ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

*International Journal of Dental Science and Innovative Research (IJDSIR)*
*IJDSIR : Dental Publication Service*
*Available Online at:www.ijdsir.com*
*Volume – 7, Issue – 5, October – 2024, Page No. : 161 - 167*

# Fracture Resistance of Restored Mandibular Molars Using Composite Resins: An in-Vitro Study

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**Citation of this Article:** Dr. Snigdha Sharma, Dr. Aditya Mitra, Dr. Debanjan Das, Dr. Abhisekh Guria, "Fracture Resistance of Restored Mandibular Molars Using Composite Resins: An in-Vitro Study", IJDSIR- October – 2024, Volume –7, Issue - 5, P. No. 161 – 167.



**Type of Publication:** Original Research Article

**Conflicts of Interest:** Nil

## Abstract

**Aim:** The aim is to evaluate fracture resistance in mandibular molars with class I cavity restoration using different composite resins.

**Materials and Methods:** 60 caries-free molars were mounted in acrylic resin till the cementoenamel junction. Cavity preparation involved punch cut with a No.2 round bur, followed by SF-11. Teeth were categorized into two groups and subdivided into three subgroups based on the composite resin used. Composite resin restorations were done, and samples were tested using a universal testing machine. Vertical load was applied on the central fossa and fracture resistance load was noted down.

**Statistical analysis:** Statistical analysis was done using one-way ANOVA and Tukey's post hoc analysis.

**Results:** The fracture resistance was highest for the buccal wall (1.5 mm) and lowest in the lingual wall (1 mm). The within-group comparison of fracture resistance for the buccal (1.5 mm) and lingual (1 mm) walls showed a decreasing order as follows: Bulkfill > Nanofilled > Nanohybrid.

**Conclusion:** Nanohybrid composite resin showed more fracture resistance than nanofilled and bulk fill composite resin.

**Keywords:** Fracture resistance, Class 1 cavity, composite resin

## Introduction

The fracture strength of a material determines the maximum stress or load it can endure before breaking. Resin-based composites have become the cornerstone of restorative dentistry. Over the past five decades, dental composite resin has undergone significant advancements, making it the preferred material for both anterior and posterior restorations.

Among tooth-colored restorative materials, composite resins are frequently chosen for their optimal aesthetics, fracture strength, and wear resistance. Fillers play a major role in determining the mechanical properties of composites. The filler enhances the strength of the composite [1].

Silica particles are among the first fillers chosen for their optimal refractive index, affordability, ease of synthesis, modification and high strength when incorporated into resins. However, to enhance the mechanical properties of resin composites and improve the long-term success of posterior restorations, researchers and manufacturers have focused on zirconia particles. Nano-zirconia particles have been added to resin composites as reinforcing or toughening components due to their unparalleled mechanical strength [2].

In this study, nanohybrid, nanofilled, and bulk fill composites were used. The introduction of nanotechnology is a development in the field of composite resin materials, including nanofilled and nanohybrid resin composites [3]. Nanohybrid resin composites are most popular because they enhance the distribution of fillers within the matrix by blending nanoparticles with submicron particles, resulting in better mechanical, chemical, and optical properties.

Bulk-fill resin-based composites were developed for a faster restoration process and to reduce the risk of voids or contamination between layers. These composites claim to enable placement and curing of up to 4 mm increments in a single step. No study to date compares the fracture resistance of different composite resins for restored Class 1 mandibular molar. The aim of this in vitro study is to analyse the fracture resistance of teeth in mandibular molars with class I cavity preparation using different composite resins.

## Materials and Method

Sixty extracted molar teeth free from caries, cracks and surface defects were used. Sample teeth were disinfected with 10% formalin and stored in normal saline. Radicular part of each teeth were mounted in acrylic resin to form a stable base.

A punch cut was created with a No.2 (Mani, Japan) round bur followed by a Straight fissure diamond (SF-11) (Mani, Japan) to finish the cavity (without any bevel). Teeth were categorized into two groups (n=30).

