light curing lamp powers, Group A - 3M Lamp had a higher compressive strength than the other sample groups; however, it was evidenced that all groups can reach strength values higher than 5000 N, in addition, it was defined that the ideal light curing intensity for Bulk Fill resins should be equal to or greater than 1000mw/cm^2.

Keywords: Dentistry; Composite Resins; Polymerization; Hardness Testing.

RESUMEN

Introducción: las resinas Bulk Fill se utilizan como materiales para sustituir la estructura dental, por lo que es importante identificar su resistencia a diferentes lámparas LED con distintas potencias, de modo que puedan soportar las fuerzas masticatorias.
Objetivo: analizar la resistencia de las resinas Bulk Fill, con fotopolimerización mediante lámparas LED de diferentes potencias, sometidas a fuerzas compresivas.

Método: la investigación fue de diseño experimental, observacional, transversal y cuantitativo. La población del estudio consistió en 30 muestras cilíndricas divididas en tres grupos de 10 resinas Bulk Fill fotopolimerizadas con lámparas 3M, Woodpecker y Valo, colocadas en una matriz acrílica con una medida ISO 4049 (6 mm x 6 mm). Los datos obtenidos se analizaron y registraron posteriormente en el programa SPSS V25.
Resultados: los datos obtenidos indican que el Grupo A, con lámpara 3M de 1550 MW, presentó una resistencia a la compresión de 3496,3 N; el Grupo B, con lámpara Woodpecker de 1350 MW, de 3496,3 N; y el Grupo C, con lámpara Valo de 1250 MW, de 2084,1 N. El Grupo A fue el que presentó una resistencia a la compresión de 3496,3 N; el Grupo B, lámpara Woodpecker 1350 MW, de 3496,3 N; y el Grupo C, lámpara Valo 1250 MW, de 2084,1 N. El Grupo A presentó la mayor resistencia a la compresión frente al resto de resinas fotopolimerizables a diferentes potencias.
Conclusiones: al comparar las resistencias a la compresión de las resinas Bulk Fill, que fueron sometidas a tres potencias diferentes de lámparas de fotopolimerización, el Grupo A - Lámpara 3M presentó una resistencia a la compresión mayor que los demás grupos de muestras; sin embargo, se demostró que todos los grupos pueden alcanzar valores de resistencia superiores a 5000 N. Además, se definió que la intensidad de fotopolimerización ideal para las resinas Bulk Fill debe ser igual o superior a 1000 mw/cm^2.

Palabras clave: Odontología; Resinas Compuestas; Polimerización; Ensayo de Dureza.

INTRODUCTION

Dental caries is a global health problem; the World Health Organization (WHO). has determined that dental caries is the most common disease affecting almost 2 billion people worldwide, 520 million of whom are children; modern dentistry offers us treatment options using restorative materials such as resins, composites and glass ionomers or the use of sealants, fluoride or other compounds that help us to treat caries; in recent years preventive approaches and oral health promotion practices have also been promoted, seeking minimally invasive dental procedures and treating caries early before they become invasive.[1]

The shrinkage of resins is associated with their composition, elastic modulus and ability to flow while facing stresses during polymerization. One of the main problems is that gaps may arise between the restoration and the tooth due to the speed of polymerization and its strength, which is crucial to maintain a tight connection between an adhesive-supported composite and the walls of the tooth cavity. When we talk about polymerization shrinkage in volume techniques, it refers to the decrease of volume in the composite, due to it undergoing the shrinkage process, but produced by light curing. Polymerization stress is the impact on the surface of the composite, adhesive and part that occurs after polymerization. For this reason, Bulk Fill resin helps in the reduction of stress since it has high molecular weight methacrylate monomers (AUDMA) that when combined help to produce less stress to polymerization, since it has less amount of reactive sets.[2]

The lamps used in dental offices for the polymerization process differ, mainly, by characteristics such as: power, comfort, the fact of being wireless or not, wavelength, acoustic signals, among others. These devices require at least 1000 mW/cm^2 in 10 seconds to polymerize the composites used in indirect restorations, while for direct restorations they require a minimum power of 400 mW/cm^2 to polymerize the material. Emphasis is placed on the direct relationship between the intensity of the lamp with the photons that will act on the restoration, causing a greater number of molecules of the initiating photon that will generate free radicals, thus allowing a polymerization reaction.[3]

The use of Bulk Fill resins stands out for presenting a minimum shrinkage when using the polymerization lamp in block restorations. The penetration and depth of the polymerization led light should be at least 4 mm; the working time is longer since a good adaptation of the material to the cavity walls is required. A quick and easy access to all the areas to be polymerized is essential; special care is emphasized in children and in patients with limited opening of the oral cavity, in which cases polymerization should be done at a single increment.[4,5]

This study is of utmost importance, since it focuses on analyzing the compressive strength of Bulk Fill resins, which are used as materials to replace lost tooth structure, therefore, they must be able to withstand continuous masticatory forces. For this research, these resins were light cured with different power LED lamps. This work would be very useful for dental professionals because it can present a scientific support that guarantees the use of Bulk Fill resins and therefore guarantees the work carried out by the professional. For this reason, the objective of this research is to analyze the compression strength of Bulk Fill resins which will be light cured with different wattages of LED light bulbs.[6]

METHOD

The research work was of experimental design (in-vitro) because the resin was divided into three groups being photocured with different lamps; observational type because thanks to the universal testing machine it was possible to measure the compressive strength of the Bulk Fill resins; cross-sectional because it was developed over a period of 10 months; quantitative character, since the laboratory where the research was applied provided data for subsequent analysis.

