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The Effect of Pre-Heating on Fracture Toughness in Three Distinct Composite Resin Systems at Two Different Temperatures: A Protocol for an In-vitro Study

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ABSTRACT

Introduction: Composite resins are considered the pinnacle of esthetic restorations, but they have their own disadvantages, such as polymerization shrinkage, low fracture toughness, and the formation of microcracks, all of which eventually results in failure of the restoration. Fracture toughness is an important factor for failure. Warming the same composites to certain temperatures will show drastic improvements in the above-mentioned flaws, especially the fracture toughness.

Need of the study: Therefore, the objective of this study is to evaluate and compare the fracture toughness of three different types of composite resin systems at two different pre-heating temperatures. The study aims to provide valuable information to clinicians in choosing the most appropriate restorative material for posterior composite restorations, which can ultimately improve the treatment's success rate and reduce the risk of complications such as secondary caries, postoperative sensitivity and ultimately restoration failure.

Objective: In summary, this study will compare and evaluate the fracture toughness of nanohybrid, micro-hybrid, and bulk-fill composite resins pre-heated at 50 degrees Celsius and 60 degrees Celsius.

Methodology: The methodology involves dividing 72 freshly extracted premolars with intact occlusal anatomy and fully developed apical foramina into three main groups based on three different composites and further dividing each group into two sub-groups based on two different pre-heating temperatures, with 12 teeth in each group. Each tooth will then be prepared with a Class-II Mesio-Occlusal-Distal (MOD) cavity and receive pre-heated composite restoration according to its assigned group and sub-group. The prepared samples will be tested for fracture toughness using a universal testing machine.

Keywords: Composite pre-warming, Composite resin, Posterior composite restoration

INTRODUCTION

Dental restorative composites have been frequently used to restore posterior teeth throughout the last decade. The most common reasons for failure in direct posterior composite fillings are occlusal wear and secondary caries. However, it has been documented that fracture is also a common reason for its replacement [1].

Because of the loss of marginal ridges and microfractures induced by applied occlusal stresses, mesio-occluso-distal cavity preparation reduces tooth strength significantly [2,3]. Cusps may be forced apart by occlusally applied stresses, and in teeth with broad Class II cavities, cusps can be fractured due to brittle tooth structural fatigue caused by microcrack propagation under repeated stress [4].

Because composites and dentinal adhesives can strengthen the dental structure by bonding to the tooth, they have made a substantial contribution to the fracture resistance of teeth; Furthermore, the choice of adhesive has a major impact on fracture resistance [5]. Over the last decade, the clinical performance of modern dental composites has greatly improved to give appropriate strength and resistance to endure mastication loads, as well as reduced polymerization shrinkage and greater cure depth. Nonetheless, in stress-bearing posterior restorations, current dental composites' relatively high brittleness and weak fracture toughness remain a difficulty [1].

A healthy tooth distributes stress differently than a tooth that has been restored [2], despite the fact that the filling procedure and cavity size have a substantial influence on composite bond strength during preparation [6,7]. Furthermore, adhesive restorations have the potential to reinforce compromised tooth structure by effectively transmitting and distributing functional stresses throughout the bonding contact [8-10]. Composite polymerization can induce deformation of the surrounding tooth structure, resulting in microcracks that can lead to fracture [11].

One of the most key attributes of dental materials is fracture resistance. It is governed by the material's resistance to internal flaw-induced fracture propagation. These cracks can result in microscopic fractures of the restoration margins or bulk fractures of the filling [12].

When compared to conventional resins, placing resins that have been preheated to a specific temperature indicates a more promising improvement in physical qualities [13].

Since their invention, resin composite has been the apex of direct cosmetic repairs. However, it comes with its own drawbacks. Polymerization shrinkage commonly causes post-operative discomfort and marginal discoloration. Microleakage and inadequate fracture resistance are the leading causes of resin composite restorative failure [12-13].

However, in recent years many studies have been put forward showing improved physical properties of composite resins following a simple pre-heating procedure [13].

Composite resins that have been pre-heated have a lower viscosity and a higher polymerization efficiency. The monomer conversion rate is increased by heating composite resins before introducing them into the cavity and immediately light-curing them. As a result, the irradiation period may be shortened. Enhanced internal adaptation to cavity walls, improved mechanical qualities, and increased wear resistance may result from increasing the degree of polymerization of composite resins [14,17-19].

The novelty of this study lies in evaluating and comparing the effect of pre-heating on the fracture toughness of three distinct composite resin systems (nanohybrid, micro-hybrid, and bulk-fill) at two different temperatures (50 degrees Celsius and 60 degrees Celsius). While pre-heating composite resins has been previously studied, the specific focus on these three distinct types of composites and the comparison of their fracture toughness at different pre-heating temperatures is a unique aspect of this study. The results of this study could provide valuable information for clinicians in choosing the most appropriate restorative material for posterior composite restorations, ultimately improving the success rate of the treatment.

