Fracture Resistance of Resin Composite restorations with different underlying core build up materials as a dentin substitute in MOD Cavities in Premolars (In-Vitro Study)

Nourhan Kamel*, Dr. Ahmed Refaat Mohamed **, Hend S. Ahmed *, Hoda Fouda **** ,Mohamed Fouad Haridy *****

*Master candidate in Conservative Dentistry Department, Faculty of Dentistry, The British University in Egypt, Cairo, Egypt.
Email: PG.nourhan91941002@bue.edu.eg
** Lecturer of conservative dentistry, Conservative dentistry department, Cairo university, Cairo, Egypt
Email: Ahmed.refaat@dentistry.cu.edu.eg
Orcid.org/0000-0003-0771-6047
*** Associate professor of Conservative Dentistry, Faculty of Dentistry, The British University in Egypt, Cairo, Egypt
Email: Hend.sayed@bue.edu.eg
orcid.org/0000-0002-2116-4253
**** Lecturer of conservative dentistry, Faculty of Dentistry, The British University in Egypt, Cairo, Egypt
Email: Hoda.fouda@bue.edu.eg
orcid.org/0009-0006-8088-7925
**** Professor of Conservative Dentistry, Faculty of Dentistry, Cairo University and The British University in Egypt, Cairo, Egypt.
Email: Mohamed.Haridy@bue.edu.eg
orcid.org/0000-0002-8361-1557

Corresponding Author: Nourhan Kamel
Email: PG.nourhan91941002@bue.edu.eg

How to cite this article: Kamel N, Mohamed AR, Ahmed HS, Fouda H, Haridy MF. Fracture resistance of resin composite restorations with different underlying core build up materials as a dentin substitute in MOD cavities in premolars (in-vitro study). Int J Drug Deliv Technol. 2026;16(75s): 189-196. DOI: 10.25258/ijddt.16.75s.22

Introduction:

Restoring maxillary premolars with extensive mesio-occluso-distal (MOD) defects remains a demanding procedure because removal of both marginal ridges markedly compromises the structural integrity of the tooth and increases its susceptibility to fracture under functional loading

Despite these advantages, polymerization contraction and the stresses generated during curing continue to represent important limitations of direct resin-based composites [3]. Several restorative strategies have therefore been developed to minimize polymerization-related stress, particularly incremental placement. More recently, bulk-fill resin composites have been introduced with formulations and curing characteristics intended to permit placement in thicker increments, commonly up to approximately 4–5 mm, while maintaining acceptable mechanical performance [4–6].

Manufacturers have approached bulk-fill technology through modifications of resin chemistry, rheological

[1,2]. Adhesive restorative procedures have consequently become an important approach for reinforcing compromised tooth structure, as bonding may improve stress distribution across the tooth-restoration complex and provide additional support to the remaining cusps.

behavior, delivery systems, and reinforcement mechanisms. SonicFill™ represents one such development. It is a sonically activated, relatively high-viscosity bulk-fill composite that becomes more flowable during sonic activation, facilitating adaptation to cavity walls and enabling placement of large posterior restorations. This approach was developed to combine simplified placement with adequate mechanical performance in extensive cavities [7,8].

A further strategy for improving the load-bearing capacity of resin restorations is the incorporation of short glass fibers. EverX-Posterior contains randomly distributed short E-glass fibers that are intended to reinforce the resin matrix in multiple directions and to limit crack development and propagation. Such fiber-reinforced composites have therefore attracted attention for the restoration of teeth subjected to substantial occlusal stresses [9].

Advances in CAD/CAM technology have also expanded the use of prefabricated indirect restorative blocks. Chairside CAD/CAM restorations offer controlled industrial processing, standardized material properties, and the possibility of producing precisely designed indirect restorations. IPS e.max CAD, a lithium-disilicate glass-ceramic CAD/CAM material, provides an alternative indirect restorative approach for structurally compromised teeth. The use of CAD/CAM restorations may reduce some of the variables associated with direct placement and polymerization while providing a material with high mechanical performance [10,11].

