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ORIGINAL ARTICLE

Comparison of marginal adaptation between a monoincremental resin with sonic activation and a conventional resin.

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Abstract: Aim: To determine differences in marginal adaptation between a conventional composite resin and a monoincremental resin with sonic activation. Materials and methods: 32 composite resin discs of 2.5mm in diameter and 2mm thick were fabricated in a propylene matrix and distributed in 2 groups of 16 samples each. Groups 1 Filtek™Z350XT resin; Group 2 SonicFill™ resin with sonic activation. The gap generated between the resin and the matrix as a result of the polymerization shrinkage was analyzed in microns using a microscope at a magnification of 40X. The percentage of the lineal polymerization shrinkage was also calculated. To calculate differences in marginal adaptation between the two resins statistical analysis was performed using the unpaired t-test. Results: The extent of the gaps measured in microns and their respective standard deviations were SonicFill™ 9.95±3.05 and Filtek™Z350XT 10.21±5.14 (p=.86). Conclusion: The use of the monoincremental resin system with sonic activation shows a marginal adaptation similar to that of conventional resin composites, with no statistically significant differences between the studied resins.

Keywords: *Polymerization; Ultrasound; Composite resins; Dental Materials.*
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INTRODUCTION.

Composite resins have had a great development since their emergence[1,2]. In the 1980s their use was extended to posterior teeth because of their reduced particle size and increased filler loading[3]. However, one limitation of this material is the generation of stress in the tooth-restoration interface caused by polymerization shrinkage[4], which may produce loss of chemical and mechanical stability, resulting in the loss of marginal integrity and the appearance of a gap, followed by marginal filtration and secondary caries[5]. The intensity of the generated stress depends, among other factors, on the modulus of elasticity of the material, and the latter, in turn, is dependent on the amount of filling[6,7].

Monoincremental composite resins[8,9] have become commercially available in recent years (Bulk Fill). They allow the restoration in one or two increments reducing clinical chair time[10], and resulting in lower polymerization shrinkage[11] and a lower stress at the interface[12]. However, high viscosity Bulk Fill resins do not seem to be advantageous in terms of generation of stress in the adhesive interface when compared with high viscosity conventional composite resins[9].

According to the manufacturer's specifications[13], the SonicFill™ system (Kerr Corporation, Orange, CA, USA) (SF) is a light-activated Bulk Fill composite resin. It possesses rheological modifiers in the matrix and in the filler; the latter represents 83.5% of the weight and 78% of the volume. Among its properties there are a depth of polymerization of up to 5mm and a polymerization shrinkage of 1.6% with respect to volume[13]. Its commercial form is a capsule that fits the handpiece provided by the manufacturer (KaVo®, Germany). It is activated sonically fluidizing the material, allowing a better adaptation to the cavi-

ty walls in a single increment. After sonic activation (SA), the resin recovers its initial viscosity in about 20 seconds[14], allowing enough time to mold it and adapt it to the cavo-surface edges. While SA aims to achieve a better adaptation of the material, it is unknown whether such activation has a significant effect in reducing the marginal gap compared to conventional composite resins.

Based on the information provided above, the aim of this study was to determine differences in marginal adaptation between a conventional composite resin and monoincremental resin with sonic activation.

MATERIALS AND METHODS.

An *in vitro* experimental quantitative study was conducted. Sample size estimation was performed using EPIDAT 4.1 (Dirección General de Innovación y Gestión de la Salud Pública, Spain) considering the following assumption criteria: known value of linear polymerization shrinkage of SonicFill™ resin (Kerr Corporation, Orange, CA, USA) (2.05±0.05%)[9] with a statistical power of 80%, a confidence level of 95% and an expected difference of 0.73% (21% reduction); as a result, 16 samples were obtained for each group, in order to achieve a parametric distribution to be analyzed by unpaired t-test.

