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Evaluation Of Compressive Strength Among Different Types Of Composite Resin: An in Vitro Study

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ABSTRACT

Background and Objectives: Wearing of composite is a major challenge in resin-based restoration, the aim of this study was to evaluate the compressive strength of different types of composite resin based on their filler content.

Material and Methods: Forty specimens of resin composite have been used in a cylindrical shape with height of four millimeter and a diameter of five millimeter. The 40 specimens were divided into two main groups according to the type of composite brand, each group consisted of 20 specimens, with further subdivision into two subgroups according to the filler content of composite. Group A: Charisma, Group B: Bisico. In Subgroups A1 and A2: Micro and Nano Charisma were used. In Subgroups B1 and B2 Micro and Nano of Bisico were used. A universal testing machine was used to determine the compressive strength of each specimen. Statistical analysis was performed using SPSS to compare between the groups.

Results: There was a significant difference between B1 (Microfiller Bisico Composite) and B2 (Nanofiller Bisico Composite), B1 had higher compressive strength. While there was no significant difference between A1 (Microfiller Charisma composite) and A2 (Microfiller Charisma composite)

Conclusion: Within the limitation of this study, it was found (A1) Microfiller Charisma composite, (B1) Microfiller Bisico composite, and (A2) Nanofiller Charisma composite, has the highest compressive strength resistance, so they can withstand greater compressive stress and are recommended for use in posterior teeth.

Keywords: Compressive strength, universal testing machine, composite resin, filler particle, micro composite, laboratory research, in vitro study

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INTRODUCTION

The ultimate aim of any dental restorative procedure is to replace the functional and aesthetic qualities of the remaining tooth structure. Amalgam and gold, which were previously employed in these procedures, have been supplanted by dental resin composites, particularly valued for their conservative tooth preparation, especially in restoring posterior teeth.[1]

Resin composites are now used in more than half of posterior restorations. Regretfully, there is still much space for improvement due to the necessity of these mechanical property restorations, particularly when it comes to their differences in thermal expansion, polymerization shrinkage, and polymerization stresses in addition to wear resistance, marginal leakage, and toxicity.[2]

Comparing the compressive strength of newer posterior composites through an in-vitro study is crucial for assessing their suitability for dental restorations. This research can provide valuable insights into the material's performance and help inform clinical decisions and advancements in restorative dentistry. The outcome can contribute to selecting the most appropriate composite materials for specific clinical applications.[1]

The qualities of dental restorative materials present a number of difficulties, and finding the perfect material for restoration is still a work in progress. The following criteria should be met by the perfect restorative material: (a) mechanical properties; (b) application; (c) biocompatibility; and (d) aesthetics. However, a thorough understanding of how current dental materials react to static and dynamic loadings is necessary for the development and application of future restorative dental materials.[3]

When selecting a core material, strength is a crucial factor to consider. The material should possess adequate tensile and compressive strength (CS) to withstand forces exerted by mastication in several directions. Better resistance and a more even distribution of stress will result from this, with lower rates of tensile or compressive failure.[4]

Composite resins have become an integral component of modern restorative dentistry, offering both esthetic and functional benefits. Their mechanical properties, including compressive strength, play a pivotal role in determining their suitability for various clinical applications. The continuous development of composite resin materials has resulted in a wide array of options available to dental practitioners. However, a comprehensive understanding of how different types of composite resins perform in terms of compressive strength is essential for making informed clinical decisions.[4]

Composite resins are becoming more popular for dental restoration due to its advantageous characteristics such as low cost, conservative approach, acceptable esthetics, and low thermal conductivity.[1]

Composite resins' physical and mechanical properties have significantly improved in recent years, yet they still have major drawbacks. Polymerization shrinkage is a typical issue in light-cure composite resins.[5]

