Original Article

Comparison of Flexural Strength between Five Commercial Bulk–Fill Resin Composites

Win Hiriotappa*, Ploypim Kraisintu*, Settapak Somyhokwilas*, Awiruth Klaisiri**, Chaimongkon Peampring***, Niyom Thamronganankul****, Tool Sriamporn*

Abstract

Objective: To compare the flexural strength of five different bulk-fill resin composites.

Material and method: Five different types of bulk-fill resin composite were used in this study (Sonic-Fill, Filtek Bulk-fill Posterior Restorative, Tetric N-Ceram Bulk-Fill, Tetric Flow Bulk-Fill and Surefill SDR). Bulk-fill resin composite specimens were prepared using a stainless steel mold with dimensions, 25x2x2 mm, as specified by the ISO 4049 standard. Each group was composed of 10 specimens, giving a total of 50 specimens. The specimens were light cured and stored in a distilled water bath at 37°C for 24 hours. All specimens were tested with the universal test machine at a crosshead speed of 1 mm/min. The data was analyzed by one-way ANOVA and Tukey's test (α=0.05).

Results: Five commercial bulk-fill resin composites had flexural strength values ranging from 84.3 to 138.9 MPa. The Sonic-Fill group showed significantly higher flexural strength, followed by Filtek-BF-Posterior, Tetric N-Ceram BF, Tetric Flow BF, and Surefill SDR.

Conclusion: According to the obtained results, Sonic-Fill resin composite had the highest flexural strength, followed by Filtek-BF-Posterior, Tetric N-Ceram BF, Tetric Flow BF, and Surefill SDR.

Keywords: Bulk-fill resin composite, Flexural strength

Received: 28 May 2019 Revised: 2 April 2020 Accepted: 7 April 2020

* Department of Prosthodontics, Faculty of Dental Medicine, Rangsit University, Pathumthani, Thailand
** Division of Operative Dentistry, Faculty of Dentistry, Thammasat University, Pathumthani, Thailand
*** Department of Prosthetic Dentistry, Faculty of Dentistry, Prince of Songkla University, Hat Yai, Songkhla, Thailand
**** Department of Prosthodontics, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand
Corresponding author: Asst.Prof.Dr. Tool Sriamporn, Department of Prosthodontics, Faculty of Dental Medicine, Rangsit University, Pathumthani, Thailand. Tel. 0-2997-2200-30 Ext. 4312 E-mail: Tool.s@rsu.ac.th

Introduction

Nowadays, resin composites and tooth-colored restorative materials are widely used. They are high in demand and commonly used for esthetic reasons. There have been many attempts to improve their physical and mechanical properties to accommodate every dentist's needs. Disadvantages of resin composites include time consumption, high shrinkage, voids due to incremental technique, marginal leakage due to their flowable capacity and limitation in depth of cure.[1] Conventional resin composite materials still have these drawbacks. Therefore, a new group of resin composites, bulk-fill resin composites, was invented to solve these problems.

Bulk-fill resin composite is an alternative tooth-colored restorative material to conventional resin composites. Bulk-fill resin composite simplifies clinical steps and reduces the procedure time as it has a curing capacity to a depth of at least 4 mm.[2] Conventional composites use incremental filling technique to manage shrinkage stress.[3] However, void formation may occur between each resin composite layer.[4] It has been proven that bulk-fill resin composites can lower shrinkage stresses, which elevate longevity of the resin composite restoration.[5]

One aspect of promoting restoration durability is prevention of secondary caries. To minimize secondary caries formation, good marginal adaptation is expected. It was shown that bulk-fill resin composites have a comparable restoration longevity to conventional resin composites.[6, 7]

Mechanical properties are always a concern when choosing restorative materials. There are studies showing that bulk-fill resin composites do not have inferior mechanical properties than conventional resin composites.[5, 8-11] On the other hand, there have been some studies showing bulk-fill resin composite had lower mechanical properties than conventional resin composites.[10, 12, 13] Nevertheless, their clinical performances are still acceptable as an alternative tooth-colored restorative material.[1, 14-16]

The present study was conducted to compare the flexural strength of five commercially available bulk-fill resin composites in Thailand. The null hypothesis was that there would be no significant difference in flexural strength among five bulk-fill resin composites.

