www.medigraphic.org.mx

Revista Odontológica Mexicana

Facultad de Odontología

Vol. 21, No. 2 ● April-June 2017

pp 107-111

ORIGINAL RESEARCH

Compressive strength of glass ionomer and composite resin. *In vitro* study

Resistencia a la compresión del ionómero de vidrio y de la resina compuesta. Estudio in vitro

Sara Blanco Lerech,* Sebastián Frías Tarón,* Arnulfo Tarón Dunoyer,§ José María Bustillo Arrieta,|| Antonio Díaz Caballero¶

ABSTRACT

Objective: To assess compressive strength of glass ionomer and composite resin restorations in premolar class I cavities. **Material and methods:** *In vitro* experimental study to assess compressive strength of two types of stomatological restoration materials, using as object of study 52 bi-radicular premolars. Samples were distributed into four groups with different characteristics such as restorative material and cavity depth (2-4 mm). Glass ionomer and composite resins were the used restorative materials. Grouped samples were subjected to a compressive vertical force using a EZ-S SHIMADZU texturometer, until achieving the material's fracture. Obtained data were subjected to the Shapiro-Wilk test in order to assess data normalcy, null hypothesis was rejected. Total data analysis was conducted with t-Student test for independent samples. **Results:** Data obtained after assessing superficial hardness of different restorative materials showed the existence of statistical differences which favored composite resin when compared to glass ionomer at both depths ($p = 6.908 \times 10^{-11}$ and $p = 0.000$). In intra-group comparison, a significant different was found between both groups (resin and glass ionomer) at different depths ($p = 0.000155887$ and $p = 0.00257443$). **Conclusion:** Assessment of 4 mm tooth cavities restored with Tetric N-Ceram resin revealed greater hardness than those accomplished with Vitremer® resin at 2 and 4 mm and with the same resin at 2 mm depth.

RESUMEN

Objetivo: Evaluar la resistencia a la compresión en restauraciones de ionómero de vidrio y de resina compuesta en cavidades clase I en premolares. **Material y métodos:** Un estudio experimental *in vitro*, para evaluar la resistencia a la compresión de dos tipos de materiales restaurador estomatológico, utilizando como objeto de estudio 52 dientes premolares birradiculares. Las muestras fueron distribuidas en cuatro grupos con diferencias en sus características, como fueron el material restaurador y la profundidad de la cavidad (2-4 mm). Se empleó como material restaurador ionómero de vidrio y resina compuesta. Las muestras grupales fueron sometidas a una fuerza vertical compresiva utilizando un texturómetro EZ-S SHIMADZU hasta lograr producir la fractura del material. Para evaluar la normalidad los datos obtenidos se sometieron a la prueba Shapiro-Wilk que rechazó la hipótesis nula. El análisis de los datos totales se realizó a través del test t-Student para muestras independientes. **Resultados:** Los resultados obtenidos al evaluar la dureza superficial de los diferentes materiales restauradores, muestran que existen diferencias estadísticas a favor de la resina compuesta en comparación con el ionómero de vidrio en ambas profundidades ($p = 6.908 \times 10^{-11}$ y $p = 0.000$), y en la comparación intragrupal se aprecia una diferencia significativa entre los dos grupos de resina e ionómeros a distinta profundidad ($p = 0.000155887$ y $p = 0.00257443$). **Conclusión:** Al evaluar las cavidades de los órganos dentarios de 4 mm de profundidad, que fueron restaurados con resina Tetric N-Ceram, éstas presentan mayor dureza en comparación con los que fueron restaurados con resina Vitremer™ a 2 y 4 mm y que la misma resina a 2 mm de profundidad.