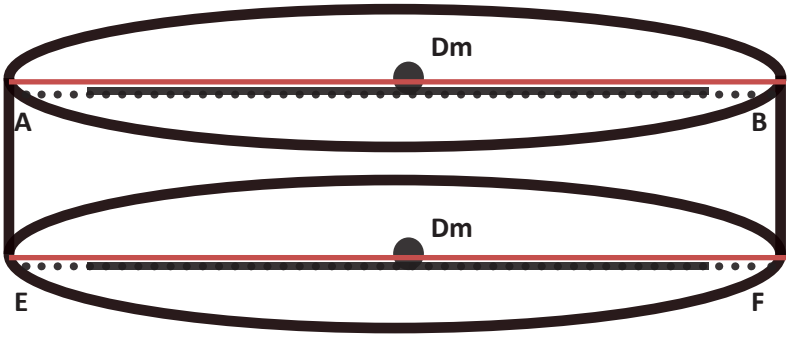
To measure the effect of polymerization shrinkage in the generation of marginal gaps with two kinds of resins, propylene matrices of 2.5mm in diameter and 2mm thick with a central bore were used (Figure 1). Two groups of composite resin discs were fabricated in the matrices (Table 1), with 16 samples each: Group 1 Filtek™ Z350XT resin (3M ESPE, St Paul, MN, USA); Group 2 SonicFill™ resin (Kerr Corporation, Orange, CA, USA).

Table 1. Composition of composite resins used in the study.

Material, code, color	Type	Composition	Manufacturer
Filtek™ Z350XT (Z350,A2)	HV,C	Bis-GMA, UDMA, TEGDMA and bis-EMA, zirconium and silica filler 78.5% by weight and 63.3% by volume.	3M ESPE, St, Paul, MN, USA
Sonic Fill™ (SF,A2)	HV,B	Bis-GMA, TEGDMA, EBPDMA, silicon, barium, boron, aluminium, glass, and oxides 83.5% by weight and 78% by volume. Organic and inorganic rheology modifiers.	Kerr corporation, Orange, CA, USA

HV: High viscosity; C: Conventional; B: Bulk-Fill.

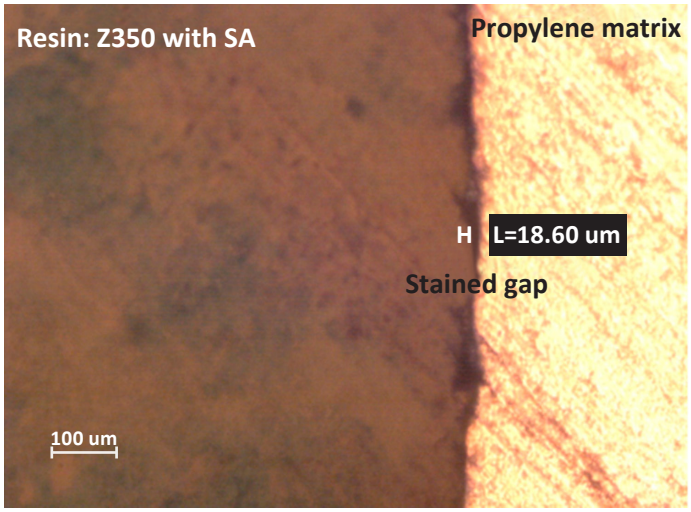
Figure 1. Diameter variation of resin disc caused by polymerization.



Diameter of the disc before polymerization. Diameter of the disc after polymerization.

Dm: Diameter; A, B, E, F: Post polymerization gaps.

Figure 2. Filtek™ Z350XT resin sample with sonic activation at 40x magnification



SA: Sonic activation.

SA was performed at an intensity of 4 on a scale of 1 to 5 of the handpiece (KaVo®, Germany). The pilot phase of this study was conducted in the laboratory of the dental clinic at Universidad Austral de Chile during April and May 2015.