Materials and Methods

Five bulk-filled resin composites were chosen for this study as shown in Table 1. Ten specimens for each group were prepared (N=50) using a metallic mold with the dimensions specified by the ISO 4049 standard, (25 ± 2) mm x (2 ± 0.1) mm x (2 ± 0.1) mm (Figure 1). A glass slide was placed over the mold, which was filled with resin composite in order to remove excess material and eliminate any voids that might have occurred. The specimens were light cured for 40 sec per surface using a LED light-curing unit (DEMI PLUS, Kerr, WI, USA) with 1,100 mW/cm^2 intensity according to the manufacturer of the test material. The excess materials were removed with scalpel blade and abrasive paper. All samples were stored in a distilled water bath at 37°C for 24 hours. Three-point bending test was performed using a universal test machine (EZ-S 500N, Shimadzu Corporation, Kyoto, Japan) using the flexural strength testing apparatus with a crosshead speed of 1 mm/min, and loading rate of 50 N/min (Figure 2). Load was exerted on the specimen until the specimen reached its yield point or at the point of fracture. The flexural strength (σ) was calculated in Mega Pascals (MPa), using the formula below.

$$\sigma = \frac{3FL}{(2bd^2)}$$

where F: the maximum load (Newton),

L: the distance (millimeter) between supports,

b: the width (millimeter) of specimen,

d: the thickness (millimeter) of the specimen.

Data was analyzed using statistical software (IBM® SPSS® 20, SPSS, Chicago, IL, USA). Parametric statistical test was used with assumptions of normal distribution and homogeneity of variance within each group. One-way ANOVA and Tukey's post hoc multiple comparison test were used to statistically analyze the mean of flexural strength data ($P \leq 0.05$).

Result

The means and standard deviations of flexural strength are demonstrated in Table 2. One-way ANOVA showed a significant difference in flexural strength values between different groups. The results of this study demonstrated that five commercially bulk-filled resin composites provided flexural strengths ranging between 84.3 to 138.9 MPa.

Sonic-Fill group demonstrated significantly higher flexural strength compared to the other groups. There was no significant difference between Filtek-BF-posterior and Tetric N-Ceram BF dental composites ($P>0.05$) in terms of flexural strength. Tetric Flow BF and Surefill SDR flowable groups demonstrated significantly lower flexural strength to all other groups. There was no significant difference between Tetric Flow BF and Surefill SDR flowable dental composites ($P>0.05$).

Discussion

Compressive and flexural strength are important factors to be considered when selecting composite resin materials for clinical use as the tooth, and restorations are always subjected to both flexural and compressive forces during the mastication.[17] As flexural strength reflects resistance to compressive and tension stresses that act in the material simultaneously, the evaluation of this property is important for resin polymerized based materials. In this study, the specimens were polymerized by light in a metal mold. The specimens were tested using the three-point bending test, in accordance with ISO 4049. It has been widely used for mechanical evaluation, especially in flexural strength, due to ease of the specimen preparation and testing. However, the major drawback of this method is that it is only performed on brittle materials and fiber-polymer composites, rarely on ductile materials such as metals.[18]

Mechanical challenge in posterior restorations for direct restorative resin composites has been considered. Filler technology has been improving, providing large variety of sizes, shapes, and constitution of filler particles, leading to the plethora of currently available options.[19] Recently, a new material has been introduced as bulk-fill resin composites. The purposes of inventing this type of resin material are to decrease the time strain of incremental filling and decrease risk of potential errors such as voids and contamination.[20] The bulk-fill resin composites are claimed to allow light-cure in depth of 4 to 5 mm in one step while generating similar shrinkage stresses to those conventional resin composite materials. Different manufacturers have used different mechanisms to achieve deeper polymerization, such as adding more efficient photo-initiators and reducing stress. In fact, using similar refractive index of fillers and monomers with reducing filler content was considered in approach to allow a greater depth of polymerization. However, lower filler content may result in lower mechanical properties, and a decrease in strength properties of the materials. The advantages of bulk-fill resin composites are adaptation to the cavity wall, reduced shrinkage stress, and particularly its suitability for patients with limited compliance.[21] For conventional composites, in order to achieve adequate polymerization, the resin composite increments should not be thicker than 2 mm.[22] In this study, the specimens were light cured from all directions, allowing overlap, which definitely allowed adequate polymerization.

Many studies have evaluated the mechanical properties of bulk-fill resin composite, most often the flexural strength testing has been investigated using the three-point bending test according to ISO 4049.[13, 23-26] In the present study, the flexural strength of bulk-fill resin composite was found to be between 84.34 to138.92 MPa, which higher than the minimum standard value required by ISO4049 (80 MPa). Thus, all of bulk-fill materials in this study can be used suitably in oral cavity as an alternative posterior filling material.