Mastication exposes composite restorations to repetitive mechanical stresses and chemical impacts. Wear occurs when forces greater than the mechanical strength of the composite is applied. Occlusal wear causes composite restorations to lose their anatomical form. As a result, the wear resistance of a composite resin is critical for the long-term success of restorations. As a result, wear resistance similar to natural teeth is a critical need for dental restorative material.[6]

Wear resistance and strength of composite are important features of posterior restorations. Composite resin has many types based on filler particle size, composition and physical properties. Several types of composites were introduced over the years to overcome the problems of composite resin and to determine which type is better than others by measuring different properties. In order to evaluate and compare different composite resins, compressive strength test is applied.[7]

Dental resin composites are primarily categorized based on the average size of inorganic filler content. The market was introduced to nano composites due to their purportedly good mechanical capabilities, low polymerization shrinkage, strong wear resistance, great polishability, and excellent optical qualities. Isolated nanoparticles and milled glass fillers make up the majority of the nano-hybrid kinds. In contrast to other composite types, nano-filled composites have discrete nano-filler particles and agglomerated particles, called "nanoclusters" which provide reinforcement mechanisms that increase their strength. Other approaches to classifying composite resins suggested because of variations in mechanical characteristics within each group resulting from compositional changes. Despite the organic matrix's demonstrated direct influence on their mechanical performance, its mechanical behavior was disregarded.[2]

None of the composite materials have the capability to achieve both the functional demands for posterior class one and class two restorations and the elevated aesthetic requirements for anterior teeth restoration. The introduction of nanotechnology in material science has paved the way for nano-composites, which effectively meet these dual criteria. Nano-composites show improved mechanical properties, including improved compressive strength, resistance to fractures, diametrical tensile strength, wear resistance, reduced polymerization shrinkage, high translucency, superior polish retention, and enhanced aesthetics. Manufacturers assert that these materials excel in providing both aesthetic appeal and robust mechanical properties while also being compatible with oral tissues and offering long-lasting restoration outcome. Therefore, comprehensive testing across all parameters is critical.[1, 8]

Using a universal testing machine (UTM) to evaluate the compressive strength of different composite resins is a well-established and reliable method in materials testing. The UTM provides controlled and precise compression forces to assess the mechanical properties of materials.[9]

The use of a Universal testing machine (UTM) in the present study guarantees a rigorous and systematic approach to evaluate the mechanical properties of these composite resins. This methodology ensures that the obtained data is reliable and directly comparable, enabling a thorough and objective evaluation of their compressive strength characteristics.

This in-vitro study aims to systematically evaluate and compare the compressive strength of various types of composite resins currently available in the dental market. The results of this research will help clinicians and researchers gain insights into the material properties of these composites, facilitating their selection for specific clinical scenarios. Additionally, it will contribute to the ongoing pursuit of enhancing dental materials to meet the ever-evolving demands of restorative dentistry.

METHODS

This study evaluated the compressive strength of micro-filler and nano-filler composite resins. Cylindrical plastic molds (4 mm height × 5 mm diameter) were used as mounting molds. Polysiloxane impression material (Durosil Putty, Germany) was mixed according to the manufacturer's instructions and placed into the molds. Within the working time (1 min 15 sec), all specimens were positioned vertically at the center of the material. The molds were then left undisturbed until the material had set (Figure 3).

Composites of two different manufacturers (Bisico and charisma) (Figure 2) chosen, nano-hybrid composite resin and micro-hybrid composites used for comparing compressive strength of each one of them, samples were prepared in cylindrical shape with diameters of five millimeters and height of four millimeters.

Composite resins were placed in silicone molds with incremental technique using two layers of composite, placed by composite manipulation instruments, each layer of composite light cured with soft start curing mode by placing glass slab of 2 millimeters thickness to standardize the distance between the light cure and the composite resin for all samples. 10 specimens assigned for each group (Figure 1) After the procedure, all samples were kept in distilled water for 24 hours in dark room with elimination of any light to affect the specimens until the next day prior to the experiment. For compression strength testing of the samples, the upper grip and lower grip of the universal testing machine were checked and adjusted before each run. Specimens were then tested one by one at a standardized crosshead rate of 2 mm/min, in accordance with ISO 4049 specifications for polymer based restorative materials. The testing process involved subjecting specimens to compressive loads until they reach their breaking point (Figure 4). The maximum force endured by each specimen is recorded, enabling the determination of compressive strength.