Aim

The aim of this study is to evaluate and compare the effect of pre-heating on the fracture toughness of three different composite resin systems at two different temperatures (50 degrees Celsius and 60 degrees Celsius).

Objectives

1	To evaluate the fracture resistance of teeth restored with pre-heated nanohybrid composite at 50 degrees Celsius.
2	To evaluate the fracture resistance of teeth restored with pre-heated nanohybrid composite at 60 degrees Celsius.
3	To evaluate the fracture resistance of teeth restored with pre-heated microhybrid composite at 50 degrees Celsius.
4	To evaluate the fracture resistance of teeth restored with pre-heated microhybrid composite at 60 degrees Celsius.
5	To evaluate the fracture resistance of teeth restored with pre-heated bulk-fill composite at 50 degrees Celsius.
6	To evaluate the fracture resistance of teeth restored with pre-heated bulk-fill composite at 60 degrees Celsius.
7	To compare the variation in fracture resistance among these three composite systems at 50 degrees Celsius and 60 degrees Celsius.

REVIEW OF LITERATURE

A review of literature was conducted, which included studies by Al-Ibraheemi ZA et al., (2021), Abdulhameed OH et al., (2018), and Moosavi H et al., (2012) [14,18,19]. Al-Ibraheemi ZA et al. investigated the effect of various cavity designs on fracture toughness of composite resin and found that the number of missing walls is inversely proportional to fracture toughness of the composite. Abdulhameed OH et al. investigated the effect of pre-heated bulk-fill composite materials on the fracture resistance of maxillary premolars and found that pre-heating significantly improves the fracture toughness of bulk-fill composite resin. Moosavi H et al. investigated the effect of various placement techniques on the fracture toughness of teeth and found that the insertion technique had a substantial impact on the fracture resistance of premolar teeth.

MATERIALS AND METHODS

The in-vitro study will be conducted at the Department of Conservative Dentistry and Endodontics, Sharad Pawar Dental College and Hospital, Sawangi (M), Wardha, Maharashtra, India from February 2023 to June 2024. Ethical clearance was obtained on 15/02/2022 by the Institutional Ethical Committee (IEC) of Datta Meghe Inhistitute of Medical Sciences, with ethical approval number DMIMS(DU)/ IEC/2022/766. The study will include 72 freshly extracted premolars for orthodontic purposes with complete mature apical foramina.

Inclusion criteria:

- Freshly extracted premolars
- Teeth without fracture
- Teeth without cracks
- Teeth without any previous restoration

Exclusion criteria:

- Carious teeth
- Previously restored teeth
- Teeth with fractures and cracks

PREPARATION OF SAMPLE

Class-II MOD cavities will be prepared on all specimens, with a 2+-0.2mm axial height, 1.5+-0.2 mm gingival width, parallel proximal walls with 3+-0.2 mm buccolingual width, 2+-0.2mm pulpal depth, and occlusal isthmus width one-third of the intercuspal distance. A single operator will restore all the cavities, and four teeth will be cut with a single bur. A single periodontal probe will be used as a guide for improved harmony among all cavities, and no bevels will be performed except for the axiopulpal line angles. A sample size of 12 samples per group will be considered, with a total of 72 teeth. The tooth will be etched with an acid etchant (37% phosphoric acid, Prime Dental, India) for 15 seconds, followed by a water rinse and gentle air drying. Bonding agent (3M ESPE Single Bond Universal Adhesive, USA) will be applied using an applicator tip and light cured for 20 seconds.

The composite syringes will be heated in the composite warmer (Endoking, India) to either 50 or 60 degrees Celsius. To ensure accurate heating, the warmer will be preheated for 45 minutes and checked for temperature every 10 minutes with an infrared non-contact digital thermometer. Once the accurate heating temperature is achieved by the warmer, the respective composite syringe will be loaded into it and allowed to undergo uniform heating for 45 minutes, it will be the minimum required heating time suggested by manufacturer. At the end of the 45-minute warming, the temperature of the composite material will again be rechecked with the help of an infra-red non-contact digital thermometer.

The composite will then be applied in 2 mm increments using a Teflon-coated instrument, with a 20-second time interval between scooping out of the syringe and placing inside the cavity. Each increment will be light-cured for 20 seconds using an oblique approach. A Teflon-coated instrument will be used to occlusally adapt the composite, and a flame-shaped finishing bur will be used to finish it.

Composite will be placed as mentioned in those specimens subjected to the control group. After storage in 37°C distilled water for one month, the specimens will be tested for fracture resistance using a universal testing machine.

Distribution of samples:

The specimens will be divided into six groups at random.

