Evaluation of the compressive strength of two composite resins in different thicknesses

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Abstract

The aim of this study was to analyze the compressive strength of composite resins P60 and Z250 (3M/ESPE) in three different thicknesses (1, 2 and 4mm). Ninety specimens were made, 45 for the P60 resin and 45 for the Z250 resin, by inserting the composite resins into a cylindrical metallic matrix (3mm in diameter), photo polymerized for 20s. The specimens were taken to the universal testing machine (Versat 500), with axial compression force at a speed of 1mm/min. The results were analyzed using the Mann-Whitney and Kruskal-Wallis statistical tests, with a significance level of 5%, which showed no differences between the composite resins P60 and Z250 in terms of compressive strength in thicknesses of 1, 2 and 4mm. Both composite resins P60 and Z250 showed greater resistance to compression in the 1mm thickness, in relation to the thicknesses of 2 and 4mm.

Keywords: composite resins, dental materials, compressive strength.

1. Introduction

In recent years, the great emphasis that has been given to aesthetics, especially in dental practice, has driven and stimulated the development of restorative materials that can meet the aesthetic demands imposed by patients.
In view of this, composite resins, which were initially designed to be used only in restorations of anterior teeth, began to be also used in posterior teeth [1-2].
However, the first restorations performed on posterior teeth were very susceptible to failures, such as: inadequate proximal contour, infiltrations, marginal gaps and, to a lesser extent, tooth and restoration fracture. These failures occurred because the restorative technique was very sensitive, inadequate resistance to occlusal wear, polymerization contraction and low mechanical properties [3].
Over the years, the properties of composite resins have been improved, enabling a safer indication when it comes to posterior aesthetic restorations. However, there is still great attention from researchers, especially with regard to the resistance to compression that composite resins for posterior teeth present, since it is known that during the masticatory act the forces that are transmitted to these restorations can fracture them or, then, provoke the fracture of the dental structure [4-7].
In this sense, the [8] established that the composite resins for posterior teeth should present good resistance to occlusal wear and abrasion, enable a good adaptation to the cavity margins and an effective sealing of the restoration to the entry of oral fluids, have adequate resistance to degradation by water and other solvents, be radiopaque and allow application and insertion techniques to be simple and easy to perform.
Composite resins for posterior teeth must have sufficient physical and mechanical properties, including compressive strength, so that, in addition to meeting aesthetic needs, they can satisfactorily resist masticatory forces. According to [9], the average occlusal forces for molars would be 59Kgf, premolars 32Kgf, canines 23Kgf and incisors 18Kgf.

In [10] carried out a study with the purpose of comparing the relative resistance to fracture (fracture toughness) in 7 days of three composites, two conventional and one processed in the laboratory. Fracture strength was determined using the mini specimen compactor, with the pre-slit created by a razor blade. The average fracture toughness of Alert was significantly higher than the other materials tested in this study. Of the composites processed in the laboratory (Beleglass) there were no significant differences. Heliomolar, a composite of microparticles, showed a significantly better average resistance than the others, with the exception of Solitaire, which exhibited a significantly lower average resistance than any other composite.

In the study carried out by [3], two different types of composite resin were selected, both of hybrid particles, Z 100 and Tetric and the alloy for amalgamation of conventional particles Velvalloy. The polymerization times used were 30s, 40s, 90s and 120s. Ten specimens were made for each experimental condition. To carry out the compressive strength test, the Universal EMIC test machine was used. The highest mean compressive strength was determined by the Z 100 material at a time of 120s and the lowest mean was determined by the Tetric material at a time of 30s. The Velvalloy material showed compressive strength levels statistically equal to the Z 100 material and higher than Tetric.

Literature [11] evaluated the mechanical properties of composite resin P60 (3M/ESPE), subjected to two different condensation methods: manual and mechanical. The properties evaluated were compressive strength and surface hardness, through testing with specimens obtained using acrylic matrices that provided the appropriate dimensions for each test. Statistical analysis showed that there was no statistically significant difference between the groups for the compressive strength test, but there was a statistically significant difference between the groups with regard to surface hardness. The results suggested that mechanical condensation can optimize the mechanical properties of high viscosity composite resins.

Literature [12] pointed out that the improvement of composite resins resulted in greater resistance to compression, less surface wear and provided the possibility of its successful use in the posterior region.

Literature [13] compared the diametral traction, resistance to compression and flexion of four high viscosity composite resins; Alert (Jeneric Pentron), Solitaire (Heraeus Kulzer), microparticle Surefil (Caulk), Heliomolar (Ivoclar) and a hybrid resin, TPH (Caulk). Ten samples of each restorative material were made for each parameter, for a total of 15 groups and 150 specimens. Samples were stored in water in lightproof bottles at 37°C for 7 days and tested using a Zwick universal testing machine. Statistical analysis showed that the TPH resin had significance of compressive strength in relation to the other groups. Alert and Surefil had comparable compressive strength and flexural strength and was significantly greater than Heliomolar, which was significantly greater than Solitaire. Surefil had the best compressive strength and was compared to TPH. Solitaire and Alert were compatible and significantly larger than Heliomolar.