Nevertheless, there is still no universal agreement regarding the most appropriate restorative strategy for weakened maxillary premolars with extensive MOD preparations. Differences in restorative material, placement technique, polymerization behavior, and indirect fabrication may all influence the final fracture resistance. Accordingly, the present investigation evaluated the effect of several restorative protocols on the fracture resistance of maxillary premolars containing standardized MOD cavities after thermocycling. The null hypothesis was that the restorative protocol would have no significant effect on the fracture resistance of the restored teeth.

Unfortunately, unresolved controversy exits concerning definitive restorative protocol and performance of restorative materials for treatment of weakened maxillary premolars with variable remaining tooth structure to improve their fracture resistance under occlusal load. Therefore, it was found that evaluation of influence of different restorative protocols on fracture resistance of maxillary premolar teeth with MOD cavities after subjecting to thermo-cycling might be of value. Accordingly, The null hypothesis of this study was that the various restorative protocols would not affect the fracture resistance of maxillary premolar teeth with MOD cavities. .

Materials and Methods:

Study materials

The study evaluated three direct resin-based restorative materials: the sonically activated bulk-fill composite SonicFill™ (Kerr Corp, Orange, CA, USA), the short fiber-reinforced composite everX-Posterior (GC, Tokyo, Japan), and the nano-hybrid resin composite Filtek™ Z250 XT (3M, St. Paul, MN, USA). An indirect CAD/CAM restorative material, IPS e.max CAD (Ivoclar, Schaan, Liechtenstein), was also investigated. The materials and their manufacturers are summarized in Table 1.

Sample size calculation:

A priori sample-size estimation was performed with G*Power 3.1.9.4 using data reported by Fahad and Majeed [16]. The statistical power was established at 95% with a two-sided significance level of 5%. The calculation indicated that eight specimens per group were required to detect an effect size of 2.07. The number was increased by 30% to allow for possible pre-test failures, resulting in 10 teeth per group and a total sample of 60 maxillary premolars.

Samples selection

Sixty extracted maxillary premolars obtained following periodontal indications were selected. Residual soft tissues were removed and the teeth were rinsed under running water before examination under 10× magnification. Teeth exhibiting caries, cracks, developmental defects, or hypoplastic changes were excluded. To reduce anatomical variation, only teeth measuring approximately 7 ± 0.5 mm mesiodistally and 8 ± 0.5 mm buccolingually were included. The specimens were stored at room temperature in distilled water containing 0.2% sodium azide for a period not exceeding three months [12,13].

Sample grouping

The selected teeth were randomly allocated into six experimental groups, with 10 specimens assigned to each group according to the restorative condition under investigation:

Group 1 (PG): intact, unprepared premolars serving as the positive control.

Group 2 (NG): premolars containing the standardized MOD preparation and left unrestored as the negative control.

Group 3 (NCG): premolars restored directly with nano-hybrid resin composite Filtek™ Z250 XT (3M, St. Paul, MN, USA).

Group 4 (BSG): premolars restored with the sonically activated bulk-fill composite SonicFill™ (Kerr Corp, Orange, CA, USA).

Group 5 (BEG): premolars restored with the short fiber-reinforced composite everX-Posterior (GC, Tokyo, Japan).

Group 6 (IGG): premolars restored with an indirect CAD/CAM IPS e.max CAD block (Ivoclar, Schaan, Liechtenstein).

Specimens' preparation:

To reproduce periodontal support during mechanical testing, the roots were coated with melted wax, leaving 2 mm of root surface apical to the cemento-enamel junction uncovered. This produced an approximately 0.5-mm uniform space around the root. Each tooth was then centrally positioned in self-curing acrylic resin within a custom cylindrical Teflon mold measuring

2 cm in length and 2 cm in diameter. A specially fabricated metal guide was used to maintain the long axis of the tooth perpendicular to the base of the mold. After polymerization of the acrylic, the tooth was removed, the wax spacer was eliminated, and the resulting space was filled with light-body polyvinyl siloxane (Speedex, Coltene Whaledent AG, Switzerland) before the tooth was repositioned [14].