Key words: (MeSH), resin, glass ionomer, restoration materials, rheological tests.
Palabras clave: (DecS), resina, ionómero de vidrio, materiales de restauración, pruebas reológicas.

www.medigraphic.org.mx

* DDS, School of Dentistry, University of Cartagena.
§ Pharmaceutical Chemist, University of Cartagena. Degree in Biotechnology, University of La Habana. PhD Candidate in Food Science, University of La Habana. Professor, University of Cartagena.
|| DDS, University of Cartagena. Orthodontics Specialist, University of Saõ Paulo. Degree in Applied Statistics, Universidad del Norte. Professor, University of Cartagena.
¶ DDS, University of Cartagena. Periodontics Specialist, Universidad Javeriana. Degree in Education, Universidad del Norte. PhD in Biomedical Sciences, University of Cartagena. Professor, University of Cartagena.

School of Dentistry Cartagena University.

Received: May 2016. *Accepted: November 2016.*

© 2017 Universidad Nacional Autónoma de México, [Facultad de Odontología]. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

This article can be read in its full version in the following page: http://**www.medigraphic.com/facultadodontologiaunam**

INTRODUCTION

Tooth degeneration is caused by different factors which can affect tooth's enamel, dentin and hard tissues.[1] If said degenerative process is found at an initial stage, it can be reversible, such is the case of the whitish spot; if this is not the case, an irreversible process sets in related to the cavitation presence. For these reasons, to count with ideal and longer-lasting materials is of the utmost importance when restoring original cavities caused by different carious processes in the mouth.[2]

Several research projects are proof that the scientific community is interested in improving mechanical properties of filling materials, remembering nevertheless that there are still some deficiencies such as low resistance to wear, micro-filtration, pigmentation and incomplete polymerization. Resistance of these materials to diverse factors is still not ideal and results in their short permanence in the mouth, nevertheless, some of these materials have proven to possess annual wear similar to that of silver amalgam.[3,4]

It is important to bear in mind some current and relevant concepts of minimally invasive dentistry: when teeth require restoration, this restoration must be as conservative as possible with the dental structure when required preparations are undertaken. This has caused abandonment of certain materials requiring extensive preparations in order to acquire resistance and adhesion to the tooth. Contrarily, the use of materials not requiring extensive preparations to be used in different cases is on the rise.[5]

Certain characteristics of the material provide confidence to the clinical operator, who will play an important role when choosing materials. These characteristics, among others, are resistance to masticatory forces, acceptable esthetics, and superficial hardness.[6]

In a publication previous to this study, Taron et al, in 2015, proposed in a pilot study as experimentation model a large number of natural teeth previously extracted due to orthodontic reasons. This sample was used to develop fracture resistance and tolerance tests. The study nevertheless demanded evidence of sample increase and model refinement.[6]

Restorative materials presently used such as composite resin and glass ionomers, possess advantages and disadvantages, therefore the aim of the present study was to compare one of the multiple characteristics essential to restorative materials, that is to say compressive strength of the aforementioned two materials.

MATERIAL AND METHODS

An *in vitro* quasi-experimental study was conducted. In it, assessment was made of compression resistance of a reconstructive glass ionomer in contrast to a nano-hybrid composite resin, both materials were used to restore Black's class I cavities with depths of 2 and 4 mm in human premolars. The convenience-selected sample was composed of 52 premolars, extracted during orthodontic treatments, lacking extensive enamel anomalies.

The sample was divided into two groups: group A, for teeth where 2 mm deep cavities were performed, and group B where 4 mm deep cavities were established. A blunt edge, cylindrical diamond burr was used. Depth of all prepared cavities was rectified with a millimeter periodontal probe (Hu-Friedy).

A self-polymerizing acrylic support was manufactured for each tooth in the sample, so as to provide stability when positioned in the compressive strength measuring instrument.

Both groups were divided into two sub-groups. Number 1 was for teeth used as sample, restored with reconstructive glass ionomer, brand 3M Vitremer®. Number 2 was for teeth restored with nano-hybrid resin Tetric N-Ceram, brand Ivoclar Vivadent *(Table I)*.

All teeth of the sample were subjected to stress tests with texturometer EZ-S SHIMADZU, series number 346-54909-33, with 50-60 Hz, with maximum capacity range of 500 Newton. Filled and restored teeth were subjected to compression in the occlusal side, with a 1 mm contact area, until achieving a 1 mm depth in one single advance *(Figure 1)*. Strength necessary to monitor necessary strength to penetrate in the vertical aspect of the restoration existing in all teeth was monitored. It must be stressed that in all samples force application was equally performed at the central point of the restoration.