Even with all the advents and innovations of composite resins for posterior teeth, they still have some deficiencies in their mechanical properties, as studies in the literature do not clearly show which resin thickness would be ideal to resist masticatory efforts, as well as to occlusal forces, without fractures or damage to these restorations. Thus, the intention is to evaluate the compressive strength of composite resins P60 and Z250, in different thicknesses, thus seeking to determine the minimum limit of material thickness compatible with the occlusal function.

Therefore, the objective of the present study was to comparatively evaluate the compressive strength of two composite resins for posterior teeth, P60 and Z250 (3M/ESPE), in different thicknesses: 1, 2 and 4 mm.

2. Materials and methods

2.1 Sampling

To carry out the compressive strength test, composite resins P60 (manufacturing batch: 4NT) and Z250 (manufacturing batch: 4PG) were used, both manufactured by 3M/ ESPE, which were part of the work sample. , divided into the following groups:

Group 1: 15 specimens of P60 resin with a thickness of 1mm.

Group 2: 15 specimens of P60 resin with a thickness of 2mm.

Group 3: 15 specimens of P60 resin with a thickness of 4mm.

Group 4: 15 specimens of Z250 resin with a thickness of 1mm.

Group 5: 15 specimens of Z250 resin with a thickness of 2mm.

Group 6: 15 specimens of Z250 resin with a thickness of 4mm.

2.2 Sequential protocol

For the realization of the specimens, a metallic matrix, manual Hollemback condenser, Thompson spatula, glass slab, polyester matrix, scalpel blade nº 11, halogen light curing unit Optilight 600 (Gnatus) previously calibrated with a radiometer Demetron at 430 mW/cm^2.

A total of 90 specimens were made, 45 of which for the P60 resin, in which 15 were for the thickness of 1mm, 15 for 2mm and 15 for 4mm. The same procedure was performed for the Z250 resin.

Three metal matrices were constructed, these measuring 1mm, 2mm and 4mm in height by 3mm in diameter, to obtain regular specimens.

The specimens were made on a glass slab, adapting resin increments of 2mm in diameter to the walls of the matrix, under light curing for 20s, with the device already mentioned, and for the matrix of 1mm and 2mm were adapted to the matrix in a single increment of 1 and 2 mm, respectively. Once the filling of the metallic matrix was finished, the last increment was leveled with a polyester matrix, in order to obtain a flat surface, prior to polymerization. With a #11 scalpel blade, small excesses were removed after polymerization. Afterwards, they were immersed for a period of 15 days in distilled water.

3. Assessment instruments

To evaluate the compressive strength of the composite resins, all specimens were taken to the universal testing machine – Versat 500, with an axial compression force at a speed of 1mm/min, applied through a metallic device. 8mm diameter flat base. The force used by the machine (in Newton's) to induce rupture of the specimens was recorded and divided by the transverse area (perpendicular to the direction of force) of the specimens (in mm^2), generating a compressive force result. in MPa [9, 14]. The calculation can $T = \frac{f}{a}$,where = result of the com- force pressure in Mpa; f = force applied by the machine in Newton; a = cross-sectional area of the specimen (πR^2) in mm^2.

4. Results

The data obtained in the compressive strength test of composite resins P60 and Z250 were tabulated and submitted to statistical analysis. In view of the situation of non-normal data distribution, the Mann-Whitney and Kruskal Wallis statistical tests were used, with a significance level of 5% (a=0.05).

The results found showed no statistically significant difference between the compressive strength of composite resins P60 and Z250 ($p>0.05$).

With regard to compressive strength in different thicknesses, there was a statistically significant difference between the groups ($p<0.001$), with the 1mm thickness presenting better results than the others (2 and 4mm), which were not different between yes.

The summarized data can be seen in Table 1.

Table 1: Means and standard deviations of values related to compressive strength of composite resins P60 and Z250 in different thicknesses (values in MPa).

	N	Average	Standard deviation	Minimum	Maximum
Z250 1mm	15	523,990	187,410	299,154	784,084
Z250 2mm	15	259,473	67,969	136,056	371,126
Z250 4mm	15	283,821	78,664	103,521	381,408
P60 1mm	15	455,614	148,654	293,943	794,084
P60 2mm	15	240,666	41,488	177,183	316,760
P60 4mm	15	296,544	69,262	182,957	429,718
Total	90	343,351	152,576	103,521	794,084

5. Discussion

In the present work, the compressive strength of composite resins P60 and Z250 in different thicknesses was analyzed, these measuring 1, 2 and 4 mm by 3 mm in diameter. From the analyzed data, it could be seen that there was no statistically significant difference between the compressive strength of the P60 and Z250 resins. With regard to compressive strength in different thicknesses, there were statistically significant differences between the groups, with the 1mm thickness presenting better results than the others (2 and 4mm), which were not different from each other.

