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**Original Research**

# Comparative evaluation of the fracture resistance of maxillary premolars with Mesio-occluso distal cavities restored with Zirconomer, Amalgam, Composite and GIC: An in vitro study

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***ABSTRACT:***
**Background:** The fracture resistance of maxillary premolars with MOD cavities restored with zirconomer, amalgam, composite, GIC, resin modified GIC and miracle mix was compared in this study. **Material and Method**: Class II MOD cavities were prepared on the teeth. The teeth were divided into the following groups depending on the restorative material. Group 1-positive control, Group 2-negative control, Group 3-restored with zirconomer, Group 4-Restored with glass ionomer cement, Group 5-Restored with resin modified glass ionomer cement, Group 6-Restored with miracle mix, Group 7-Restored with amalgam, and Group 8-Restored with composite. The teeth after restoration were thermocycled and subjected to compressive loading in a Universal Testing Machine. **Results:** The teeth restored with composite showed the highest fracture resistance followed by teeth restored with zirconomer further followed by teeth restored with amalgam, GIC, RMGIC and miracle mix. **Conclusion**: Composite reinforces the teeth due to its adhesive nature.

**Keywords:** Zirconomer, Fracture resistance, Maxillary premolars, Universal testing machine

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## INTRODUCTION

In the oral cavity, restorations undergo stress from masticatory forces producing different reactions that lead to deformation, which can ultimately compromise their durability over time.[1] This is limited if the strength of restorative materials is close to the strength of the tooth structure.[2] The failure of dental restorations through recurring caries, marginal discrepancies, and tooth fracture are topics of substantial clinical significance.

According to a study conducted by Joynt *et al*, in 1987, [3] preparation of an occlusal cavity reduces the tooth stiffness by 20%. If a marginal ridge is also involved the tooth stiffness further reduces by 2.5 folds resulting in an overall 46% reduction in tooth stiffness. If both marginal ridges are included in the cavity preparation design, the stiffness decreases by 63%.[3, 4] Cavity preparation and endodontic treatment can cause higher stress concentration in dentin, compared with vital teeth, but proper restoration can minimize internal stresses.[5]

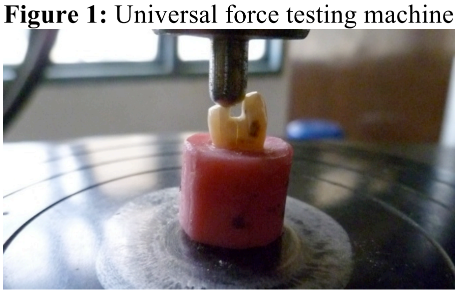
The basic purpose of the restorative materials is to substitute the biological, functional, and esthetic properties of healthy tooth structure. The compressive strength of a material is defined as the amount of stress required to distort the material in an arbitrary amount. Compressive strength is considered to be a critical indicator of success because high compressive strength is necessary to resist masticatory and parafunctional forces.[6]

This study evaluated the fracture resistance of extracted maxillary premolars with mesio occluso distal (MOD) cavities restored with zirconomer, amalgam, composite, glass ionomer cement, resin modified glass ionomer cement and miracle mix.

## MATERIAL AND METHODS

80 caries-free maxillary premolars extracted for orthodontic purposes were taken. Exclusion criteria included caries, fractured, cracked and dried teeth. Modelling wax was used to prepare moulds of 10 mm in diameter and length equal to the length of the respective root of the maxillary premolars. These moulds were used to make acrylic blocks into which the teeth were mounted. The teeth were embedded in self-cure resin, crowns exposed and the level of the resin was limited to 1 mm below the cemento- enamel junction. Class II MOD cavities were prepared with the 245 carbide bur. The occlusal preparation was 2 mm deep, with a width of one third the intercuspal distance. The proximal boxes were prepared at a width one third the bucco-lingual distance and depth of 1.5 mm axially with cavosurface angle of 90°.
The teeth were divided into the following groups depending on the restorative material being used. Each group had 10 teeth
Group 1 positive control (unprepared)
Group 2 negative control (prepared but not restored)
Group 3 restored with zirconomer (Shofu)
Group 4 Restored with glass ionomer cement [Ketac ™ Molar (3M ESPE)]
Group 5 Restored with resin modified glass ionomer cement
Group 6 Restored with miracle mix (Hi Dense, Shofu)
Group 7 Restored with amalgam (DPI high copper, Non-Gamma 2 amalgam)
Group 8 Restored with composite (Nano Composite, Coltene)
Then the teeth were thermocycled for 5000 cycles at 5°c and 55°c with each cycle corresponding to a 15 second bath at each temperature. Thermocycling was done in Polymerase Chain Reaction Unit at Central Potato Research Institute, Shimla. Each specimen was subjected to compressive loading in a Universal Testing Machine at PEC (Punjab Engineering College), Chandigarh. The compressive load was applied with a round stainless steel probe, 5 mm in cross section at a cross head speed of 1mm/ min until the cusp fractured and the fracture resistance was noted.