Ethical considerations of this project were in concordance with resolution 008430 (1983), Ministry of Health, Colombian Republic.

www.medigraphic.org.mx

Table I. Groups, cavity depth and restoration material.

Group	Cavity depth (mm)	Restoration material
A1	2	Vitremer® ionomer
A2	2	Tetric N-Ceram resin
B1	4	Vitremer® ionomer
B2	4	Tetric N-Ceram resin

Figure 1.

Superficial penetration in bi-rooted teeth restored at 2 and 4 mm depth. Device EZ-SHIMADZU, series 346-54909-33.

Statistical analysis

A matrix table was manufactured from obtained results, to this effect Microsoft Excel version for Windows 7 was used. After this, the Shapiro-Wilk test was applied to each of the samples. The following results were obtained: A1 = 0.059, A2 = 0.940, B1 = 0.987 and B2 = 0.300. Since values were above 0.05, normalcy hypothesis could not be discarded. This test was conducted with program SPSS Statistic v22 IBM. T-Student test was applied for independent samples, with significance level p > 0.05, using Statgraphics portable program centurion XV.II.

RESULTS

After Applying t test for independent samples analyzed two by two, it was found that cavities measuring 2 mm and filled with Vitremer® and those filled with Tetric N-Ceram exhibited significant differences (p = 0.00000000006908). A 95% confidence interval was obtained for mean differences, supposing equal variances (-60.0973 up to -41.1631). Since confidence interval does not contain 0 there was a statistically significant difference between means of both samples, with a 95% confidence level. Tested resin exhibited greater significance, since it possessed greater mean (419.9500) as observed in *figure 2*.

Figure 3 shows results of the comparison of both used restorative materials, after conducting an analysis of the 4 mm cavities filled with Vitremer® and Tetric N-Ceram resin. They exhibited significant difference (p = 0.000) and a confidence interval comprised between values of -94.8257 up to -76.604. Due to the fact that confidence interval does not contain 0, there was a statistically significant difference with confidence interval of 95%. Resin was more significant since it possessed greater mean (438.9784 N).

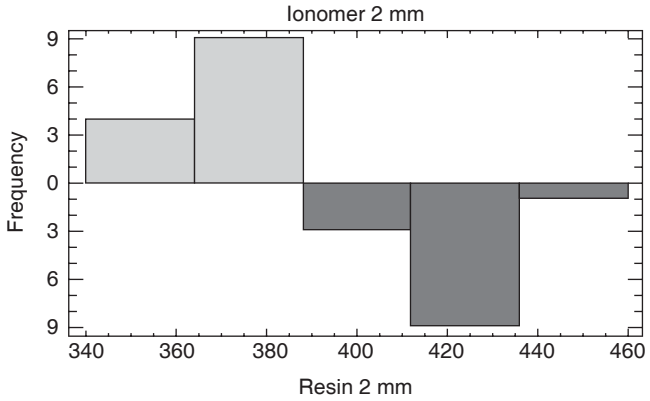

Figure 2. Comparison of superficial hardness of different restoration materials at 2 mm depth.

When comparing 2 and 4 mm cavities filled with Vitremer®, results showed no statistically significant difference (p = 0.00257443), confidence interval 6.07823 up to 25.3742, since interval contains 0 no statistically significant difference was found between both samples, with a 95% confidence level. Comparison with 2 and 4 mm cavities filled with Tetric N-Ceram resin, results revealed statistically significant difference (p = 0.000155887), alternatively, appealing to the confidence interval (-28.2774 up to -10.4401); since interval did not contain 0 there was a statistically significant difference between means of both samples, with confidence interval of 95%. Significance of resin at 4 mm was greater since it possessed greater media (438.9784 N) *(Tables II and III)*.

