A COMPARISON OF MICROHARDNESS OF INDIRECT COMPOSITE RESTORATIVE MATERIALS

ESTUDO COMPARATIVO DA MICRODUREZA DE MATERIAIS RESINOSOS INDIRETOS

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The purpose of this study was to compare the microhardness of four indirect composite resins. Forty cylindrical samples were prepared according to the manufacturer's recommendations using a Teflon mold. Ten specimens were produced from each tested material, constituting four groups (n=10) as follows: G1 - Artglass; G2 - Sinfony; G3 - Solidex; G4 - Targis. Microhardness was determined by the Vickers indentation technique with a load of 300g for 10 seconds. Four indentations were made on each sample, determining the mean microhardness values for each specimen. Descriptive statistics data for the experimental conditions were: G1 - Artglass (mean ±?standard deviation: 55.26 ± 1.15HVN; median: 52.6); G2 - Sinfony (31.22 ± 0.65HVN; 31.30); G3 - Solidex (52.25 ± 1.55HVN; 52.60); G4 - Targis (72.14 ± 2.82HVN; 73.30). An exploratory data analysis was performed to determine the most appropriate statistical test through: (I) Levene's for homogeneity of variances; (II) ANOVA on ranks (Kruskal-Wallis); (III) Dunn's multiple comparison test (0.05). Targis presented the highest microhardness values while Sinfony presented the lowest. Artglass and Solidex were found as intermediate materials. These results indicate that distinct mechanical properties may be observed at specific materials. The composition of each material as well as variations on polymerization methods are possibly responsibles for the difference found in microhardness. Therefore, indirect composite resin materials that guarantee both good esthetics and adequate mechanical properties may be considered as substitutes of natural teeth.

UNITERMS: Microhardness; Indirect composite.

INTRODUCTION

Esthetic Dentistry has been widely advocated, since there has been an increasing demand for materials that resemble the natural tooth. Therefore, dental treatments that provide a harmonious smile have been widely requested in dental offices.

Since Buonocore[2] introduced the acid-etching concept followed by Bowen's research[1] on composite resin, new perspectives were born for Restorative Dentistry. Initially, composite resins presented low wear resistance due to the weak bonding of the filler content to the organic matrix[11]. When later improvements were achieved regarding the material's composition, better chemical and mechanical properties were accomplished, thus improving its clinical performance and extending its utilization to posterior teeth[4]. The incorporation of smaller particles associated to higher filler content has guaranteed higher mechanical properties, better marginal sealing and longer color stability[9,10].

Indirect composite resins have been introduced with high expectations to overcome direct composite resins drawbacks. Among the proposed advantages are the potential for achieving positive interproximal contacts, less polymerization shrinkage and better marginal sealing because of the polymerization process that takes place in a laboratory setting[7].

Such enhanced properties are the result of a higher degree of conversion obtained from the utilization of different polymerization procedures that involve heat, pressure, light, vacuum, or nitrogen atmosphere[16]. The degree of conversion increases when multifunctional monomers are present, offering extra reactive sites that enlarge the polymer chains. Better mechanical properties may also be ensured through reinforcements of glass and polyethylene fibers added to indirect composite resin materials[6].

Therefore, indirect composite restorations have become a popular alternative to all-ceramic restorations for the esthetic treatment of posterior teeth. Since there has been a rapid introduction of new dental restorative composite resins, the selection of the appropriate material becomes rather difficult. As mechanical properties are one of the most important characteristics when deciding for a suitable material, scientific validation on the efficacy of these new technologies is necessary[14].

Microhardness tests are considered an efficient method to investigate the physical strength of a material and therefore may be one an appropriate indicative method to guide indirect composite application. The hardness of a material is a relative measure of its resistance to indentation when a specific, constant load is applied. Thus, hardness may be described as a measure of the ability of a material to resist indentation or scratching[13].

Aiming to clear the confusion with respect to clinical decision-making when selecting an indirect composite resin, the purpose of this study was to investigate the microhardness of four indirect resins by using the indentation technique.

MATERIAL AND METHODS

Microhardness tests were carried out on four different indirect composite resins: Artglass (Heraeus-Kulzer, Hanau - Germany), Sinfony (3M-ESPE, Minnesota - United States), Solidex (Shofu, California, United States), and Targis (Ivoclar, Liechtenstein - Switzerland). Table 1 lists the brand names, manufacturers, estimates of percent and size range of filler content of each material, and polymerization methods.

Ten cylindrical specimens of each of the test composites were prepared by placing the materials into a Teflon matrix (5mm deep and 5mm in diameter) for polymerization according to the manufacturer's recommendations. All samples were inserted into a polyester resin (Arotec T208 - Valglass Comércio e Indústria Ltda., São José dos Campos - Brazil) in order to ease sample handling. Special care was taken to leave the tested surface uncovered by the polyester resin. Standardized surfaces were obtained though a sequential sandpaper finishing to ensure that both upper and lower surfaces were parallel to each other. After 24 hours, all the specimens were submitted to the proposed testing, constituting four groups (n=10) as follows: G1 - Artglass; G2 - Sinfony; G3 - Solidex; G4 - Targis.