Cavity preparations:

Except for the positive-control teeth, all specimens received standardized Class II MOD cavity preparations. Direct-restoration cavities were prepared with a high-speed round-end parallel diamond bur (881.31.014 FG; Brasseler USA) under continuous air-water cooling. For specimens designated for the indirect restoration, the #4261 inlay preparation kit (Komet Inlay Preparation Kit, Brasseler GmbH, Germany) was used sequentially with #845KR, #8845KR, and #845KREF burs [15]. A new bur was used after every three preparations. The MOD outline was marked with a waterproof marker and standardized to a buccolingual width of 3 mm and an occlusocervical depth of 4 mm measured from the cusp tip, without proximal steps. Direct cavities had parallel walls and rounded internal line angles, whereas the indirect preparations were given an occlusal divergence of approximately 6–10°. Dimensions were verified with a periodontal probe and digital caliper after preparation [2,16].

Restorative procedures

All restorative procedures were performed in accordance with the manufacturers' recommendations and with the corresponding adhesive systems. A Tofflemire matrix and retainer (Miltex Inc, York, PA, USA) were used for the direct restorations to approximate clinical conditions. Selective enamel etching was performed with 37% phosphoric acid for 30 seconds, followed by 60 seconds of rinsing with air and water and gentle air drying. The adhesive was subsequently applied to enamel and dentin and light cured with an Elipar S10 LED unit (3M ESPE, St. Paul, MN, USA) operating at 1200 mW/cm² [17].

For Group 3, Filtek™ Z250 XT was placed using an incremental restorative technique after polymerization of the adhesive. The first approximately 2-mm increment was positioned obliquely and vertically and light cured for 20 seconds. A second increment was then placed and polymerized. The restoration was subsequently finished and polished with Sof-Lex™ aluminum-oxide discs (3M ESPE, USA) using progressively finer grits.

For Group 4, SonicFill™ was applied using the manufacturer's sonically activated delivery system after curing of the OptiBond Universal adhesive (Kerr Corporation, Orange, CA, USA). The composite compule was mounted in the sonic handpiece and the delivery speed was set to level 3. The tip was positioned near the cavity floor and the material was expressed continuously until the cavity was filled. A ball burnisher was used to adapt and compact the material and remove excess, followed by 20 seconds of light curing.

For Group 5, everX-Posterior was placed after application and polymerization of G-Premio Bond (GC, Tokyo, Japan). The material was inserted using the same incremental approach described for Group 3. Following restoration, all specimens were finished and polished with four descending grits of Sof-Lex™ aluminum-oxide discs.

For Group 6, each prepared tooth was optically scanned with the Omnicam intraoral camera using CEREC software version 4.60 (Sirona Dental Systems GmbH, Germany). The preparation margins were identified digitally, and the restoration was designed with verification of margin continuity, contour, and overall uniformity. An IPS e.max CAD block of the appropriate size was secured in the milling unit and the restoration was fabricated according to the digital design. After milling, the restoration was separated from the block and evaluated intraorally on its corresponding preparation. The restoration was then finished and polished in accordance with the manufacturer's recommendations. The internal surface was treated according to the bonding protocol, followed by silanization, adhesive application, and cementation with a dual-cured resin cement. Excess cement was removed and the restoration was light cured from all surfaces for 40 seconds.

The fitting surfaces of the milled restorations were treated with the CoJet® system using 30-μm silica-coated alumina powder, followed by application of Bis-Silane (Bisco) for 60 seconds and air drying for 5 seconds. Futura Bond DC was actively applied with a microbrush and light cured for 20 seconds. Bifix SE dual-cured self-adhesive resin cement (VOCO) was then used for cementation, and the excess cement was removed before light curing for 40 seconds from each surface.

All specimens were maintained for 24 hours before thermocycling. Thermal aging was performed for 5000 cycles between 5 ± 2°C and 55 ± 2°C, with a 30-second dwell period at each temperature; this regimen has been used to represent approximately six months of clinical service [18]. Within 24 hours of completing thermocycling, each specimen was subjected to axial compressive loading in a computer-controlled universal testing machine (LRX-plus, Lloyd Instruments Ltd., Fareham, UK) at a crosshead speed of 1 mm/min until fracture. The maximum load at failure was recorded in Newtons [19].