**Figure 1:** Universal force testing machine



**Statistical Analysis**
Data was entered in Microsoft excel spreadsheet, corrected for errors if any and analysed using SPSS version 21.0 Quantitative variables were presented as mean ±, standard deviation. One way analysis of variance (ANOVA) for comparison of means was used. For the post hoc comparisons the Tukey test was used. A two-sided 'P' value of < 0.05 was taken as statistically significant.

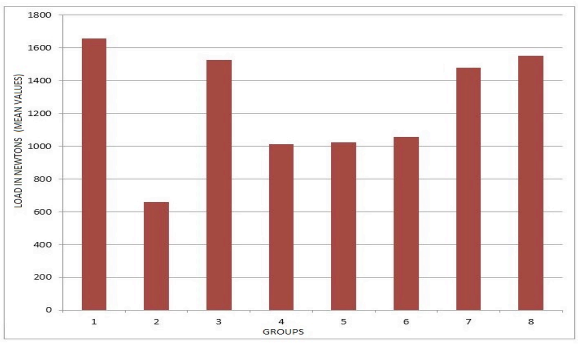
## RESULTS

Teeth in group 1 (positive control) need the maximum load application in order to fracture (M=1657, SD=20.57). Among the experimental groups teeth restored with composite (group 8) [M=1552, SD=13.98] have the highest fracture resistance followed by group 3 (teeth restored with zirconomer). Teeth restored with zirconomer (M=1525, SD=10.80) need more force or load application than teeth restored with amalgam (group 7), glass ionomer cement (group 4), resin modified glass ionomer cement (group 5) and miracle mix (group 6)

**Table 1:** Mean load and standard deviation

| Groups | Mean | SD |
|---|---|---|
| 1 | 1657 | 20.575 |
| 2 | 659 | 25.582 |
| 3 | 1525 | 10.801 |
| 4 | 1011 | 8.756 |
| 5 | 1022 | 13.166 |
| 6 | 1056 | 10.750 |
| 7 | 1480 | 8.165 |
| 8 | 1522 | 13.984 |

**Graph 1:** Graphical Representation of the mean load values




## DISCUSSION

Forces generated intra-orally during function vary in magnitude, speed of application, and direction. In this study force was applied vertically at a constant speed using a universal testing machine. When the probe of the Universal Testing Machine makes contact with the tooth, it acts as a wedge between the buccal and lingual cusps and promoting catastrophic types of fracture.

The present study was conducted using maxillary premolars because these teeth have a similar fracture potential compared to molar teeth.[7] Several investigations done by de Freitas CR, Hannig C regarding tooth fracture resistance have used premolars, which facilitates the comparison of results.[8, 9] Maxillary premolars were used also because studies have shown that these teeth are more prone to fracture due to the anatomical shape of maxillary premolars that creates a tendency for the separation of their cusps during mastication. Some authors have noted difficulty in obtaining uniform fracture strengths for human teeth due to natural variations in tooth morphology.[10] Maxillary premolars were selected as it is known that they show the least variations.

MOD cavities were designed in order to mimic a situation that may often be seen in clinical settings. Comparable situation has also been extensively reproduced in other clinical studies done by Yoshio et al.[11] The general effect of MOD cavity preparations is the creation of long cusps; thus, there is the need for a restorative material that not only replaces the lost tooth structure, but also increases the fracture resistance of the residual tooth. Reeh et al[12] reported MOD preparation results in loss of 63 % relative cusp rigidity.

Intercuspal distance is a factor in the strength of prepared teeth.[13] Past studies indicate that MOD preparations with an isthmus width greater than one fourth of the intercuspal distance have significantly reduced resistance to fracture. [14,15] A width of one third of the intercuspal distance was chosen for the occlusal portion of the preparation and one third of the total facial-lingual distance was used for the width of the proximal boxes to standardise the cavity dimensions. Similar cavity designs were used by Joynt et al.[16] to check the fracture resistance of posterior teeth.