DISCUSSION

In a previous publication of this research group, the cavity model was primed in natural teeth, in order

to try to establish the importance of research in an environment much more similar to the reality of the oral cavity in human beings.[6] Irrespectively of cavity depth, greater superficial hardness could be observed in all teeth restored with nano-hybrid resin. Nevertheless, in all study groups resin placed in 4 mm deep cavities exhibited higher hardness. Group B1 exhibited lowest results upon penetration.

Carrillo (2008)[7] reported similar results to those obtained in the present study with respect to resistance of some filling materials used in dentistry. This study reported comparison of composite resin, reconstructive glass ionomer and fluid resin; in it, hardness values of composite resin were widely greater than those of the two remaining materials.[8,9]

In 2014, Suarez and Lozano[10] studied hardness of different types of resins, but, differing from the present study, they conducted their study examining the material in the shape of pre-formed elements, built with the studied materials, and not in a tooth by filling directly a prepared cavity, mimicking thus clinical reality. It is considered that the model proposed in the present study, far more resembles a real scenario of resistance measurement and compressive forces.

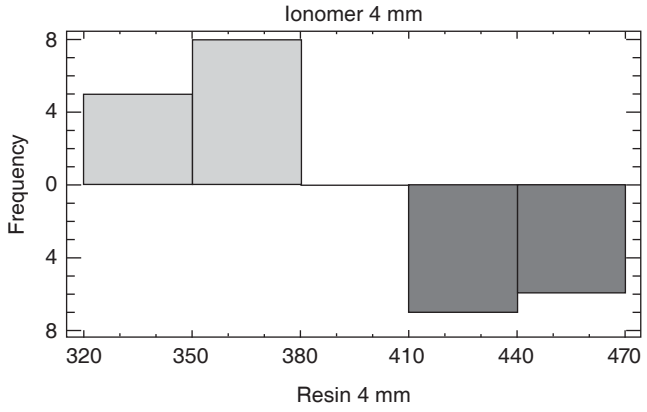

Figure 3. Comparison of superficial hardness of different restoration materials at 4 mm depth.

Sun Ae Song et al, in 2014[11] conducted research on resin hardness at different polymerization stages. Nevertheless, they conducted that research with Vickers' microdurometer, which differs from the texturometer using in the present study, since its measurement is not directed to assess what force is needed by the machine in order to achieve penetration.[12]

To conduct studies on assessment of superficial hardness of two dental filling materials at two different thicknesses or depths is very important for the industry of dental materials, and for modern dentistry since contributions achieved with these research projects help to refine clinical indications and guide dental materials manufacturers in the search for further benefits for dental patients. This point was taken by Shanthala (2013)[12] and Erazo (2010)[13] since they considered this a series of factors which allowed to achieve longer and more effective dental treatments for patients in cases when glass ionomer or resins were used as filling materials.[14,15]

CONCLUSION

Bearing in mind limitations inherent to an *in vitro* study, it could be concluded that teeth with 4 mm deep cavities restored with Tetric N-Ceram exhibited greater hardness than those restored with Vitremer® at 2 and 4 mm and 2 mm deep cavities with the same resin, nevertheless it must be accepted that evolution of present research might alter these results.

Resistance to compressive strength showed that to restore posterior teeth, studied resin possessed significantly higher hardness when compared to reconstructive glass ionomer.

Table II. Descriptive statistics. Comparison of superficial hardness of restoration materials at different depths.

www.medigraphic.org.mx

	Types			
	2 mm		4 mm	
	A1	A2	B1	B2
Mean	368.9894	419.950	426.790	438.9784
Median	373.6000	140.851	151.403	438.7540
Variance	132.6760	11.8680	355.221	101.9020
Stat. desc.	11.51850	419.619	12.3046	10.09467
ICR	18.89000	14.0900	15.4700	18.33000
IC	362.02-375.94	412.44-426.79	345.82-360.69	432.87-445.07

Table III. Significance among comparisons of superficial hardness of restoration materials.

	p-value
A1 vs. B1	0.00270
A2 vs. A1	6.980×10^{-11}
A2 vs. B2	0.00015
B2 vs. B1	0.00000

Range of obtained forces by no means compare to range of forces recorded in human teeth bite. This points out to the need to improve presently used dental materials.