Statistical analysis:

Data were analyzed using IBM SPSS Statistics version 2.0 for Windows. Descriptive statistics were expressed as mean ± standard deviation. Statistical significance was established at $P \leq 0.05$. Distribution normality was evaluated using the Kolmogorov–Smirnov and Shapiro–Wilk tests.

Differences among the six groups were assessed using one-way analysis of variance (ANOVA), followed by Tukey's post-hoc test for pairwise comparisons.

Table 1: Materials description, composition and manufacture

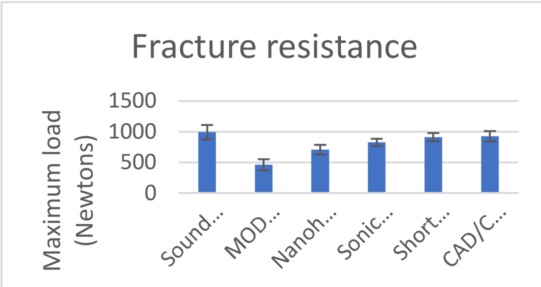
Materia	**Descriptic**	**Composition**	**Manufactu**
Sonic-fi	Nanohybrid bulkfill composite material	**Matrix**: Glass, oxide, chemicals (10–30%), 3-trimethoxysilyl propyl methacrylate (10–30%), silicon dioxide (5–10%), ethoxylatedbisphenol A dimethacrylate (1–5%), bisphenol A bis(2-hydroxy-3-methacryloxypropyl) ether (1–5%), and TEGDMA (1–5%) **Filler:** 83.5 % by	Kerr Corp, CA, USA
everX-P	short-fiber reinforced resin composite	**Resin matrix:** Semi-interpenetrating polymer network (semi-IPN): netpoly(methyl meth'acrylate)-inter-net-poly(bis-glycidyl- A-dimethacrylate) : Bis-GMA, TEGDMA, and PMMA **Fillers**: E-glas barium borosilica	GC, Tokyo,
Filtek Z250 XT	Nano-hybrid resin composite Nano-hybrid resin composite Nano-hybr composite	Matrix: (methacrylate-, acid-modified methacrylate-, inorganic polycondensate - or epoxide based) modified version of the polysiloxane. it is combined with a well-established *poly*-urethane-methacrylate as well as bis-EMA and TEGDMA. **Fillers:** 77-79 we	DENTSPLY Trey, Germany
IPS e.ma	Lithium-disilicate glass-ceramic CAD/CAM block Lithium-di glass-cera CAD/CAN	86% Nanohybrid Filler 14% UDMA+ DMA	VOCO Germany, C

Results:

One-way ANOVA demonstrated a statistically significant difference in fracture resistance among the six groups (P<0.001). The intact positive-control group, IPS e.max CAD group (IGG), and everX-Posterior group (BEG) exhibited the highest mean maximum-load values. The SonicFill™ group (BSG) was statistically comparable with both IGG and BEG. The Filtek™ Z250 XT group (NCG) showed a significantly lower fracture resistance than the positive-control, IGG, BEG, and BSG groups, while remaining significantly higher than the negative-control group. The unrestored MOD group demonstrated the lowest fracture resistance of all groups.

Mean ± SD and P-value for the effect of restoration type on fracture resistance of MOD cavities in maxillary premolars (Newtons).

Restoration type	**Maximum load (Newtons)**
Sound Teeth (Positive Control)	992.84 ± 117.16^{a}
MOD Cavity (Negative Control)	459.52 ± 90.66^{d}
NCG	707.07 ± 80.34^{c}



BSG	825.99 ± 60.68^{b}
BEG	910.00 ± 67.30^{ab}
IGG	926.46 ± 83.25^{ab}
P-value	<0.001*

An asterisk indicates statistical significance at P≤0.05.
Means carrying different superscript letters are significantly different at P≤0.05.

Discussion:

The management of structurally weakened maxillary premolars remains a major concern in restorative dentistry because extensive loss of tooth tissue can substantially increase the risk of cuspal fracture. Adhesive restorations can improve the mechanical behavior of compromised teeth by creating a bonded tooth-restoration unit capable of distributing applied loads and supporting remaining tooth structure [20,21]. The present investigation therefore compared different direct restorative strategies with an indirect CAD/CAM restoration in standardized MOD cavities.