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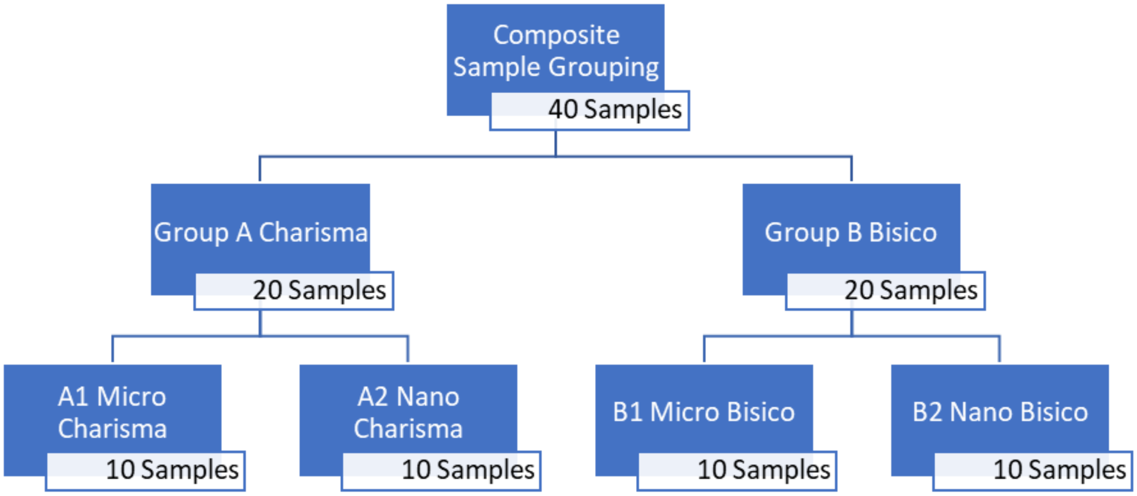

Figure 1. Diagram of sample grouping

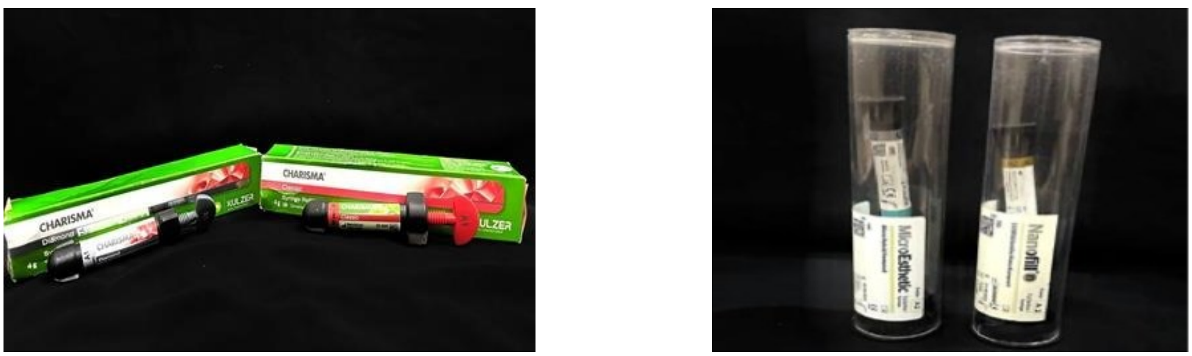

Figure 2. Composite resin material “CHARISMA” and composite resin material “BISICO

Figure 3. Prepared samples

Figure 4. Universal testing machine, compressive strength test

RESULTS
Data obtained from the compressive strength test for four different groups of composite resin underwent a one-way ANOVA statistical test and post Hoc test (multiple comparison) (Table 1&2). The maximum load applied to each sample was evaluated in Newtons. When the comparison was done between groups, significant differences found among them.