**Group I -** Class I cavity preparation was prepared with a remaining thickness of 2mm mesiodistally, 2mm at the lingual wall, 1.5mm at the buccal wall, and a depth of 1.5mm.

They were then subdivided into three groups based on the composite resin.

- IA: Nanohybrid composite
- IB: Nanofilled composite
- IC: Bulk fill composite

**Group II –** Class I cavity preparation was prepared with a remaining thickness of 2 mm mesiodistally, 1.5 mm at the lingual wall, 2 mm at the buccal wall, and a depth of 1.5 mm.

They were subsequently divided into three groups according to the type of composite resin used.

- IIA: Nanohybrid composite
- IIB: Nanofilled composite
- IIC: Bulk fill composite

Samples of all the groups were restored with the composite resin. (Table 1).

**Acid etching**: 37% orthophosphoric acid was applied to the prepared cavity for 15 seconds and was rinsed with water spray for 30 seconds.

**Application of dentin bonding agent**: The dentin bonding agent was applied with a micro-applicator tip on the etched cavity. The bonding agent was light cured with an LED composite resin light curing unit with a light intensity of 1200mW/cm2, placed perpendicular to the specimen's surface at a distance of <1.0 mm for 10 seconds.

**Composite resin placement:** Composite resin was filled on the prepared cavity. After that polymerization was done with an LED composite resin light curing unit with a light intensity of 1200mW/cm2, placed perpendicular to the specimen's surface at a distance of <1.0 mm for 20 seconds (0.75mm increment).

Samples were prepared for the universal testing machine. Force was applied with a 1-mm/min crosshead speed. The vertical load was applied to the central fossa of the long axis of the tooth. The ball diameter was 0.8mm. The load at which the restorations fractured was noted and recorded and was statistically analysed.

Table 1: Composite resin materials and adhesive system used in the study

| Composite resin | Type | Resin Matrix (According to Manufacturers) | Filler Description (According to Manufacturers | Filler loading (Wt %) | Adhesive system |
|---|---|---|---|---|---|
| Tetric N Ceram | Nanohybrid | Bis-GMA, UDMA, TEGDMA Bis-EMA resins | Barium aluminium silicate glass (400 – 700 nm), Ytterbium Trifluoride (200 nm) Mixed oxide and copolymers (80 – 81 wt%) | 80.5 | Tetric N Bond |
| Filtek Z350XT | Nanofill | Bis-GMA, UDMA, TEGDMA, Bis-EMA resins | 20nm silica (nonagglomerated) 4-11nm zirconia (non agglomerated) | 78.5 | Single Bond Universal |
| Filtek Bulkfill | Bulkfill | UDMA, BISGMA, AUDMA,DDDMA procrylate resin, Silane-treated ceramic and YbF filler | Zirconia/silica: 0.01-3.5 µm Ytterbium trifluoride: 0.1-5.0 µm | 64.5 | Single Bond Universal |

**Results**

The two-way Analysis of Variance (ANOVA) with the *post-hoc* Tukey HSD test was used to analyse the differences between the two groups. The *P* value of ≤0.05 was considered as the level of significance. It was observed that the Fracture resistance(N) for the lingual wall with 1.5mm was greater than the buccal wall with 1.5mm (Table 2). Comparisons were carried out using the two-way ANOVA test and it revealed that both the teeth structure and the type of material used significantly influenced the Fracture resistance($P$<0.001) (Table 3).

Table 2: Fracture resistance of the study groups

| LINGUAL 1.5mm | | | BUCCAL 1.5 mm | | |
|---|---|---|---|---|---|
| Nanohybrid (Tetric N Ceram) (N) (IA) | Nanofilled (3m Filtek Z350 XT) (N) (IB) | Bulkfill (3m Filtek) (N) (IC) | Nanohybrid (Tetric N Ceram) (N) (IIA) | Nanofilled (3m Filtek Z350 XT) (N) (IIB) | Bulkfill (3m Filtek) (N) (IIC) |
| 1966 | 1734 | 1174 | 1863 | 1463 | 950 |
| 2078 | 1736 | 1180 | 1876 | 1471 | 979 |
| 2082 | 1803 | 1196 | 1893 | 1481 | 992 |
| 2098 | 1765 | 1245 | 1932 | 1492 | 1136 |
| 2124 | 1754 | 1268 | 1956 | 1529 | 1158 |
| 2148 | 1810 | 1296 | 1978 | 1544 | 1170 |
| 2176 | 1774 | 1323 | 1997 | 1550 | 1184 |
| 2193 | 1789 | 1374 | 2035 | 1561 | 1197 |
| 2112 | 1797 | 1388 | 2064 | 1577 | 1206 |
| 2243 | 1825 | 1391 | 2070 | 1584 | 1220 |