All samples were performed by the same operator (RM). Matrices were placed and fixed on a slide (Hospital & Homecare, China) to avoid the resin flowing out of the matrix. Matrices were filled with composite resin to the surface edge; excess material was removed, making sure there were no spaces between the resin and the matrix by means of a magnifying glass at 4x magnification (Olympus SZ61, Olympus Corporation, Japan). A coverslip (Hirschmann M0260, Germany) was used for standardizing the distance between the resin matrix and the tip of the light, polymerizing for 40 seconds with a halogen lamp (QHL75 curing light, Dentsply, USA), establishing a minimum irradiance of 580 mW/cm^2 with a radiometer[15] (LED radiometer, SDI, Australia). Resin samples were stored immersed in methylene blue (Laboratorio Valma S.A., Chile) for 24 hours at room temperature.

As the shape of the object in which the difference between initial and after polymerization length is measured has a circular diameter of 2500 microns, each of the changes caused by polymerization of the resin body were performed by measuring the variation of its diameter in 4 segments determined by mutually perpendicular axes through the center of the disc (Figure 1). Two upper segments A - B, C - D) and two lower (E - F, G - H), where A, B, C, D, E, F, G and H correspond to the gaps caused by post polymerization in each segment.

A gap was defined as the space between the composite resin matrix occupied by the staining agent, measured by a single operator (JV) (Figure 2). Because the gap between the matrix and the composite resin due to polymerization shrinkage was irregular, measurement points were standardized as explained in the preceding paragraph, in which the measurement performed by the observer was made with a transmission microscope (Olympus CX41, Olympus Corporation, Japan) at a 40x magnification using Micrometrics™ SE Premium (Microsoft, USA). All measurements of gaps in microns (µm) were tabulated in Google Docs (Google Inc, USA).

A statistical analysis with t-test for unpaired samples was performed using GraphPad Prism 6 (GraphPad Software, USA). To achieve this objective, the type of resin was considered as the independent variable, and the amplitude of the gap measured in microns as the dependent variable. To detect statistically significant differences a $p<.05$ value was established.

This paper was written following the CONSORT[16] guidelines modified for the publication of *in vitro* studies of dental materials.

RESULTS.

The average values of amplitude of gaps in the Group 1 (Filtek™ Z350X) was 10.21±5.14 microns, and in the Group 2 (SonicFill™) was 9.95±3.05 microns. The post-hoc Tukey test did not detect significant differences in the amplitude of the gaps of both groups of composite resins ($p=.86$).

DISCUSSION.

The use of a system of monoincremental resins showed gaps with an amplitude similar to that of conventional res-

ins. There were no statistically significant differences between the resins tested.

When monomers forming the matrix of a composite resin join to form cross-linked polymer chains, polymerization shrinkage causes a decrease in the volume of the resin[17]. It can be expressed as linear and volumetric shrinkage, both measured in percent, with varied[18] values of linear shrinkage (0.33%-1.53%)[19,20] and volumetric shrinkage (0.9%-5.14%)[11,22,23] mainly due to two reasons: The percentage varies depending on the method used and is also dependent on the operator[5,18]. On the other hand, there are several factors involved in the amount of polymerization shrinkage, including the type of resin, percentage and composition of filling and degree of conversion of the organic matrix[3]. This polymerization shrinkage causes stress in the tooth-restoration interface, which can result in loss of marginal integrity generating a gap, followed by marginal filtration and secondary caries[5]. This is partly compensated by the use of adhesive systems by 20%[24], further contributing to the abovementioned variation.

While these values depend on the type of measurement, volumetric or linear, Gieck & Gieck[25] (reviewed by Sakaguchi[17]) established a mathematical correlation between them, showing an approximate ratio of 3:1. Queiroz *et al.* measured the percentage of volumetric polymerization shrinkage of Filtek™ Z350X with 3 different methods, with results varying from 1.02% to 4.45%. In the present study this composite resin showed a percentage of linear polymerization shrinkage of 0.81%, which when multiplied by 3 is located within the ranges obtained by Queiroz *et al.*, producing an average gap of 10.21±5.14 microns.

Garcia *et al.* obtained a volumetric shrinkage for SF resin of 1.76%±0.53; however, they used a separating agent between the composite resin and the matrix, which may have generated an increase in the gap in their results. Nevertheless, multiplying our results by the factor 3 makes them similar to the values found by those authors.