The study population consisted of 30 cylindrical samples divided into three groups of 10 Bulk Fill resins light cured with 3M, Woodpecker and Valo lamps, placed in an acrylic matrix with a size of 6mm x 6mm, based on ISO 4049 standards, which were subjected to the universal testing machine, which constantly applies vertical forces until causing the fracture of the object recorded, therefore, the data collection was given by the logbook provided by the stress and vibration laboratory of the engineering faculty of the Universidad Politécnica Nacional, then the data obtained were analyzed and recorded in the SPSS V25 program and after that the respective tables were made with the description of the results obtained.

RESULTS

The study was carried out in an environment with controlled temperature between 24,3 ± 3,0 °C and humidity around 47,1 ± 8,5 %. The samples were made with a measure of 6x6 (according to ISO 4049) photopolymerized with 3 photocuring led lamps with different powers each one; however, at the moment of polishing the samples there is a margin of error of 0,5 to 1mm of thickness.

Table 1. Identification of samples

LAEV identification (group)	Sample (lamp used for light curing)
1. M23.064.01-M23.064.10	Group A - 3M lamp 1550 MW
2. M23.064.11-M23.064.20	Group B - Woodpecker Lamp 1350 MW
3. M23.064.21-M23.064.30	Group C - Valo 1250 MW lamp

Each group contains 10 Bulk Fill resin samples that were light cured with a different LED lamp. For group 1A the 3M lamp with strength of 1550 MW was used. Group 2B used the Woodpecker lamp with strength of 1350 MW. And for group 3C the Valo lamp with a force of 1250 MW was used.

Compression load test

Tables 2, 3 and 4 detail the results with the values of the compressive load in newtons (N) and lbf (pounds of force) recorded in each of the 10 samples in each group, where 1 N is equivalent to 0,22481 lbf. The data contain some variability between samples as a result of the margin of error at the time of polishing the resins and the difference in the power of the same lamp that usually occurs at each curing time, which may depend on the position of the light in relation to the resin sample.

Table 2. Compression load results of group 1 samples

Id LAEV.	Maximum registered load	
	N	Lbf
M23.064.01	4788	1076
M23.064.02	5293	1190
M23.064.03	3065	689
M23.064.04	4002	900
M23.064.05	3692	830
M23.064.06	3751	843
M23.064.07	4241	953
M23.064.08	5333	1199
M23.064.09	3314	745
M23.064.10	3825	860

It was identified that the maximum load with the highest value recorded is 5333 N and 1199 lbf and the

minimum value is 3065 N and 689 lbf, obtaining an average value of 4130,4 N.

Table 3. Compression load test results for Group 2B specimens

Id LAEV.	Maximum registered load	
	N	Lbf
M23.064.11	3529	793
M23.064.12	3729	838
M23.064.13	2863	644
M23.064.14	3977	894
M23.064.15	1609	362
M23.064.16	4059	912
M23.064.17	1924	433
M23.064.18	5340	1201
M23.064.19	4721	960
M23.064.20	3212	722

It was identified that the maximum load with the highest recorded value is 5340 N and 1201 lbf and the minimum value is 1609 N and 362 lbf, with an average value of 3496,3 N.

Table 4. Compression load test results for specimens group 3C

Id LAEV.	Maximum registered load	
	N	Lbf
M23.064.21	889	200
M23.064.22	2793	628
M23.064.23	689	155
M23.064.24	2369	532
M23.064.25	2061	463
M23.064.26	5507	1238
M23.064.27	1687	379
M23.064.28	1194	268
M23.064.29	1688	380
M23.064.30	1964	441

It was identified that the maximum load with the highest recorded value is 5507 N and 1238 lbf and the minimum value is 689 N and 155 lbf, with an average value of 2084,1 N.