Table 3: Descriptive statistics and comparison of the Fracture resistance (N) between the study groups for the various types of composite resin used

| Type of Composites | Lingual(1.5 mm)(n=10) | Buccal(1.5 mm)(n=10) | P value§ |
|---|---|---|---|
| Nanohybrid | 2122±75.9$^{a1}$ | 1966±75.7$^{a2}$ | <0.0001** |
| Nanofilled | 1779±31.3$^{b1}$ | 1525±44.8$^{b2}$ | <0.0001** |
| Bulkfill | 1284±84.6$^{c1}$ | 1119±104$^{c2}$ | <0.0001** |
| P value‡ | <0.0001** | <0.0001** | |

*n:sample size per group*

§:Inter-group comparisons(between the study groups); ‡: intra-group comparisons(between the composites within each study group)

ns: not significant($P$ >0.05), *: statistically significant ($P$ <0.05), **:highly statistically significant ($P$<0.01)

Different superscript letters indicate a significant difference between the follow-up period in each study group Tukeys HSD test was carried out to assess the actual differences within groups and between the groups and the following was inferred:

Within-Group comparisons:

For lingual**(1.5 mm)** group, the Fracture resistance was found in the following order of decrease: Nanohybrid(2122±75.9N)<Nanofilled(1779±31.3N)< Bulk fill(1284±84.6N)

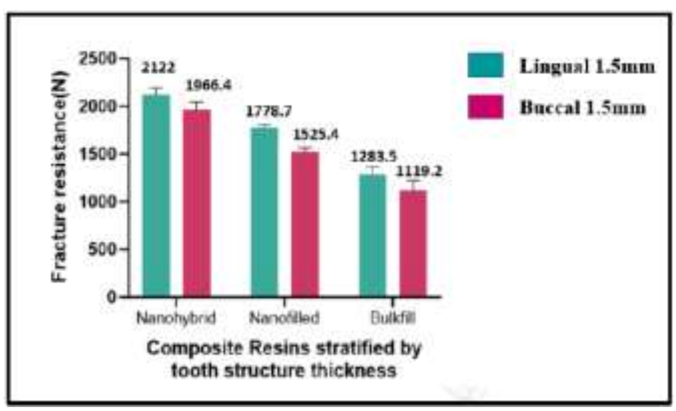
Comparisons indicated that there was a significant difference between the Fracture resistance of all three types of composite materials.

- For **buccal (1.5 mm)** group, the Fracture resistance was found in the following order of decrease: Nanohybrid (1966±75.7 N)<Nanofilled(1525±44.8 N)<Bulk fill(1119±104N)

Comparisons indicated that there was a significant difference between the Fracture resistance of all three types of composite materials.

➢ Between-Group comparisons:

- For the **Nanohybrid** composite specimens, it was observed that the Fracture resistance of the specimens with a lingual wall thickness of 1.5 mm was significantly greater than the specimens with a buccal wall thickness of 1.5 mm ($P$<0.0001).
- For the **Nanofilled** composite specimens, it was observed that the Fracture resistance of the specimens with a lingual wall thickness of 1.5 mm was significantly greater than the specimens with a buccal wall thickness of 1.5 mm ($P$<0.0001).
- For the Bulkfill composite specimens, it was observed that the Fracture resistance of the specimens with a lingual wall thickness of 1.5 mm was significantly greater than the specimens with a buccal wall thickness of 1.5 mm ($P$<0.0001) (Figure 1).