Groups	Composite material	Temperature	Sample size
Group-1	Preheated nanohybrid composite(3M Filtek Z250XT)	50 degree celsius	12
Group-2	Preheated microhybrid composite (3M Filtek P60)	50 degree celsius	12
Group-3	Preheated bulk fill composite (IVOCLAR Tetric-N-Ceram Bulk Fill)	50 degree celsius	12
Group-4	Preheated nanohybrid composite(3M Filtek Z250XT)	60 degree celsius	12
Group-5	Preheated microhybrid composite (3M Filtek P60)	60 degree celsius	12
Group-6	Preheated bulk fill composite (IVOCLAR Tetric-N-Ceram Bulk Fill)	60 degree celsius	12

STATISTICAL ANALYSIS

Statistical analysis will be conducted using IBM SPSS Statistics for Windows, version 27.0 (Armonk, NY: IBM Corp.). The study will be powered at 80% with a 95% confidence interval. Descriptive statistics, including mean, standard deviation, frequency, and percentage, will be computed. ANOVA, followed by Tukey's post-hoc test, will be applied to compare the fracture resistance of teeth between and within groups. Statistical significance will be set at $p<0.05$.

REFERENCES

[1] Garoushi S, Tanner J, Vallittu PK, Lassila L. Preliminary clinical evaluation of short fiber-reinforced composite resin in posterior teeth: 12-months report. Open Dent J. 2012;6:41-45.
[2] Bharadwaj TN, Solomon P, Parameswaran A. Tooth restored with composite resins- A comparative analysis. Trends Biomater Artif Organs. 2002;15(2):57-61.
[3] Bichacho N. The centripetal build-up for composite resin posterior restorations. Pract Periodontics Aesthet Dent. 1994;6(3):17-23.
[4] Eakle WS. Fracture resistance of teeth restored with Class-II bonded composite resin. J Dent Res. 1986;65(2):149-53.
[5] Siso ŞH, Hürmüzlü FE, Turgut M, Altundaşar EM, Serper AH, Er K. Fracture resistance of the buccal cusps of root filled maxillary premolar teeth restored with various techniques. Int Endod J. 2007;40(3):161-68.
[6] He Y, Zhao SL, Zhang XL, Liu HJ, Zhang XY. Effect of composite restoration on the reinforcement of teeth. Zhonghua kou Qiang yi xue za zhi=Zhonghua Kouqiang Yixue Zazhi=Chinese Journal of Stomatology. 2007;42(5):300-03.
[7] He Z, Shimada Y, Tagami J. The effects of cavity size and incremental technique on micro-tensile bond strength of resin composite in Class-I cavities. Dent Mater. 2007;23(5):533-38.
[8] Belli S, Erdemir A, Ozcopur M, Eskitascioglu G. The effect of fibre insertion on fracture resistance of root filled molar teeth with MOD preparations restored with composite. Int Endod J. 2005;38(2):73-80.
[9] Mondelli J, Sene F, Ramos RP, Benetti AR. Tooth structure and fracture strength of cavities. Braz Dent J. 2007;18(2)134-38.
[10] Hürmüzlü FE, Serper AH, Siso ŞH, Er K. In vitro fracture resistance of root-filled teeth using new-generation dentine bonding adhesives. Int Endod J. 2003;36(11):770-73.
[11] Franca FM, Worschech CC, Paulillo LA, Martins LR, Lovadino JR. Fracture resistance of premolar teeth restored with different filling techniques. J Contemp Dent Pract. 2005;6(3):62-69.
[12] Bonilla ED, Mardirossian G, Caputo AA. Fracture toughness of posterior resin composites. Quintessence Int. 2001;32(3):206-10.
[13] Bhopatkar J, Ikhar A, Chandak M, Mankar N, Sedani S. Composite pre-heating: A novel approach in restorative dentistry. Cureus. 2022;14(7):e27151.
[14] Abdulhameed OH, Abdul-Ameer ZM. Fracture resistance of weakened premolars restored with different preheated bulk fill composites (A comparative in vitro study). Int. J. Biosci. 2018;13(4):237-47.
[15] Panchbhai A. Nanotechnology in dentistry. In Applications of Nanocomposite Materials in Dentistry 2019 Jan 1 (Pp. 191-203). Woodhead Publishing.
[16] Rathi S, Nikhade P, Chandak M, Motwani N, Rathi C, Chandak. Microleakage in composite resin restoration- a review article. J Evol Med Dent Sci. 2020;9(12):1006-11.
[17] Shah K, Mankar N, Bajaj P, Nikhade P, Chandak M, Gilani R. Comparative evaluation of microleakage in cavities restored with nanohybrid and microfilled composites using oblique incremental technique-an in vitro-study. J Evol Med Dent Sci. 2020;9(13):1087-90.
[18] Al-Ibraheemi ZA, Abdullah HA, Jawad NA, Haider J. Assessing fracture resistance of restored premolars with novel composite materials: An in vitro study. Int J Dent. 2021;2021:5512708.
[19] Moosavi H, Zeynali M, Pour ZH. Fracture resistance of premolars restored by various types and placement techniques of resin composites. Int J Dent. 2012;2012:973641.

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