Bulk-fill composites were developed primarily to simplify posterior restorative procedures by permitting placement in deeper increments than conventional composites. Their manufacturers have reported improvements in curing efficiency and mechanical performance intended to permit use in posterior stress-bearing regions while reducing operative time and the risk of voids associated with multiple increments [22,23]. In the present study, SonicFill™ was selected as a representative sonically activated bulk-fill system, whereas everX-Posterior represented a fiber-reinforced approach.

SonicFill™ uses sonic activation to temporarily reduce the viscosity of the material during placement. This change in rheological behavior facilitates delivery and adaptation to the cavity walls while allowing the material to be placed as a bulk increment. The system was designed to combine the handling characteristics required for adaptation with the mechanical properties needed for posterior restorations [16].

The incorporation of short glass fibers provides a different mechanism for reinforcement. In everX-Posterior, randomly oriented E-glass fibers are embedded within the resin matrix. Under loading, these fibers can transfer stresses away from the surrounding polymer matrix and interfere with crack propagation, providing reinforcement in more than one direction [9,38]. This mechanism may explain the high fracture-resistance values obtained for the fiber-reinforced group in the present experiment.

Filtek™ Z250 XT was used as the conventional nano-hybrid direct restorative material in the present investigation. Unlike the bulk-fill and fiber-reinforced approaches, it was placed incrementally, allowing the cavity to be restored in controlled layers. The lower fracture-resistance values obtained for this group compared with SonicFill™, everX-Posterior, and IPS e.max CAD indicate that the material and placement strategy used in the present study did not restore the fracture resistance to the same level as the other tested protocols.

The indirect group was restored with IPS e.max CAD using a digital impression, CAD design, milling, finishing, surface treatment, and adhesive cementation sequence. An indirect CAD/CAM restoration differs fundamentally from a direct composite restoration because the restorative material is manufactured from a prefabricated block rather than polymerized directly within the cavity. The industrial processing of CAD/CAM blocks provides a controlled manufacturing environment and may contribute to their predictable mechanical properties. Previous studies have emphasized the importance of material composition and processing in determining the mechanical behavior of CAD/CAM restorative materials [25,35,36].

Maxillary premolars were selected because their anatomy and cusp configuration make them particularly susceptible to fracture when substantial tooth structure is removed [27]. Restricting the sample to teeth with comparable mesiodistal and buccolingual dimensions helped minimize anatomical variability. The MOD preparation was deliberately standardized to compromise the remaining tooth structure, while the 4-mm depth permitted assessment of the restorative protocols under conditions relevant to bulk-placement claims [28,29].

Laboratory fracture testing becomes more clinically informative when the specimens are exposed to conditions that approximate the oral environment. For this reason, the present specimens were subjected to thermocycling before mechanical testing. Thermal changes and moisture can influence the tooth-restoration interface and the mechanical properties of restorative materials, and their inclusion provides a more representative experimental condition than immediate testing alone.

None of the restored groups reached the fracture-resistance level of intact sound teeth. This finding is reasonable because the original tooth structure lost during MOD preparation cannot be completely reproduced by a restorative material. Differences in elastic behavior between enamel, dentin, and restorative materials, together with the presence of adhesive interfaces, may further limit complete recovery of the original mechanical strength [30,31]. Nevertheless, every restored group performed significantly better than the unrestored MOD group, demonstrating that restoration provided substantial reinforcement of the weakened teeth.

The statistical findings showed that IPS e.max CAD, everX-Posterior, and SonicFill™ produced the highest fracture-resistance values among the restorative groups, whereas Filtek™ Z250 XT demonstrated a lower mean value. The absence of a significant difference among IPS e.max CAD, everX-Posterior, and the positive control indicates that these restorative protocols were capable of restoring a substantial proportion of the fracture resistance lost following MOD preparation. Accordingly, the null hypothesis was rejected because restorative protocol significantly influenced fracture resistance.

Differences in restorative performance may be related to the composition, structure, elastic behavior, and manufacturing or placement method of each material. For direct resin composites, filler characteristics and the interaction between filler and resin matrix are important determinants of strength and stiffness [33,34]. For CAD/CAM materials, the controlled fabrication process and the intrinsic properties of the prefabricated block may provide advantages that are difficult to reproduce when a material is polymerized directly inside the cavity [35,36].