As a result, one-way ANOVA showed significant difference in flexural strength values between different groups. Therefore, the hypothesis of this study was rejected. Sonic-Fill composite contains higher filler content (~83.5%), and demonstrated significantly higher flexural strength compared to the other groups. The result of this study is similar to previous studies that compared the flexural strength of bulk-fill resin composite.[13, 27] The flexural strengths of Filtek-BF-Posterior and Tetric N-Ceram BF, high viscosity bulk-fill resin composites, are relatively similar which may be due to the similarity of percentage of inorganic filler contents of the two materials (~76.5% and ~80.0%wt, respectively). On the other hand, Tetric Flow BF and Surefill SDR groups, which are low viscosity bulk-fill resin composites, demonstrated the lowest flexural strength value due to a lower filler load percentage compared to the other groups (~68-69 wt%).

The results of this study were in agreement with a previous study. The flexural strength of the three brands of low viscosity bulk-fill resin composite (Beautifil Bulk Flow, SDR, and Filtek Bulk Flow), which contains approximately 64.5 - 72.5 wt% filler load content, were significantly lower than that of the high viscosity bulk-fill resin composite group with higher filler load content (76.5-80.0 wt%).[28]

Kim et al.[29] reported that high percent filler loading influenced the mechanical properties of resin composite, with the highest filler content demonstrating the highest flexural strength, flexural modulus, and microhardness.

Leprince et al.[13] reported that the percent filler mass fraction of commercial bulk-fill resin composites range between 60.7 to 85.3, this is in positive correlation with mechanical properties. They also stated that the mechanical properties of the conventional high viscosity resin composite were mostly higher than the bulk-fill resin composite. Thus, placement of bulk-fill composite materials under high occlusal loading should be carefully considered.

Previous studies reported that the degree of filler loading only slightly affected the mechanical behavior of composite resin materials. Therefore, it cannot be concluded that filler loading alone affected the outcome of this study. Several other factors that may also contribute to the results include the use of different resin matrixes, different types of fillers, or filler size and their distribution. Normally, both conventional microhybrid and nanohybrid composites have superior mechanical properties when compared to bulk fill composite. Therefore, previous studies recommended veneering bulk fill material with conventional composite.[30]

Conflicts of interest

The authors declare no conflict of interest.

Acknowledgements

This work was supported by the Reseach of Rangsit University, Thailand (project no.45/2562). Tanapon Tarateeraseth and Lilliy See are thanked for the proofreading. Lastly, Anisorn Temudom, Bunnasorn Chinkulkitnivat, Phatpanadda Satnurak, Puvanon Manjitjantra, Supattra Laopatarakasem were thanked for the hard work and contributed time together for this work.

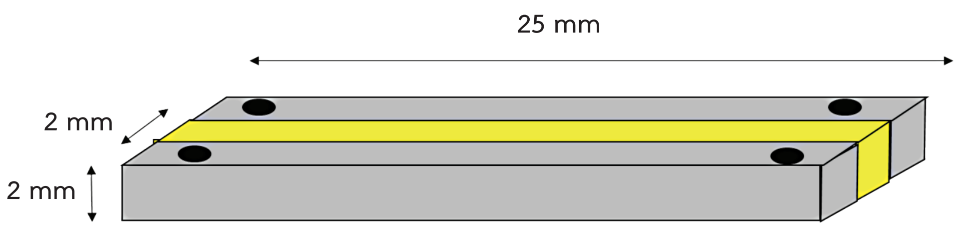

Figure 1 The schematic diagram of the metal mold used in this study.

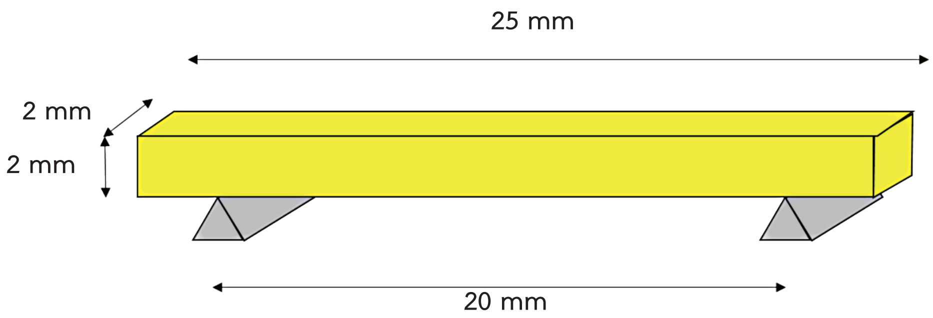

Figure 2 The schematic diagram of the three-point bending test.