Group A1 (Micro composite Charisma) and A2 (Nano composite Charisma) showed no significant difference (0.242). Also there was no significant difference between group B1 (Micro composite Bisco) and A2 (Nano composite Charisma) (0.318), while there were significant differences among other groups. The significance level between B2 (Nano composite of Bisico) with A1 (Micro composite of Charisma) was (0.007), with B1 (Micro composite Bisco) was (0.000) and with A2 (Nano composite Charisma) was (0.000). Then A1 micro-Charisma compared with B1 micro Bisco, there was also significant difference between them (0.038). When (A1) Micro filled Charisma composite compared with (A2) Nano filled Charisma composite, no significant difference found (0.242) between them even though their filler particles are different. While when (B1) Micro filled Bisico composite compared with (B2) Nano filled Bisico composite, there was significant difference that micro filled bisico composite has higher compressive strength than nano filled bisico composite (0.000). When A1 micro charisma compared with B1 micro Bisico composite resin, the results showed that that micro Bisico composite resin was better than micro charisma (Table 2). Lastly when A2 nano charisma compared with B2 nano Bisico composite resin the results found that nano charisma had better compressive strength.

Table 1. Comparison of compressive strength value of nano composite group and micro composite group by using ANOVA test

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
max load(N)	Between Groups	16554363.102	3	5518121.034	9.519	0.000
	Within Groups	21448413.006	37	579686.838		
	Total	38002776.108	40			

Table 2. Comparison of compressive strength value of nano composite group and micro composite group by using Multiple Comparisons

Multiple Comparisons							
LSD						95% Confidence Interval	
Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
max load(N)	nano B	micro C	-977.88400	340.49577	0.007	-1667.7940	-287.9740
		micro B	-1709.86300	340.49577	0.000	-2399.7730	-1019.953
		nano C	-1373.44836	332.66723	0.000	-2047.4962	-699.4005
	micro C	nano B	977.88400	340.49577	0.007	287.9740	1667.7940
		micro B	-731.97900	340.49577	0.038	-1421.8890	-42.0690
		nano C	-395.56436	332.66723	0.242	-1069.6122	278.4835
	micro B	nano B	1709.86300	340.49577	0.000	1019.953	2399.7730
		micro C	731.97900	340.49577	0.038	42.0690	1421.8890
		nano C	336.41464	332.66723	0.318	-337.6332	1010.4625
	nano C	nano B	1373.44836	332.66723	0.000	699.4005	2047.4962
		micro C	395.56436	332.66723	0.242	-278.4835	1069.6122
		micro V	-336.41464	332.66723	0.318	-1010.4625	337.6332

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DISCUSSION

In terms of mastication and resistance against parafunctional stresses, the mechanical characteristics of restorative materials are significant predictors of success. Various factors influence the mechanical characteristics and clinical efficacy of restorative materials.[10]

The incorporation of fillers into dental restorative composites is a crucial step in improving their mechanical, tribological, and physical characteristics. It has been demonstrated that adding fillers in different forms, sizes, and weight percentages greatly increases the material's strength, resilience to wear, and longevity. The filler particles' treatment with silane, a substance that improves adhesion between the fillers and the resin matrix, is a crucial step in this reinforcing procedure. This stronger bonding creates a more cohesive structure and improves the composite's overall mechanical qualities. International standards are necessary to provide a framework for evaluating these materials' performance and guaranteeing quality in therapeutic applications, as well as consistency and reliability. In the end, filler technology improvements lead to last longer and more effective dental restorations, which is advantageous for both dentists and patients.[11]

Since most masticatory forces are compressive by nature, compressive strength plays a crucial part in the mastication process. The original cross-sectional area of the test specimen and the highest force applied are used to compute the maximum resistance to compression.[12]