The relatively high fracture resistance recorded for SonicFill™ may also be associated with its placement characteristics and material formulation. Sonic activation lowers viscosity during delivery, improving adaptation and potentially reducing the formation of clinically relevant voids [7,37]. Better adaptation can contribute to a more continuous tooth-restoration interface, while the material's bulk-fill formulation allows the cavity to be restored without multiple placement steps.

The everX-Posterior and Filtek™ Z250 XT groups had comparable reported filler-weight ranges in the original dataset, yet their fracture-resistance values differed substantially. This observation emphasizes that filler percentage alone cannot fully explain the mechanical behavior of a restorative system. The nature, geometry, distribution, and reinforcing role of the fillers, together with the resin matrix and placement technique, can all affect the way stresses are transmitted through the restoration.

The short glass fibers in everX-Posterior provide a distinctive reinforcement mechanism. Fibers approximately 1–2 mm long are distributed through the composite and can act as barriers to crack growth while transferring applied stresses from the resin matrix to the reinforcing phase. Their multidirectional orientation may be particularly advantageous when the restoration is subjected to complex occlusal loading [38].

Filtek™ Z250 XT, in contrast, is a nano-hybrid resin composite intended for conventional direct restorative procedures. Its lower fracture-resistance value in this study may reflect the combined effect of its material characteristics, incremental placement, polymerization behavior, and the geometry of the extensive MOD preparation. The finding should not be interpreted as an inherent lack of clinical suitability, but rather as the performance of this particular restorative protocol under the experimental conditions used in the present study.

Conclusion:

Within the limitations of this laboratory investigation, the fracture resistance of maxillary premolars with standardized MOD cavities was significantly influenced by the restorative protocol. The IPS e.max CAD, everX-Posterior, and SonicFill™ protocols provided the highest fracture-resistance values among the tested restorations, whereas Filtek™ Z250 XT showed a lower value. All restorative approaches nevertheless improved the fracture resistance compared with unrestored MOD preparations.

These findings indicate that careful selection of the restorative material and technique is important when managing structurally compromised premolars. Further laboratory studies incorporating longer-term aging and cyclic fatigue, followed by well-designed clinical investigations, are required to determine whether the differences observed in this in-vitro model translate into meaningful differences in long-term clinical survival.

Conflicts of interests

All authors declare to have no conflict of interests.

References:

1. Plotino G, Buono L, Grande NM, Lamorgese

V, Somma F. Fracture resistance of endodontically treated molars restored with extensive composite resin restorations. *(J Prosthet Dent*. 2008;99:225-232.