Table 1 shows type of bulk-fill resin composite, lot number, manufacturer and compositions.

Bulk-fill resin composites (Color)	Abbreviation	Manufacturer	Resin Matrix	Filler	Lot no.
Sonic Fill 2 (A1)	Sonic-Fill	Kerr, Orange, CA, USA	Bis-EMA, Bis-GMA, poly (oxy-1,2-ethanediyl), a, a'- [(1-methylethylidene) ßdi-4, 1-phenylene]bis [x-[(2-methyl-1-oxo-2-propen-1-yl)oxy]- 2,20-ethylenedioxydiethyl dimethacrylate, TEGDMA	Barium glass filler, Silica glass filler	6527299
Filtek™ Bulk-fill Posterior Restorative (A1)	Filtek-BF-Posterior	3M ESPE, St Paul, MN USA	Aromatic UDMA, UDMA, 1,12-dodecanedimethacrylate	non-agglomerated/ non-aggregated silica filler, non-agglomerated/ non-aggregated filler, aggregated zirconia/silica cluster filler, ytterbium trifluoride filler	N948473
Tetric® N-Ceram Bulk-Fill (IVA)	Tetric N-Ceram BF	Ivoclar Vivadent	Bis-EMA, Bis-GMA, UDMA	Silanated barium glass filler	Y02738
Tetric® N-Flow Bulk-Fill (IVA)	Tetric Flow BF	Ivoclar Vivadent	Bis-EMA, Bis-GMA, UDMA	Silanated barium glass filler	X43433
Surefill SDR Flow	Surefill SDR	DENTSPLY Caulk	Modified UDMA, Bis-EMA, TEGDMA	Barium-alumino -fluoro-silicate glass, Strontium alumino-fluoro-silicate glass	1706000617

Abbreviations: Bis-GMA: bisphenol-A-glycidyl dimethacrylate, UDMA: urethane dimethacrylate, Bis-MPEPP: Bisphenol A polyethoxy methacrylate, Bis-EMA: ethoxylated bisphenol-A-dimethacrylate, TEGDMA: triethyleneglycol dimethacrylate,

Table 2 Mean and standard deviation of flexural strength value of each Bulk-Fill resin composite.

Brands	Mean ± SD (MPa)
Sonic-Fill	138.9 ± 4.3^{A}
Filtek-BF-Posterior	118.3 ± 5.5^{B}
Tetric N-Ceram BF	114.6 ± 4.3^{B}
Tetric Flow BF	86.0 ± 6.5^{C}
Surefill SDR	84.3 ± 6.2^{C}

The same superscript letter indicates no significant difference between groups (P>0.05).

References

1. Chesterman J, Jowett A, Gallacher A, Nixon P. Bulk-fill resin-based composite restorative materials: a review. Br Dent J 2017;222(5):337-44.
2. Do T, Church B, Verissimo C, Hackmyer SP, Tantbirojn D, Simon JF, et al. Cuspal flexure, depth-of-cure, and bond integrity of bulk-fill composites. Pediatr Dent 2014;36(7):468-73.
3. Ferracane JL. Resin composite--state of the art. Dent Mater 2011;27(1):29-38.
4. Kwon Y, Ferracane J, Lee IB. Effect of layering methods, composite type, and flowable liner on the polymerization shrinkage stress of light cured composites. Dent Mater 2012;28(7):801-9.
5. Rosatto CM, Bicalho AA, Verissimo C, Braganca GF, Rodrigues MP, Tantbirojn D, et al. Mechanical properties, shrinkage stress, cuspal strain and fracture resistance of molars restored with bulk-fill composites and incremental filling technique. J Dent 2015;43(12):1519-28.
6. Bayraktar Y, Ercan E, Hamidi MM, Colak H. One-year clinical evaluation of different types of bulk-fill composites. J Investig Clin Dent 2017;8(2):1-9.
7. van Dijken JW, Pallesen U. Randomized 3-year clinical evaluation of Class I and II posterior resin restorations placed with a bulk-fill resin composite and a one-step self-etching adhesive. J Adhes Dent 2015;17(1):81-8.
8. Mandava J, Vegesna DP, Ravi R, Boddeda MR, Uppalapati LV, Ghazanfaruddin MD. Microtensile bond strength of bulk-fill restorative composites to dentin. J Clin Exp Dent 2017;9(8):1023-8.
9. Isufi A, Plotino G, Grande NM, Ioppolo P, Testarelli L, Bedini R, et al. Fracture resistance of endodontically treated teeth restored with a bulkfill flowable material and a resin composite. Ann Stomatol (Roma) 2016;7(1-2):4-10.
10. Sousa-Lima RX, Silva L, Chaves L, Geraldeli S, Alonso R, Borges B. Extensive Assessment of the Physical, Mechanical, and Adhesion Behavior of a Low-viscosity Bulk Fill Composite and a Traditional Resin Composite in Tooth Cavities. Oper Dent 2017;42(5):159-66.
11. Engelhardt F, Hahnel S, Preis V, Rosentritt M. Comparison of flowable bulk-fill and flowable resin-based composites: an in vitro analysis. Clin Oral Investig 2016;20(8):2123-30.