Graph 1: Graph depicting mean fracture resistance

## Discussion

In the earlier study, four groups were examined based on remaining wall thickness: lingual wall thicknesses of 1.5 mm and 1 mm and buccal wall thicknesses of 1.5 mm and 1 mm. Only nanohybrid composite resin was used. A lingual wall thickness of 1.5 mm showed higher fracture resistance than a buccal wall of 1.5 mm. A buccal wall thickness of 1 mm showed less fracture resistance than a lingual wall thickness of 1 mm.

Nanocomposites with clusters exhibit enhanced filler loading, leading to superior mechanical properties, although they may compromise strength. Larger particles of finely ground glass or nano-particle filled organic resin fillers are combined with nanomeric-dispersed nanoparticles to improve mechanical properties. These are often termed nanohybrid composite resin (a mixture of two or more filler particles at least one of which is in the nanometric range i.e. below 100 nm) [4]. This combination reduces the interstitial spacing of the filler particles, thus increasing filler loading. This is reflected in their higher fracture toughness.

The present study showed that nanohybrid composite resin exhibited the highest fracture resistance, followed by the nanohybrid and then the bulk-fill composite. This is because Tetric-N-Ceram has a higher filler loading (80.5%) and contains larger-sized (400-700nm) barium alumina silicate glass fillers with greater hardness (1.25 Moh's) and ytterbium fluoride (Knoop hardness 206). This material offers good physical properties with a flexural strength of 130 Mpa, compressive strength of 267 Mpa and Vickers hardness of 630 Mpa.

Filtek Z350XT is a visible light-activated, nano-filled composite resin. The fillers consist of a combination of non-agglomerated/non-aggregated 20 nm silica, 4 to 11 nm zirconia, and aggregated zirconia/silica cluster fillers. This material offers a compressive strength of 360 Mpa, Tensile strength of 85 Mpa and flexural strength of 160 Mpa. It has lower filler loading (78.5 %) and comparatively lesser hardness of filler than Tetric N Ceram.

Filtek Bulk Fill Posterior contains two novel methacrylate monomers that, in combination, act to lower polymerization stress. A high molecular weight aromatic urethane dimethacrylate decreases the number of reactive groups in the resin. This helps to moderate the volumetric shrinkage. The addition-fragmentation monomers contain a third reactive site that cleaves through a fragmentation process during polymerization. This process provides a mechanism for the relaxation of the developing network and subsequent stress relief. The fragments, however, still retain the capability to react with each other or with other reactive sites of the developing polymer [5]. However, the inorganic filler loading of bulkfill composite resin (64.5%) is less which contributed to lower fracture resistance.

Pachore et al. conducted a study to evaluate the fracture resistance of maxillary molar teeth restored with different composite resins [6]. The MOD cavity was prepared on the specimens. They found that fracture resistance was slightly higher in teeth restored with Tetric N Ceram (nanohybrid composite) compared to those restored with Polofil Supra (microhybrid composite) and Filtek Z350(nanofilled composite).

Leyton et al. evaluated the fracture resistance of extended Class I restorations by employing various restorative methods with nanofilled and nanohybrid composites [7]. Sixty extracted human third molars were prepared with extended Class I cavities and allocated into six groups: FS-F (Filtek bulk-fill Flow + Filtek Supreme Ultra, 3M) and GR-F (X-tra base + GrandioSO, VOCO), which were restored using a flowable bulk-fill composite as a base topped with a nanofilled or nanohybrid composite. FB (Filtek One Bulk-Fill, 3M) and AF (Admira Fusion X-tra, VOCO) were restored using a bulk-fill resin composite, while FS (Filtek Supreme Ultra, 3M) and GR (GrandioSO, VOCO) were restored incrementally with a nanofilled or nanohybrid composite. Restorations utilizing a nanofilled bulk-fill composite or traditional resin composites combined with a flowable bulk-fill base successfully restored fracture strength to levels comparable to that of intact teeth.