2. Sarabi N, Taji H, Jalayer J, Ghaffari N. Fracture Resistance and Failure Mode of Endodontically Treated Premolars Restored with Different Adhesive Restorations. *JDMT*. 2015;4(1):13-20.
3. Kaisarly D, Gezawi M El. Polymerization shrinkage assessment of dental resin composites : a literature review. *Odontology*. 2016;104(3):257-270. doi:10.1007/s10266-016-0264-3
4. Jarisch J, Lien W, Guevara PH, Greenwood WJ, Dunn WJ. Microcomputed tomographic comparison of posterior composite resin restorative techniques: Sonicated bulk fill versus incremental fill. *Gen Dent*. 2016;64(5):20-23.
5. Frankenberger R, Zeilinger I, Krech M, et al. Stability of endodontically treated teeth with differently invasive restorations : Adhesive vs . non-adhesive cusp stabilization. *Dent Mater*. 2015;31(11):1312-1320. doi:10.1016/j.dental.2015.08.160
6. Goracci C, Cadenaro M, Fontanive L, et al. Polymerization efficiency and flexural strength of low-stress restorative composites. *Dent Mater*. 2014;30(6):688-694. doi:10.1016/j.dental.2014.03.006
7. Hirata R, Pacheco R, Caceres E, et al. Effect of Sonic Resin Composite Delivery on Void Formation Assessed by Micro-computed Tomography. *Oper Dent*. 2018;43(2):144-150. doi:10.2341/16-331-l
8. Kerr , USA Scientific Compendium 2015 for SonicFill ™ Sonic Activated Composite.
9. Tekçe N, Aydemir S, Demirci M, Tuncer S, Sancak EI, Baydemir C. Clinical performance of direct posterior composite restorations with and without short glass-fiber-reinforced composite in endodontically treated teeth: 3-year results. *J Adhes Dent*. 2020;22(2):127-137. doi:10.3290/j.jad.a44279
10. Ling L, Ma Y, Malyala R. A novel CAD/CAM resin composite block with high mechanical properties. *Dent Mater*. 2021;10.1016:1-6. doi:10.1016/j.dental.2021.03.006
11. Lucsanszky IJR, Ruse ND. Fracture Toughness, Flexural Strength, and Flexural Modulus of New CAD/CAM Resin Composite Blocks. *J Prosthodont*. 2020;29(1):34-41. doi:10.1111/jopr.13123
12. Santana FR, Pereira JC, Pereira CA, Fernandes Neto AJ, Soares CJ. Influence of method and period of storage on the microtensile bond strength of indirect composite resin restorations to dentine. *Braz Oral Res*. 2008;22(4):352-357. http://www.ncbi.nlm.nih.gov/pubmed/19148392
13. Humel MMC, Oliveira MT, Cavalli V, Giannini M. Effect of storage and disinfection methods of extracted bovine teeth on bond strength to dentin. *Brazilian J Oral Sci*. 2007;6(22):1402-1406.
14. Soares CJ, Pizi ECG, Fonseca RB, Martins LRM. Influence of root embedment material and periodontal ligament simulation on fracture resistance tests. *Braz Oral Res*. 2006;19(1):11-16. doi:10.1590/s1806-83242005000100003
15. Alshiddi IF, Aljinbaz A. Fracture resistance of endodontically treated teeth restored with indirect composite inlay and onlay restorations – An in vitro study. *Saudi Dent J*. 2016;28(1):49-55. doi:10.1016/j.sdentj.2015.09.001
16. Fahad F, Majeed MA-R. Fracture Resistance of Weakened Premolars Restored with Sonically - Activated Composite , Bulk - Filled and Incrementally - Filled Composites : A Comparative in Vitro Study. *J Baghdad Coll Dent*. 2014;26(4):22-27. doi:10.12816/0015250
17. PRICE(d) FARMGCAGARBT, (a). Light curing in dentistry and clinical implications : a literature review Polymerization. *Braz Oral Res*. 2017;31(61):64-91.
18. Gale MS, Darvell BW. Thermal cycling procedures for laboratory testing of dental restorations. *J Dent*. 1999;27(2):89-99. doi:10.1016/S0300-5712(98)00037-2
19. Wu Y, Cathro P, Marino V. Fracture resistance and pattern of the upper premolars with obturated canals and restored endodontic occlusal access cavities. *J Biomed Res*. 2010;24(6):474-478. doi:10.1016/S1674-8301(10)60063-2
20. Mergulhão V, de Mendonça L, de Albuquerque M, Braz R. Fracture Resistance of Endodontically Treated Maxillary Premolars Restored With Different Methods. *Oper Dent*. 2019;44(1):E1-E11. doi:10.2341/17-262-l
21. Bilal H. Ibrahim HJA-A. Fracture Resistance of Endodontically Treated Premolar Teeth with Extensive MOD Cavities Restored with Different Bulk Fill Composite Restorations (An In vitro Study). *J Bagh Coll Dent*. 2017;29(2):26-32.