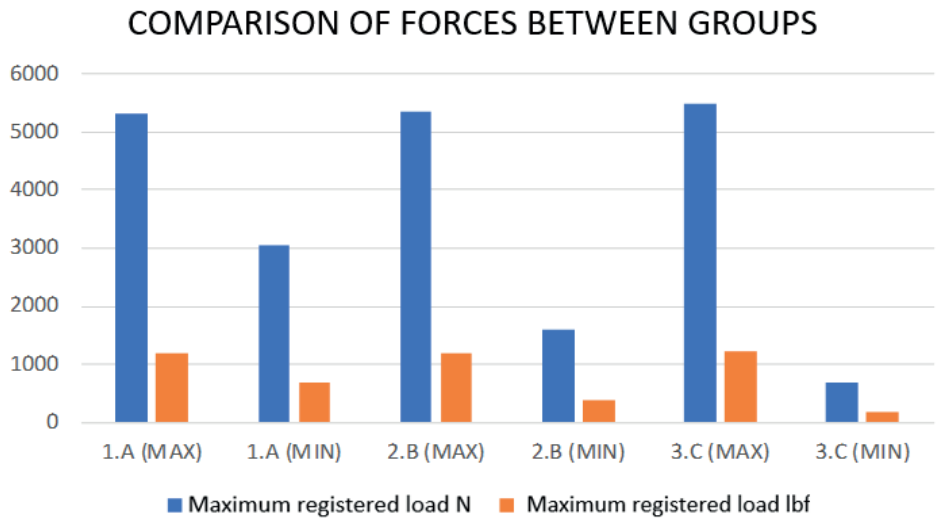

Figure 1. Comparison of forces between groups of samples

It was analyzed that between each group of samples the highest recorded values do not have a significant difference in the maximum load in N and lbf that they support, while in the rest of the recorded values there are more evident differences that are the result of the different power of the lamps, which gives us as a result that each lamp can provide a maximum value of more than 5000 N and 1200 lbf but on average the lamps of group 2A and 3C do show values notably lower than that of group 1A.

DISCUSSION

The success of direct composite restorations depends, among other factors, on their resistance to occlusal forces during mastication. This resistance is directly proportional to the quality of the material and the thickness of the restoration. States that if the resin does not provide sufficient resistance to occlusal loads there is a risk of restoration failure as a result of bacterial microleakage causing lateral caries and hypersensitivity leading to treatment failure. A 2021 study by Vaca and Mena found that Bulk Fill resins have higher restoration success rates because they provide certain composites that are more resistant to shrinkage and temperature when polymerized, therefore, Bulk Fill resins are more resistant to compression. These results are consistent with research conducted by Benavente in 2017, which showed that this resin has higher success rates compared to conventional resins.[7,8,9]

In 2017, conducted a comparative study on the compressive strength between Bulk Fill resins and conventional composite resins, obtaining a similar result to that achieved by Domínguez in 2015; with this, it was concluded that Bulk Fill type resins present a higher resistance to compressive loads due to the fact that in their composition there are methacrylate monomers which are: AFM (dynamic stress-relieving monomer) and AUDMA (high molecular weight aromatic urethane di methacrylate).[9,10]

The Bulk Fill resins, for this study, were light cured with 3 different high intensity lamps, which are especially indicated for this type of dental biomaterials because they require a minimum intensity of 1000 MW/cm^2, a factor that is essential for the photopolymerization to be adequate for the restorative material. The light curing time to which composite resins are subjected also plays an important role, according to Vasquez in 2022, a longer exposure time to light translates into high values of microhardness in the resin; he also suggests that when restoring deep cavities where the lamp is more than 3mm away from the resin, the time for light curing should be 40 seconds, because that way microhardness results were obtained similar to 20s of exposure at distances of 0 to 3 mm.[11,12,13]

On the other hand, according to a study conducted by for the Faculty of Dentistry of Viña del Mar, they are convinced that high intensity lamps in conventional resins create more tension during photopolymerization and as a result a higher shrinkage, on the other hand lamps of a lower intensity than the one already mentioned only dry Bulk Fill resins because there is no activation of their photo initiator due to their low power.[14,15,16]

It is important to note that the success of direct resin restorations also depends in part on risk factors related to the restoration, such as the type of cavity prepared, distance and light-curing time, among others. However, the results of this study show that Bulk Fill resins are highly effective compared to similar studies and, given their high compressive strength, have a higher success rate in restoring posterior teeth than conventional resins.

CONCLUSIONS

When comparing the compressive strengths of the Bulk Fill resins, which were subjected to three different powers of light curing lamps on the cylindrical matrices with the assistance of the Universal Tinius Olsen Super L 120 testing machine, it was concluded that group A - 3M lamp had a compressive strength that is higher than that of the other sample groups, in most of its values; however, it was evident that all groups have the ability to achieve force values of more than 5000 N. In addition, it is defined that the ideal light curing intensity for Bulk Fill resins should be equal to or greater than 1000mw/cm^2, since only with high powers there is an activation of the photoinitiator. It was determined that in the polymerization of the Bulk Fill resins with a power of 1550 mw/cm^2 used with the 3M lamp, all the values are above 3000 N, with an average of 4130,4 N; reason for which it is established that the hypothesis outlined in the research is fulfilled by proving that there are differences between the polymerization and in the compression force of the Bulk fill resins to light curing with LED light of different powers

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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