Bearing in mind diverse applications of used methods and materials, it would be possible to create new research projects targeting changes in hardness of restorative materials.

REFERENCES

1. Hebbal M, Ankola AV. Dental caries, salivary parameters and plaque scores as caries risk predictors among 12 year old school children - A follow up study. *IJCRIMPH*. 2012; 4 (5): 544-554.
2. Chun KJ, Lee JY. Comparative study mechanical properties of dental restorative materials and dental hard tissues in compressive loads. *J Dent Biomech*. 2014; 5: 1758736014555246.
3. Tauquino J. Evaluación *in vitro* de la microdureza superficial de una resina compuesta microhíbrida, una resina compuesta fluida, y un cemento ionómero vítreo de restauración frente a la acción de una bebida carbonatada. 2002. Available in: http://cybertesis.unmsm.edu.pe/handle/cybertesis/1135
4. Gutiérrez B, Planells P. Actualización en odontología mínimamente invasiva: remineralización e infiltración de lesiones incipientes de caries. *Cient Dent*. 2010; 7: 183-191.
5. Lahoud SV. Factores determinantes que ejercen influencia sobre el rendimiento clínico de restauraciones con resina. *Odontología Sanmarquina*. 2002; 1 (10): 39-40.
6. Tarón-Dunoyer A, Frías-Tarón S, Blanco-Lerech S, Camacho-Vergara A, Bustillo JM, Díaz-Caballero A. Comparación de la dureza superficial de diferentes tipos de materiales restauradores en premolares birradiculares, un estudio *in vitro*. *Av Odontoestomatol*. 2015; 31 (6): 355-361.
7. Carrillo-Sánchez C. Revisión de los principios de preparación de cavidades. Extensión por prevención o prevención de la extensión. *Rev ADM*. 2008; 65 (5): 263-271.
8. Bala O, Arisu HD, Yikilgan I, Arslan S, Gullu A. Evaluation of surface roughness and hardness of different glass ionomer cements. *Eur J Dent*. 2012; 6 (1): 79-86.
9. Fron-Chabouis H, Prot C, Fonteneau C, Nasr K, Chabreron O, Cazier S et al. Efficacy of composite versus ceramic inlays and onlays: study protocol for the CECOIA randomized controlled trial. *Trials*. 2013; 14: 278.
10. Suárez R, Lozano F. Comparison of surface hardness of nanotechnology composites according to polishing time: *in vitro*. *Rev Estomatol Herediana*. 2014; 24 (1): 11-16.
11. Son SA, Roh HM, Hur B, Kwon YH, Park JK. The effect of resin thickness on polymerization characteristics of silorane-based composite resin. *Restor Dent Endod*. 2014; 39 (4): 310-318.
12. Shanthala GS, Xavier MK. The effect of thermocycling on fracture toughness and hardness of different core build up materials. *Indian J Dent Res*. 2013; 24 (6): 653-658.
13. Erazo L, Vinasco FE, Ruan-Antury JD. Comparation of the microhardness vickers of the self-etch adhesive cement relyx unicem and dual cement relyx arc. *Col J Dent Res*. 2010; 1 (3): 68-76.
14. Fukuhara NM, Quintana del Solar M, Aguilar MJ. Comparación *in vitro* del efecto del pulido en la morfología superficial de tres resinas compuestas. *Rev Estomatol Herediana*. 2013; 23 (4): 185-192.
15. Gil-García S, Mosquera-Arenas S, Hoyos-Arias LA, Domínguez-Jiménez T, Arango LM, Gallego CL. Cambios en la resistencia compresiva del ionómero de vidrio al ser grabado con ácido ortofosfórico. *Rev Nal Odont*. 2013; 9 (16): 67-73.

Mailing address:
Arnulfo Tarón Dunoyer
E-mail: atarond@unicartagena.edu.co

www.medigraphic.org.mx