Hardness was determined by the indentation technique performed on a microhardness tester (Digital Microhardness Tester FM - Future-Tech Corporation, Kawasaki - Japan) with a load of 300g for 10 seconds. Four indentations were made on each sample using a

TABLE 1- Product information

Material & Manufacturer	Filler content & Size	Filler content (%vol)	Polymerization methods
Artglass (Heraeus-Kulzer)	Barium glass, colloidal silica (1µm)	68%	Xenon strobe light (320-520nm)
Sinfony (3M-ESPE)	Borosilicate glass, quartz, silica (50nm-1µm)	45%	Light (400-500nm) and vacuum
Solidex (Shofu)	Silicon dioxide, aluminum oxide (1µm)	53%	Halogen light (400-550nm)
Targis (Ivoclar)	Barium glass, silicon dioxide (30nm-1µm)	55%	Halogen Light (450-500nm) and tempering heat (95ºC)

Vickers diamond point in order to determine the mean microhardness values for each specimen.

Statistical methods

Descriptive statistic data are presented as mean, standard deviation and median values for the following four experimental conditions: G1 - Artglass (mean±standard deviation: 55.26 ± 1.15; median: 55,20); G2 - Sinfony (31.22 ± 0.65; 31.30); G3 - Solidex (52.25 ± 1.55; 52.60), and G4 - Targis (72.14 ± 2.82; 73.30). An exploratory data analysis was performed to determine the most appropriate statistical test. Data obtained were analyzed by: (I) Levene' s for homogeneity of variances; (II) ANOVA on ranks: Kruskal-Wallis; (III) Dunn' s multiple comparison test. Level of significance chosen for all tests was 0.05.

RESULTS

Microhardness (HVN) descriptive data obtained are demonstrated in Figure 1 (Box and Whisker Plot represents median and interquartil range) and Figure 2 (column bar representation holds mean and standard deviation).

Regarding measures of central tendency, it may be observed that: (I) according to median values, Figure 1 shows that Targis presented the highest microhardness values (73.3 HVN) while Sinfony presented the lowest (31.3 HVN). Artglass (55.2 HVN) and Solidex (52.6 HVN) resulted into intermediate behavior; (II) observing mean values at Figure 2, Targis (72.14 ± 2.82 HVN) presented a superior behavior when compared to all tested materials (Artglass - 55.26 ± 1.15 HVN, Solidex 52.25 ± ?1.55 HVN, and Sinfony 31.22 ± 0.65 HVN).

Regarding data variability, it may be verified that: (I) there was not overlapping of data correspondent to the interquartil range (which is the most stable and important data of the distribution) among the tested materials (Figure 1); (II) Targis resulted into higher standard deviation (Figure 2) when compared to the other tested materials (Levene's Test: $F_{3;36}$= 4.544; p=0.008).

Statistical significance was observed between the median values of the tested materials when data were submitted to Kruskal-Wallis test (kw=17.67; df=3; p=0.001).

The results obtained from Dunn's multiple comparison test (0.05) are displayed on Table 2 and demonstrate that: (I) Targis is the hardest material tested, but it is not statistically different from Artglass; (II) Sinfony demonstrated lower resistance to indentation and is statistically similar to Solidex; (III) Solidex holds an intermediate behavior when compared to Artglas and Sinfony.

DISCUSSION

This study performed microhardness tests in order to evaluate some of the indirect composite resin systems commercially available. Theoretically, all indirect resin materials should present similar mechanical properties since the composition of the filler content of such materials is almost identical, basically constituted of oxygen, aluminum, silicon, and barium[13]. However, the results obtained in this study demonstrate that the different tested materials present intrinsic characteristics, which resulted into specific behaviors.

The overall properties of a composite are influenced by the type, size, and volume fraction of the filler particles and the degree to which the filler is bonded to the resin matrix. Therefore, the type of

FIGURE 1- Box and Whisker Plot representation of microhardness values (HVN) for each indirect composite resin

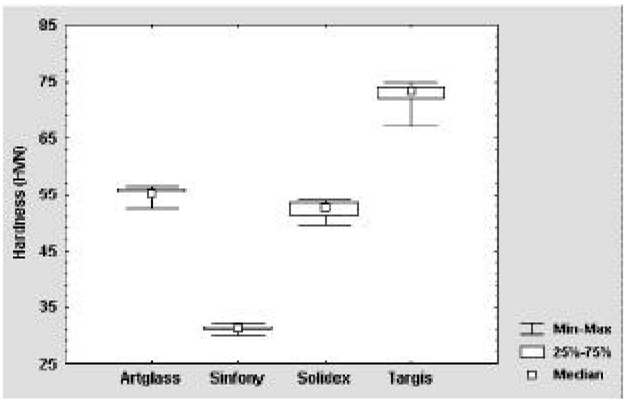

FIGURE 2- Mean microhardness values (HVN) and standard deviation for each tested material