Taha et al. investigate the effect of ormocer, nanofilled, nanoceramic, and microhybrid composite restorative systems on the fracture resistance of maxillary premolars with Class II mesio-occlusodistal (MOD) cavities[8]. They found that during compressive load testing, teeth restored with microhybrid, ormocer, and nanofilled composites exhibited lower cuspal fracture resistance compared to those restored with nanoceramic composites.

Suhasini K et al. examine the clinical effectiveness of nanohybrid composite restorations utilizing resin-modified glass-ionomer and flowable composite liners [9]. Among forty patients, a total of eighty Class I restorations were performed, with one group using a resin-modified glass-ionomer cement liner and the other group employing a flowable composite liner (smart dentin replacement). They concluded that nanohybrid composite restorations with RMGIC and a flowable composite liner showed clinically satisfactory performance after 12 months.

Mandibular molars are selected due to their susceptibility to fractures caused by occlusal contact with the pointed and protruding palatal cusps of maxillary molars, which exert significant force onto the central groove of the mandibular molars. In the present study, it was observed that the lingual wall remaining thickness of 1.5mm showed the highest fracture resistance. This might be explained by the weakened state of the buccal cusp in extracted teeth, potentially caused by attrition. The lingual cusp generally shows greater resistance to fracturing than the buccal cusp. Attrition can cause a flatter wall and less cuspal inclination.

**Conclusion**

- The minimum wall thickness of the buccal and lingual wall in Class I should be kept at 1.5mm.
- Nanohybrid composite resin showed more fracture resistance than nanofilled and bulkfill composite resin.
- Greater marginal thickness can help preserve the fracture resistance of teeth.

**References**


1. Yadav R, Singh M, Shekhawat D, Lee SY, Park SJ. The role of fillers to enhance the mechanical, thermal, and wear characteristics of polymer composite materials: A review. Composites Part A: Applied Science and Manufacturing. 2023 Dec 1;175:107775.
2. Hong G, Yang J, Jin X, Wu T, Dai S, Xie H, Chen C. Mechanical properties of nanohybrid resin composites containing various mass fractions of modified zirconia particles. International journal of nanomedicine. 2020 Dec 8:9891-907.
3. Angerame D, Biasi MD. Do nanofilled/nanohybrid composites allow for better clinical performance of direct restorations than traditional microhybrid composites? A systematic review. *Oper Dent*. 2018;43(4):E191–E209. doi:10.2341/17-212-L
4. Bouvier D, Duprez JP & Lissac M (1997) Comparative evaluation of polishing systems on the surface of three aesthetic materials Journal of Oral Rehabilitation 24(12) 888-894

5. Czasch P, Ilie N. *In vitro* comparison of mechanical properties and degree of cure of bulk fill composites Clin Oral Investig. 2013;17:227–35
6. Pachore, P. J., Chokshi, S., Sanghvi, Z., Patel, B. D., Chudasama, K., & Malde, N. (2022). Comparative evaluation of fracture resistance of posterior teeth restored with recent composite resins: An in vitro study. International Journal of Health Sciences, 6(S8), 4413– 4426
7. Leyton BS, Rached RN, Ignácio SA, Souza EM. Fracture strength of extended class I composite restorations with different restorative techniques. Odontology. 2022 Apr;110(2):269-277. doi: 10.1007/s10266-021-00656-7. Epub 2021 Sep 14. PMID: 34519962.
8. Taha DG, Abdel-Samad AA, Mahmoud SH. Fracture resistance of maxillary premolars with class II MOD cavities restored with Ormocer, Nanofilled, and Nanoceramic composite restorative systems. Quintessence Int. 2011 Jul-Aug;42(7):579-87. PMID: 21716986.
9. Suhasini K, Madhusudhana K, Suneelkumar C, Lavanya A, Chandrababu KS, Kumar PD. Clinical performance of Class I nanohybrid composite restorations with resin-modified glass-ionomer liner and flowable composite liner: A randomized clinical trial. J Conserv Dent. 2016 Nov-Dec;19(6):510-515. doi: 10.4103/0972-0707.194030. PMID: 27994310; PMCID: PMC5146764.