In terms of mastication and resistance against parafunctional stresses, the mechanical characteristics of restorative materials are significant predictors of success. Various factors influence the mechanical characteristics and clinical efficacy of restorative materials.[10]

The compressive strength values of naturally mineralized tissues may serve as the basis for a therapeutically meaningful compressive strength value. It has been determined that enamel has a compressive strength of 384 MPa. However, compared to other teeth, which typically have lower fracture strengths, natural teeth have a fracture strength of about 305 MPa. The latter figure might provide a useful mechanical benchmark to choose the ideal strength of composite resins for posterior teeth.[12]

The filler system has undergone the most dramatic alterations in recent years in commercial composites. Commercial composites' resin matrix filler particle sizes have been steadily getting smaller, leading to nanofilled and nanohybrid materials with better material properties.[13]

Nanohybrid composites are hybrid resin composites made up of discrete nanoparticles or nanofillers in pre-polymerized filler form as well as finely milled glass fillers. The fact that some composites with nanofillers added to traditionally filled hybrid type composites have been classed as nanohybrid composite resins may explain why the performance of nanohybrid composite material is dependent on.[14]

Because teeth and restorations are constantly subjected to compressive forces during chewing, compression is a crucial factor to take into consideration when choosing composite resin materials for clinical purpose. Additionally, assessment of its quality is crucial for restorations placed on posterior teeth. The chewing pressures make the compressive strength test extremely crucial and simple to conduct.[15]

The qualities of modern composites can vary greatly depending on the filler size, morphology, volume, distribution, chemical composition, matrix, and photo-polymerization initiator. Silica, quartz, ceramic, and zirconium make up the fillers. Reduced polymerization shrinkage, linear expansion coefficient, and water absorption are associated with higher filler content. On the other hand, the compressive and tensile strength, the elastic modulus, and the wear resistance are often increased with increasing filler content.[16]

The concentration of the filler particles in dental composites affects their mechanical qualities. In a nutshell, the qualities of a composite and its density are exactly proportional to one another. It is generally accepted that mechanical characteristics increase with increasing filler loading.[17]

The findings of this study are consistent with earlier research, which indicates that increasing the volume fraction of filler particles was the main factor in enhancing the compressive strength of dental composites. The current study's findings, however indicate a correlation between compressive strength and filler fraction. The manufacturing brands of nanocomposites are extremely diverse. As the filler quantity and size specified by the manufacturer directly affect the physical and mechanical properties of composite resin materials, the volumetric content of the inorganic particles may be used to explain the study's results.[17, 18]

According to a study done by Kiran KV and his colleagues found, compressive strength of nano-composites is higher than micro hybrids while in this study Micro hybrid of BISICO showed greater performance under compressive strength.[19]

In another study done by John and Hedge in 2022 the results are consistent in term of the micro hybrid composite resin has a comparable compressive strength with nano hybrid composite resins allows it to be used under posterior restorations.[1]

There is still a discrepancy between the experimental and theoretical data for the compressive strength of photocurable composite resin, which is expected to be 246–448 MPa, and the compressive strength of self-curing titanium composite resin, which is expected to be 212–280 MPa. As a result, the material should be tested longitudinally through controlled clinical trials. After placing the composite resin in distilled water at various temperatures, Chadwick et al. carried out thermal cycling. They discovered that the compressive strengths of various composite resins varied in response to temperature changes. The compressive performance of composite resin materials is typically between 240 and 320 MPa.[18, 22]

A comparable experiment was also carried out by Carreiro et al. The compressive strengths of various composite resin materials were tested after being submerged in distilled water for 180 days. They discovered that there was little variation in the composite material's compressive performance. The composition of the resin and filler volume may have an impact on the compressive strength differences observed amongst various composite material types.[21, 22]

There are several different nano-composites available on the market. To achieve the right material, the best strength and the lowest postoperative sensitivity frequently confounds the clinician. This study compares the compressive strength of four distinct kinds of commercially available composite materials.