The same was observed in the work carried out by [11], which showed that there was no statistically significant difference between manual and mechanical condensation of composite resin P60 in relation to resistance to compression. However, it showed a statistically significant difference in relation to surface hardness.

Literature [3] carried out an in vitro study of the compressive strength as a function of the polymerization time of two composite resins (Tetric/Z100) and dental amalgam (Velvalloy). They concluded that the composite resins he studied: Tetric and Z 100 did not present a statistically significant difference and the longer the polymerization time used, the greater the resistance to compression. And, the Velvalloy material showed greater compressive strength than the two composite resins for posterior teeth.

Literature [15] reported that the Alert resin showed greater resistance to fracture when compared to the other composites tested (Surefil, Solitaire, Heliomolar, Herculite, Belleglass). There were no significant differences between the fracture toughness measurements of Belleglass, Surefill and Herculite.

It is important to analyze all the properties of composite resins, such as abrasion resistance, fracture resistance, flexural resistance, compressive strength and hardness, among others. Several authors tried to relate other mechanical properties of composite resins with their surface hardness. However, [16], stated that this direct relationship between hardness, resistance to compression and wear does not necessarily exist, there is a greater number of works that confirm the existence of this correlation, such as [17] who, despite considering the hardness test to be of relative importance, proved its direct relationship with other mechanical properties of composite resins.

One of the major concerns in Dentistry, especially in Restorative Dentistry, is to be able to find a material that, in addition to restoring the lost function of the tooth, has good tensile strength, determines strong marginal adaptation and is biocompatible, in addition to reproduce in the most natural way possible the colour of the teeth and with the maximum preservation of the healthy dental structure [18].

With the emergence of acid etching in 1955, by Buonocore, and of composite resins in [19], a great step was taken in the conquest of a restorative material that would transform restorative philosophy. Thus, composite resins, in a short period of time, replaced silicate cements, as well as their immediate predecessor, acrylic resins. They were first indicated as an aesthetic restorative for anterior teeth, but it was with their improvement and the emergence of new techniques that composite resins increased their range of indications, including posterior teeth. With the successive development of composite resins, today we have arrived at photopolymerizable resins, more stable in terms of the organic/inorganic matrix ratio, which among many advantages, undoubtedly the most important is resistance to wear, since any restorative material must resist to the complex masticatory efforts resulting from the dynamics of mastication [20-21].

When it comes to composite resin, [21-22], considers it a stable material, resistant to compression, and that has a low coefficient of thermal conductivity and adequate cavity adaptation.

The literature shows that the physical, chemical and mechanical properties of current composite resin systems present standards considered good for clinical application. These considerations are based on research, in most cases, of a laboratory nature, which test, mainly, the compressive, tensile, shear and flexural strength properties [23].

The most important principle that the professional should keep in mind is that tissue removal should be as limited as possible, simply because no restorative material, no matter how good, can replace the quality of the tissue. quality of enamel, dentin and cementum, when they are properly interrelated. The preparation should be as narrow as possible and, preferably, without a bevel in the occlusal area, due to the fact that retention of the restoration takes place through acid etching. In addition, the beveling expands the cavity and leaves a layer of thin composite resin on the surface [24].

However, [25] recommends the execution of a bevel in the cavos superficial angle, in class II restorations. The bevel must be executed with a tapered diamond point, in order to form 45 degrees with the external surface of the enamel and present approximately 0.25 to 0.5 mm in width. The purposes of the bevel are: to remove the fluorine-rich outer layer of enamel, to provide greater surface area for adhesion, to expose enamel prisms transversely, to increase the free energy of the enamel surface, and finally to enable obtaining restorations that will present a lower degree of marginal leakage.

Literature [26] proposed a modified cavity preparation, with a short enamel bevel to obtain better results in class I and II restorations.

Despite disagreements in the literature on whether or not to bevel in posterior teeth, it is known that, in principle, this was not used due to the small thickness of resin over the area of the bevel, with risk of fracture. However, through the results of the present work, the possibility of doing so is discussed, since the small thickness of the composite resin did not show greater fragility, but rather, it presented greater resistance to compression. In this way, one could count on the advantages of the bevel in posterior teeth as well.

The constant evolution of techniques and dental products, provided by scientific research, makes the information quickly become obsolete [24-25]. But, especially due to the fact that composite resins in posterior teeth have been reaching an increasingly expressive and striking space in the daily lives of dentists, it was decided to carry out this in vitro study of compressive strength of composite resins in different thicknesses.

Therefore, based on the data obtained, it is believed that it is possible to maintain a small thickness of composite resin in areas of masticatory stress, including making the bevel in posterior teeth, which, according to [27], it can bring benefits to the restoration, especially related to the reduction of marginal microleakage. However, the validation of these results must be confirmed by other studies within this line of research.

Conclusion

Based on the results found in this study, it can be concluded that:

• The composite resins P60 and Z250 did not show differences between them, in relation to the resistance to compression in the thicknesses of 1, 2 and 4mm.

• Composite resins P60 and Z250 showed greater resistance to compression at a thickness of 1mm, compared to thicknesses of 2 and 4mm.

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