12. Meenakumari C, Bhat KM, Bansal R, Singh N. Evaluation of Mechanical Properties of Newer Nanoposterior Restorative Resin Composites: An In vitro Study. Contemp Clin Dent 2018;9:142-6.
13. Leprince JG, Palin WM, Vanacker J, Sabbagh J, Devaux J, Leloup G. Physico-mechanical characteristics of commercially available bulk-fill composites. J Dent 2014;42(8):993-1000.
14. Veloso SRM, Lemos CAA, de Moraes SLD, do Egito Vasconcelos BC, Pellizzer EP, de Melo Monteiro GQ. Clinical performance of bulk-fill and conventional resin composite restorations in posterior teeth: a systematic review and meta-analysis. Clin Oral Investig 2019;23(1):221-33.
15. Fugolin APP, Pfeifer CS. New Resins for Dental Composites. J Dent Res 2017;96(10):1085-91.
16. van Dijken JWV, Pallesen U. Bulk-filled posterior resin restorations based on stress-decreasing resin technology: a randomized, controlled 6-year evaluation. Eur J Oral Sci 2017;125(4):303-9.
17. Brosh T, Ganor Y, Belov I, Pilo R. Analysis of strength properties of light-cured resin composites. Dent Mater 1999;15(3):174-9.
18. Yap AU. Effectiveness of polymerization in composite restoratives claiming bulk placement: impact of cavity depth and exposure time. Oper Dent 2000;25(2):113-20.
19. Sabbagh J, Ryelandt L, Bacherius L, Biebuyck JJ, Vreven J, Lambrechts P, et al. Characterization of the inorganic fraction of resin composites. J Oral Rehabil 2004;31(11):1090-101.
20. Opdam NJ, Roeters JJ, Joosten M, Veeke O. Porosities and voids in Class I restorations placed by six operators using a packable or syringable composite. Dent Mater 2002;18(1):58-63.
21. Kim RJ, Kim YJ, Choi NS, Lee IB. Polymerization shrinkage, modulus, and shrinkage stress related to tooth-restoration interfacial debonding in bulk-fill composites. J Dent 2015;43(4):430-9.
22. Yap AU, Teoh SH. Comparison of flexural properties of composite restoratives using the ISO and mini-flexural tests. J Oral Rehabil 2003;30(2):171-7.
23. Goracci C, Cadenaro M, Fontanive L, Giangrosso G, Juloski J, Vichi A, et al. Polymerization efficiency and flexural strength of low-stress restorative composites. Dent Mater 2014;30(6):688-94.
24. Garoushi S, Sailynoja E, Vallittu PK, Lassila L. Physical properties and depth of cure of a new short fiber reinforced composite. Dent Mater 2013;29(8):835-41.
25. Ilie N, Bauer H, Draenert M, Hickel R. Resin-based composite light-cured properties assessed by laboratory standards and simulated clinical conditions. Oper Dent 2013;38(2):159-67.
26. Czasch P, Ilie N. In vitro comparison of mechanical properties and degree of cure of bulk fill composites. Clin Oral Investig 2013;17(1):227-35.
27. Ilie N, Bucuta S, Draenert M. Bulk-fill resin-based composites: an in vitro assessment of their mechanical performance. Oper Dent 2013;38(6):618-25.
28. Tsujimoto A, Barkmeier WW, Takamizawa T, Latta MA, Miyazaki M. Depth of cure, flexural properties and volumetric shrinkage of low and high viscosity bulk-fill giomers and resin composites. Dent Mater J 2017;36(2): 205-13.
29. Kim KH, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002;87(6):642-9.
30. Abuelenain D, Abou Neel E, Aldharrab A. Surface characterization and mechanical behavior of bulk fill versus incremental dental composites. Tanta Dental Journal 2017;14:56-61.