In this study when we compared Charisma composite of two different filler content (Micro and Nano) the results were similar, they had similar physical performance under compression while the Bisico composites (nano and micro) micro filled composite showed a better physical performance under compression stress. The findings of this study shows that micro filled composite and nano filled composite can give similar performances under compression stress. This study shows differences between and among the groups, further studies are recommended to support the findings of these results.

CONCLUSION

Within the limitation of this study, we found out that (A1)Microfiller Charisma composite, (B1) Microfiller Bisico composite, and (A2)Nanofiller Charisma composite, has the highest compressive strength resistance, so they can withstand more compressive stress, and it's recommended to be used in the posterior teeth. Further evaluation in vitro studies are recommended with different brands of composite resin with different filler contents. Studies over comparison resin should be continued until the most suitable filling composite material will be achieved physically, mechanically, and chemically.

Author's Contribution: We confirm that the manuscript has been read and approved by all named authors. We also confirm that each author has the same contribution to the paper. We further confirm that the order of authors listed in the manuscript has been approved by all authors.

CONFLICT OF INTEREST

There is no conflict of interest for this paper

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REFERENCES

1. John A, Hegde MN. Comparative evaluation of compressive strength and flexural strength of newer posterior composites: an in-vitro study. International Journal of Clinical Den. 2022; 15(1).
2. El Shahawi A, Elbatanony M. Comparative evaluation of mechanical properties of three resin composite materials with different filler particle sizes. E.D.J. 2020; 66(4): 2715-2720. DOI : 10.21608/edj.2020.36673.1183
3. Khosravani MR. Mechanical behavior of restorative dental composites under various loading conditions. Journal of the Mechanical Behavior of Biomedical Materials. 2019; 93: 151-157. doi.org/10.1016/j.jmbbm.2019.02.009
4. Cho K, Rajan G, Farrar P, Prentice, Prusty BG. Dental resin composites: A review on materials to product realizations. Composites Part B: Engineering J. 2022;230(1). doi.org/10.1016/j.compositesb.2021.109495
5. Abbasi M, Moradi Z, Mirzaei M, Kharazifard MJ, Rezaei S. Polymerization Shrinkage of Five Bulk-Fill Composite Resins in Comparison with a Conventional Composite Resin. J Dent (Tehran). 2018 Nov;15(6):365-374. PMID: 30842797; PMCID: PMC6399456.
6. Asadian F, Zahra S, Zohreh M. Evaluation of Wear Properties

of Four Bulk-Fill Composites: Attrition, Erosion, and Abrasion. BioMed Research International. 2021, Article ID 8649616, 8 pages. https://doi.org/10.115/2021/8649616