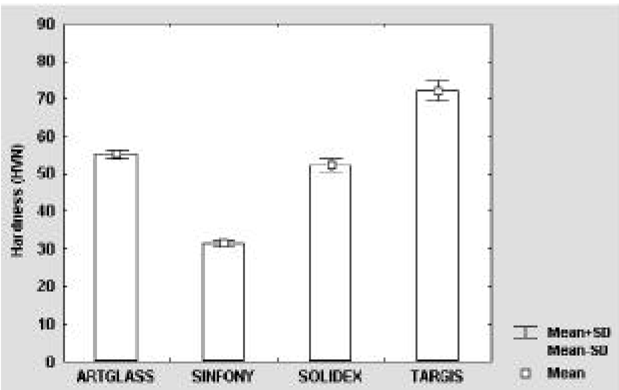

TABLE 2- Homogeneous grouping and median microhardness values of indirect composite resins (Dunn Multiple Comparison Test - 0.05)

Indirect Resin	Median (HVN)	Homogeneous grouping*		
TARGIS	73,30	A		
ARTGLASS	55,20	A	B	
SOLIDEX	52,60		B	C
SINFONY	31,30			C

* Different letters correspond to statistically different mean microhardness values.

matrix and the degree to which conversion occurs during polymerization might also influence the mechanical properties, especially when aging occurs in the oral environment[3].

There may be yet a positive correlation between the method of polymerization and the microhardness property. Tanoue, et al.[15] pointed out that achieving the best mechanical and physical properties is directly related to a combination of composite material and curing unit from the same manufacturer. It could be observed that Targis, which was polymerized trough light (450-500nm) integrated to tempering heat (95ºC), presented the highest microhardness numbers. Yamaga et al.[18] reported that heat might facilitate monomer conversion by breaking the double bonds on the polymer network into single bonds, thus optimizing the polymerization of the residual monomers. The indirect composites that suffered polymerization under light-activation only (400-550nm) were found to hold intermediate mean microhardness values (Artglass and Solidex). On the other hand, Sinfony presented the lowest mechanical property tested, even when its polymerization method associated light (400-500nm) and vacuum. This suggests that the composition of the material influences the degree of conversion during polymerization resulting into lower resistance to indentation.

The presence of filler particles increases the compressive strength and hardness of the resin matrix[17]. Initially, it was thought that increasing the level of filler content in composites could optimize properties such as wear resistance, compressive strength, hardness, water sorption, and elastic modulus[12]. Later researches have reported that there is no correlation between filler content and mechanical properties[5,13,15]. This study verified that Targis resulted into the highest microhardness mean values when compared to the other tested materials (Artglass, Solidex, and Sinfony) although it did not present the highest filler content. Interestingly, the indirect composite with the lowest filler content (Sinfony) presented the lowest mean microhardness data. Although divergence exists when considering a possible correlation between filler particle content and composite mechanical properties, it must be pointed out that perhaps the manufacturer's information about the filler particle size and filler content is not as closely monitored as they advertise[8]. Therefore, further research is necessary to determine indirect composite behavior in order to assist clinicians in a better understanding of their clinical indications.

CONCLUSION

Within the limits of this study, different indirect composite resins presented distinct microhardness mean values through the indentation technique under constant load of 300gf. Such differences may be related to the intrinsic composition of each material as well as the variation of their polymerization methods.

CLINICAL IMPLICATIONS

As proper substitutes of natural teeth, indirect composite resins should gather both adequate mechanical properties and good esthetic in order to produce successful results.

RESUMO

O objetivo deste estudo foi comparar a microdureza de 4 resinas compostas indiretas. Quarenta amostras cilíndricas foram obtidas com o auxílio de uma matriz de teflon, seguindo-se as recomendações dos fabricantes. Foram obtidas 10 amostras para cada material testado, contituindo-se 4 grupos (n=10) como se segue: G1-Artglass; G2-Sinfony; G3-Solidex; G4-

Targis. A microdureza foi determinada pela técnica da indentação Vickers com uma carga de 300g por 10 segundos. Quatro indentações foram realizadas em cada amostra, obtendo-se um valor médio. Os dados da análise estatística descritiva para cada condição experimental foram: G1-Artglass (média ± desvio padrão:55,26 ± 1,15HVN; mediana: 52,6); G2-Sinfony (31,22 ± 0,65HVN; 31,30); G3- Solidex (52,25 ± 1,55HVN; 52,60); G4- Targis (72,14 ± 2,82HVN; 73,30). Uma análise exploratória dos dados foi realizada para determinar o teste estatístico mais apropriado: (I) Teste de Levene para variâncias homogêneas; (II) Teste de ANOVA (Kruskal-Wallis); (III) Teste de comparação múltipla de Dunn. O Targis apresentou os maiores valores de microdureza, enquanto que o Sinfony apresentou os menores valores. O Artglass e o Solidex se comportaram como materiais intermediários. Estes resultados indicaram que propriedades mecânicas distintas podem ser observadas nos materiais. A composição de cada material, bem como as variações nos métodos de polimerização são possivelmente responsáveis pelas diferenças observadas na microdureza. Portanto, materiais resinosos indiretos que garantam estética e propriedades mecânicas satisfatórias podem ser considerados como substitutos dos dentes naturais.

UNITERMOS: Microdureza; Resina composta indireta.

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