บทคัดย่อ

การเปรียบเทียบความทนแรงดัดระหว่างเรซินคอมโพสิตชนิดบัลค์ฟิลล์ห้าผลิตภัณฑ์

วิน หิริโอตัปปะ*, พลอยพิมพ์ ไกรสินธุ์*, เศรษฐภัค โสมหยกวิลาศ*, อวิรุทธ์ คล้ายศิริ, ชัยมงคล เปี่ยมพริ้ง***, นิยม ธำรงค์อนันต์สกุล****, ตุลย์ ศรีอัมพร***

* ภาควิชาทันตกรรมประดิษฐ์ วิทยาลัยทันตแพทยศาสตร์ มหาวิทยาลัยรังสิต

** สาขาวิชาทันตกรรมหัตถการ คณะทันตแพทยศาสตร์ มหาวิทยาลัยธรรมศาสตร์

*** ภาควิชาทันตกรรมประดิษฐ์ คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

**** ภาควิชาทันตกรรมประดิษฐ์ คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ผู้ให้ติดต่อ: ผศ.ทพ.ดร.ตุลย์ ศรีอัมพร ภาควิชาทันตกรรมประดิษฐ์ วิทยาลัยทันตแพทยศาสตร์ มหาวิทยาลัยรังสิต โทร. 0-2997-2200-30 ต่อ 4312 อีเมล: Tool.s@rsu.ac.th

วัตถุประสงค์: เพื่อศึกษาเปรียบเทียบค่าความทนแรงดัดของเรซินคอมโพสิตชนิดบัลค์ฟิลล์ห้าผลิตภัณฑ์

วัสดุและวิธีการ: เตรียมชิ้นทดสอบจำนวน 50 ชิ้น จากบัลค์ฟิลล์เรซินคอมโพสิต 5 ผลิตภัณฑ์ คือ Sonic-Fill, Filtek Bulk-fill Posterior Restorative, Tetric N-Ceram Bulk-Fill, Tetric Flow Bulk-Fill และ Surefill SDR ขนาด 25x2x2 ลูกบาศก์มิลลิเมตร กลุ่มละ 10 ชิ้น จากนั้นนำชิ้นทดสอบไปแช่ในน้ำกลั่น ณ อุณหภูมิ 37 องศาเซลเซียส เป็นเวลา 24 ชั่วโมง ตาม ISO 4049 แล้วนำไปทดสอบค่าความทนแรงดัด ด้วยเครื่องทดสอบสากลที่ความเร็วหัวกด 1 มิลลิเมตรต่อนาที และวิเคราะห์ข้อมูลทางสถิติด้วยการวิเคราะห์ความแปรปรวนทางเดียวและเปรียบเทียบความแตกต่างระหว่างกลุ่มด้วยสถิติชนิดทูกีย์ที่ระดับความเชื่อมั่นร้อยละ 95

ผลการศึกษา: ค่าความทนแรงดัดของวัสดุแต่ละชนิดมีค่าเฉลี่ยที่แตกต่างกันอย่างมีนัยยะสำคัญทางสถิติโดยทั้ง 5 ผลิตภัณฑ์มีค่าเฉลี่ยอยู่ระหว่าง 84.3 – 138.9 MPa ค่าความทนแรงดัดของกลุ่ม Sonic-Fill สูงที่สุด ตามด้วยกลุ่มของ Filtek Bulk-fill Posterior Restorative, Tetric N-Ceram Bulk-Fill, Tetric Flow Bulk-Fill และ Surefill SDR ตามลำดับ

สรุป: ค่าความทนแรงดัดของกลุ่ม Sonic-Fill สูงที่สุด ตามด้วยกลุ่มของ Filtek Bulk-fill Posterior Restorative, Tetric N-Ceram Bulk-Fill, Tetric Flow Bulk-Fill และ Surefill SDR ตามลำดับ

คำสำคัญ: เรซินคอมโพสิตชนิดบัลค์ฟิลล์, ความทนต่อแรงดัดของวัสดุ