7. Arigbede AO, Adeyemi BF, Akinlosotu OF. Relative biocompatibility of micro-hybrid and nano-hybrid light-activated composite resins. J Dent Res Dent Clin Dent Prospects. 2017; 11(1): 1–6. doi: 10.15171/joddd.2017.001
8. Chan KH, Mai Y, Kim H, Tong KC, Ng D, Hsiao JC. Resin Composite Filling. Materials. 2010 Feb;3(2):1228-1243. https://doi.org/10.3390/ma3021228
9. Gonçalves F, Boaro LC, Ferracane JL, Braga RR. A comparative evaluation of polymerization stress data obtained with four different mechanical testing systems. Dent Mater. 2012 Jun;28(6):680-6. doi: 10.1016/j.dental.2012.03.004. Epub 2012 Mar 27. PMID: 22456007.
10. Briant S, Ozcan H, Koruyucu M, Seymen F. Assesment of the compressive strength of the current restorative materials. Pediatric Dental Journal. 2021; 31(1):80-85. DOI: 10.1016/j.pdj.2020.12.007
11. Joshi G, Goyal D, Chaturvedi G, VishrutMah-not, Saini S. Mechanical Properties of Dental Restorative Composite Materials: A Review. In Prashant Singh Rana, Deepak Bhatia & Himanshu Arora (eds.), SCRS Proceedings of International Conference of Undergraduate Students, 2021: 65– 73. Computing & Intelligent Systems, SCRS, India. https://doi.org/10.52458/ 978-81-95502-01-1-7
12. Galvão MR, Rabelo Caldas S, Calabrez-Filho S, Campos ED, Bagnato VG, Souza Rastelli AN, Andrade MF, Dra P, Alessandra N, De S, Rastelli U, Estadual. Compressive Strength of Dental Composite Resins Photo-Activated with Different Light Tips. Laser Physics. 2013; 23. 10.1088/1054 DOI: 10.1088/1054-660X/23/4/045604 [accessed Apr 27 2024].
13. Liu J, Zhang H, Sun H, Liu Y, Liu W, Su B, Li S. The Development of Filler Morphology in Dental Resin Composites: A Review. Materials (Basel). 2021 Sep 27;14(19):5612. doi: 10.3390/ma14195612. PMID: 34640020; PMCID: PMC8509641.
14. Moraes, Rafael & Gonçalves, Luciano & Lancellotti, Ailla & Consani, Simonides & Sobrinho, Lourenço & Sinhoreti, Mário. Nanohybrid Resin Composites: Nanofiller Loaded Materials or Traditional Microhybrid Resins?. Operative Dentistry. 2009 34. 551-7. 10.2341/08-043-L.
15. Yanıkoğlu ND, Sakarya RE. Test methods used in the evaluation of the structure features of the restorative materials: a literature review. Journal of Materials Research and Technology. 2020; 9, (5): 9720-9734. ISSN 2238-7854, https://doi.org/10.1016/j.jmrt.2020.06.049.(https://www.sciencedirect.com/science/article/pii/S2238785420314514)
16. Elfakhri F, Alkahtani R, Li Ch, Khaliq J. Influence of filler characteristics on the performance of dental composites: A comprehensive review. Ceramics International. 2022; 48, (19), Part A: 27280-27294, ISSN 0272-8842, https://doi.org/10.1016/j.ceramint.2022.06.314.(https://www.sciencedirect.com/science/article/pii/S0272884222023495)
17. Bociong K, Szczesio A, Krasowski M and Sokolowski J. The influence of filler amount on selected properties of new experimental resin dental composite. Open Chemistry. 2018; 16(1):905-911. https://doi.org/10.1515/chem-2018-0090
18. Randolph LD, Palin WM, Leloup G, Leprince JG. Filler characteristics of modern dental resin composites and their influence on physico-mechanical properties. Dent Mater. 2016 Dec;32(12):1586-1599. doi: 10.1016/j.dental.2016.09.034. Epub 2016 Oct 6. PMID: 27720423.
19. Kiran KV, Aravind Tatikonda, Kapil Jhajharia, Seema Raina, Himani Lau, Divya Katare, Rose Kanwaljeet Kaur. In Vitro Evaluation of the Compressive Strength of Microhybrid and Nanocomposites. OHDM. 2014; 13 (4).
20. Chadwick, R.G. Thermocycling—The effects upon the compressive strength and abrasion resistance of three composite resins. J. Oral Rehabil. 2010, 21, 533–543.
21. Carreiro, A.D.F.P.; Cruz, C.A.D.S.; Vergani, C.E. Hardness and compressive strength of indirect composite resins: Effects of immersion in distilled water. J. Oral Rehabil. 2010, 31, 1085–1089.
22. Zhang, X.; Zhang, Q.; Meng, X.; Ye, Y.; Feng, D.; Xue, J.; Wang, H.; Huang, H.; Wang, M.; Wang, J. Rheological and Mechanical Properties of Resin-Based Materials Applied in Dental Restorations. Polymers 2021, 13, 2975. https://doi.org/10.3390/polym13172975