doi:10.14744/eej.2018.70299
22. Van Ende A, De Munck J, Diogo /, Lise P, Meerbeek B Van. Bulk-Fill Composites: A Review of the Current Literature. *J Adhes Dent*. 2017;19(2):95-109. doi:10.3290/j.jad.a38141
23. Didem A, Gözde Y, Nurhan Ö. Comparative Mechanical Properties of Bulk-Fill Resins. *J Compos Mater*. 2014;4:117-121.
24. Patel CJMPPDP. Comparative Analysis of Fracture Resistance of Maxillary Premolars with Class II MOD Cavities Restored with Novel Nanocomposites Including Fibre Reinforced Composite Restorative System: A Step Ahead in Composite Dentistry. *Adv Hum Biol*. 2014;4(2):14-21.
25. Alamoush RA, Silikas N, Salim NA, Al-Nasrawi S, Satterthwaite JD. Effect of the Composition of CAD/CAM Composite Blocks on Mechanical Properties. *Biomed Res Int*. 2018;10. doi:10.1155/2018/4893143
26. Ivoclar, Scientific Documentation for IPS e.max CAD.
27. Emamieh S, Hojati P, Ghasemi A, Torabzadeh H. Effect of cusp coverage and water storage on compressive strength of composite restorations of premolars. *J Clin Exp Dent*. 2018;10(4):2-6. doi:10.4317/jced.54668
28. Nazari A, Bajaj D, Zhang D, Romberg E, Arola D. Aging and the reduction in fracture toughness of human dentin. *J Mech Behav Biomed Mater*. 2009;2(5):550-559. doi:10.1016/j.jmbbm.2009.01.008
29. Mollaverdi F, Bassir M, Labibzadeh A. The effect of amount of lost tooth structure and restorative technique on fracture resistance of endodontically treated premolars. *J Conserv Dent*. 2015;16(5):413. doi:10.4103/0972-0707.117494
30. VIANNA ALS de V, PRADO CJ do, BICALHO AA, PEREIRA RA da S, NEVES FD das, SOARES CJ. Effect of cavity preparation design and ceramic type on the stress distribution, strain and fracture resistance of CAD/CAM onlays in molars. *J Appl Oral Sci*. 2018;26:1-10. doi:10.1590/1678-7757-2018-0004
31. Suksaphar W, Banomyong D, Jirathanyanatt T, Ngoenwiwatkul Y. Survival rates against fracture of endodontically treated posterior teeth restored with full-coverage crowns or resin composite restorations: a systematic review. *Restor Dent Endod*. 2017;42(3):157. doi:10.5395/rde.2017.42.3.157
32. Ástvaldsdóttir Á, Dagerhamn J, Van Dijken JWV, et al. Longevity of posterior resin composite restorations in adults - A systematic review. *J Dent*. 2015;43(8):934-954. doi:10.1016/j.jdent.2015.05.001
33. Habib E, Wang R, Zhu XX. Correlation of resin viscosity and monomer conversion to filler particle size in dental composites. *Dent Mater*. 2018;34(10):1501-1508. doi:10.1016/j.dental.2018.06.008
34. Kyo-Han Kim, MS, PhD,a Joo L. Ong, MS, PhD,b and Osamu Okuno, MS P. The effect of filler loading and morphology on the mechanical properties of contemporary composites. *J Prosthet Dent*. 1992;87(6).
35. Grzebieluch W, Mikulewicz M, Kaczmarek U. Resin Composite Materials for Chairside CAD/CAM Restorations: A Comparison of Selected Mechanical Properties. *J Healthc Eng*. 2021;(882895):8. doi:10.1155/2021/8828954
36. Shereen Hafez * , Amir Hafez ** HA*** and HAA****. EFFECT OF DIFFERENT FILLER LOADING ON FRACTURE RESISTANCE OF CAD/CAM RESIN COMPOSITE RESTORATION IN PREMOLAR TEETH: AN IN VITRO STUDY. *Egypt Dent J*. 2019;65(1:9):2457-2465.
37. Manchester M. Post-cure depth of cure of bulk fill dental. *Dent Mater*. 2013;30(2):149-154. doi:10.1016/j.dental.2013.10.011
38. Jafarnia S, Valanezhad A, Shahabi S, Abe S, Watanabe I. Physical and mechanical characteristics of short fiber-reinforced resin composite in comparison with bulk-fill composites. *J Oral Sci*. 2021;63(2):148-151. doi:10.2334/josnusd.20-0436
39. Dentsply, DeTrey, Scientific Compendium 2016 for Ceram Universal Nano-Ceramic Restorative.
40. Blackham JT, Vandewalle KS, Lien W. Properties of Hybrid Resin Composite Systems Containing Prepolymerized Filler Particles. *Oper Dent*. 2009;34(6):697-702. doi:10.2341/08-118-l