The process of thermocycling was done to mimic the intraoral temperature variations. The artificial aging induced by thermal cycling accelerates hydrolysis of interfacial composite resin components. The higher thermal contraction/ expansion coefficient of the restorative material could generate stresses at the tooth-material interface; thereby weakening the adhesive bonding and decreasing the fracture resistance.[17] Group 1 with intact teeth needed the maximum value of force to fracture (mean 1657 N). The sound teeth presented highest resistance to fracture because of the rigidity and the integrity of the tooth structure. The fracture resistance of teeth in group 1was significantly ($P < .0001$) higher than the fracture resistance of teeth in all other groups. Samples in group 2, the maxillary premolars with MOD cavities which were left unrestored needed the least amount of force (659 N) to fracture and is statistically significant ($p < .0001$) This shows that MOD cavities weaken the tooth structure. This is in accordance with studies done by Ranga et al,[18] and Jyont et al,[16] this demonstrates the deleterious effect that cavity preparation has on the fracture resistance of teeth. Irrespective of the restorative system used, all of the restored teeth presented higher resistance to fracture when compared to the prepared, unrestored teeth because the "emptiness" of the preparation was replaced by rigid restorative materials. It has been shown the mean fracture strength for unrestored teeth with MOD preparation was 50% less than that of unaltered premolar teeth.[19] Group 8 (premolars restored with composite) displayed the highest fracture resistance (mean 1552 N ) among the experimental groups followed by premolars restored with zirconomer (group 3), (mean 1525 N). This is in accordance with the study done by Mohanty et al.[20] It has been suggested that the use of resin composite in restorations reinforces dental stiffness as the adhesive nature of the composite binds the cusps and decreases their flexion.

Teeth in group 3 (restored with zirconomer) have significantly ($P < 0.0001$) more fracture resistance (mean 1525 N) than teeth in all groups except for teeth restored with composite, group 8 (mean 1552 N) and unprepared teeth, group 1 (mean 1657 N). This is in accordance with the results of the studies done by Chalissery.[21] The explanation for zirconomer's high fracture resistance is the addition of zirconia as filler particle in the glass component of Zirconomer which improved the mechanical properties of the restoration by reinforcing structural integrity of the restoration and thus can be used in load bearing areas, such as posterior restorations.

Teeth restored with amalgam (group 7) had a mean fracture resistance of 1480 N which is significantly more than the fracture resistance of teeth restored with GIC, RMGIC and miracle mix. One possible explanation for the increase in resistance to fracture of teeth restored with amalgam versus prepared unrestored teeth is that prepared teeth restored with a material having a higher modulus of elasticity than dentin (such as amalgam) have increased resistance to fracture as was tested by Goel et al.[22]

Teeth restored with amalgam required less load to fracture as compared to teeth restored with composite as amalgam did not adhere to the tooth structure. Teeth in group 4 (restored with GIC) have significantly less fracture resistance (mean 1011 N) than teeth restored with zirconomer (mean 1525 N), amalgam (mean 1480 N), miracle mix (mean 1056 N) and composite (mean 1552 N (groups 3, 6, 7 and 8) but the difference in fracture resistance is insignificant between teeth restored with GIC (1011 N) and RMGIC (mean 1022 N) (group 4 and 5). The resin-modified glass ionomer cement presented higher fracture resistance values than the conventional GIC due to the inclusion of resinous polymers that present higher mechanical strength. These results were already expected, as observed in other studies by Xie et al, [23] and in the classic dental materials literature. Teeth restored with miracle mix have fracture resistance more than GIC as silver particles increased gelation of the cement. Fracture resistance of miracle mix was less than that of zirconomer because the simple mixtures of metal powders failed at the metal and polyacrylate matrix interface and this was the weak link.[24] Thus, the

restorative material helps the tooth with MOD cavities to restore its strength. Intact teeth have the highest fracture resistance and the prepared unrestored teeth have the least fracture resistance.
However further research is required to determine the fracture resistance of teeth with MOD cavities restored with different materials. The ideal restorative material which definitely increases the fracture resistance or prevents teeth from fracture when in function should be researched in both in- vitro and in -vivo studies.

## CONCLUSION

With the limitations of the study it is concluded that composite reinforce the teeth as the adhesive nature of the composite binds the cusps and decreases their flexion. Zirconomer's high fracture resistance is due to the addition of zirconia as filler particle in the glass component of Zirconomer which improved the mechanical properties of the restoration by reinforcing structural integrity of the restoration. Teeth restored with GIC, RMGIC and miracle mix have significantly less fracture resistance due to their poor mechanical properties and poor bonding abilities.

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