The group with the lowest average gap was group 2. This is consistent with the information provided by manufacturers (1.6% SF[13] and 2% Filtek™ Z350X[26]). This can be attributed in part to the composition of the material, since SF resin has a higher percentage of filler by weight and volume compared to Filtek™ Z350X resin (Table 1). One of the effects of ultrasonic activation in a polymer is to reduce its viscosity due to degradation of the polymer chains[27] and the increase in the kinetic energy of the particles together with an increase in the temperature of the polymer[28], increasing the degree of adaptation to cavity walls; however, this difference was not statistically significant. One possible explanation is that the Sonic Fill resin group showed the presence of bubbles inside. According to Peters *"Ultrasound is transmitted through a medium via waves by inducing vibrational motion of the molecules which alternately compress and stretch the molecular structure of the medium. Therefore, the distances between the molecules vary as the molecules oscillate about their mean position"*, which explains the presence of bubbles in the group with SA. This could mean that there is a percentage of the resin that does not polymerize due to the presence of oxygen inside the bubbles, which acts as a polymerization inhibitor[29,30].

Kim *et al.* found no statistically significant differences in the percentage of linear polymerization shrinkage when comparing high viscosity conventional composite resins and monoincremental resins that include SA in their protocol and another one that does not include it[9]. These results are similar to the results obtained in this study; however, this is not the only factor that contributes to the generation of a gap in the tooth-restoration interface. They also found that the stability of adhesion was dependent on the stress produced at the interface, a factor not assessed in this study, since we did not include the use of adhesive systems.

One limitation of this study is that the SA used in the handpiece had an intensity of 4 on a scale of 1 to 5, and it is possible that the amount of bubbles in the resin body is related to the intensity of SA used, creating a new factor in polymerization shrinkage, and thus in producing gaps in the interface. We suggest to conduct further or

additional studies to evaluate the effect of the intensity of the SA in bubble generation and the subsequent variation in the mechanical properties of the resin along with other long-term clinical studies.

Another limitation of the study is that arbitrary points were used to measure the gaps caused by polymerization shrinkage, which can be a source of bias.

There are no statistically significant differences in the generation of gaps caused by polymerization shrinkage between the conventional use of Filtek™ Z350X resin and SF with SA. Therefore, the advantage of using a system of monoincremental resin with SA is that it allows the use of a high viscosity fluidized resin, achieving a better adaptation to the cavity walls in larger increments with similar polymerization shrinkage, and a marginal adaptation similar to that of a conventional resin but in less clinical time.

CONCLUSION.

The use of the monoincremental resin system with sonic activation shows a similar marginal adaptation to that of a conventional resin. There were no statistically significant differences between the resins studied.

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Comparación de adaptación marginal entre una resina compuesta monoincremental activada sónicamente y una resina convencional

Resumen: Determinar diferencias de adaptación marginal entre una resina compuesta convencional y una resina monoincremental activada sónicamente. Material y métodos: 32 discos fabricados de resina compuesta de 2.5 mm de diámetro y 2 mm de grosor en una matriz de propileno se distribuyeron en 2 grupos de 16 muestras cada uno: grupo 1 resina Filtek™ Z350X; grupo 2 resina SonicFill™ activada sónicamente. La brecha generada entre la resina y la matriz producto de la contracción de polimerización se midió en micrones en un microscopio con magnificación 40x. Para evaluar las diferencias de adaptación marginal entre las dos resinas se realizó análisis estadístico con un t-test de muestras no pareadas. Resultados: La amplitud de las brechas medidas en micrones y sus respectivas desviaciones estándar fueron: SonicFill™ 9.95±3.05 y Filtek™ Z350X 10.21±5.14 (p=.86). Conclusión: El uso del sistema de resina monoincremental activado sónicamente presenta similar adaptación marginal que la resina convencional, no existiendo diferencias estadísticamente significativas entre las resinas estudiadas.

Palabras clave: *Polimerización; Ultrasonido; Resinas compuestas; Materiales dentales.*

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