INTRODUCTION

A good restorative material has to stand up to the strain and wear induced by high stress during chewing.\(^1\) Dental amalgam has been the restorative material of choice for many decades, however, in recent years there has been increasing awareness about the safety of amalgam. The main concerns were about mercury toxicity that may affect human health and environment.\(^2\) Another disadvantage of extensive restorations in amalgam is that, since it does not stick to the dental structure, it does not reinforce the weak walls of the cavity.\(^3\) Removal of tooth structure via cavity preparation has been shown to weaken the teeth and increase their susceptibility to fracture. Even if the fracture does not occur, deflection of a weakened cusps may open the tooth-fracture interface and lead to micro leakage resulting in recurrent caries. Depending on the extent of the cavity, the restorative treatment is a pre-disposing factor for an incomplete or complete tooth fracture.\(^4\)

Resin composites are increasingly used for restorative purposes because of good aesthetic and capability of establishing a bond to enamel and dentin. The color stability, wear, fracture resistance of these materials have been greatly improved since their introduction which was about 50 years ago.\(^5\) Early composite materials were used only for anterior restorations because of their weak mechanical properties. In the past few decades, however dental composites have developed from an inferior resin material into the material of choice for the fabrication of highly aesthetic, durable posterior and anterior restorations in direct restoration dentistry.\(^6\) The main problems incurred with posterior composite restorations have been their tendency to form marginal gaps due to polymerization shrinkage and lack of strength. Composites are stressed severely when used for class II filling. Polymerization shrinkage stresses of dental composites are often associated with failures of bonded restorations. Several new materials have been developed with modifications in filler technology, composite materials were used only for anterior restorations because of good aesthetic and capability of establishing a bond to enamel and dentin. The color stability, wear, fracture resistance of these materials have been greatly improved since their introduction which was about 50 years ago.\(^5\) Early composite materials were used only for anterior restorations because of their weak mechanical properties. In the past few decades, however dental composites have developed from an inferior resin material into the material of choice for the fabrication of highly aesthetic, durable posterior and anterior restorations in direct restoration dentistry.\(^6\) The main problems incurred with posterior composite restorations have been their tendency to form marginal gaps due to polymerization shrinkage and lack of strength. Composites are stressed severely when used for class II filling. Polymerization shrinkage stresses of dental composites are often associated with failures of bonded restorations. Several new materials have been developed with modifications in filler technology,
filler distribution, filler loading etc. The basic formula is that higher the filler content, lower is the resin content which causes less shrinkage. In the quest for a higher filler load, several newer materials micro hybrids, packable composites and nano composites have been introduced.[9]

During the last decade, resin pre impregnated fiber reinforced composites have been introduced for dental use. Pre impregnation of the fibers has proven to be important to produce high quality fiber reinforced composite restorations.[11] The development of fiber reinforced composites (FRC) has given real opportunity to create reliable composite structures. FRC’s have highly favourable mechanical properties and their strength are superior to those of most alloys.[12] A new type of short fibre reinforced composite was launched recently whose properties are similar to those of composite base or dentin replacing materials. It consists of a resin matrix, E-glass fibers and inorganic particulate fillers. While packing, Short glass fibers are oriented.[13] Interface properties are critical to the performance of fiber reinforced composites because of high masticatory forces that are transferred across this interface.[14]

In this invitro study, Comparison and assessment of the fracture resistance of microhybrid, fiber reinforced and nanohybrid composite resins used in restoring class2 MOD preparation of maxillary premolars was done and the fracture resistance was measured by loading the specimens on a universal testing machine.

**METHODOLOGY**

**MATERIALS**

This in vitro study was carried out in Department of Conservative Dentistry and Endodontic, Royal dental college, Chalissery, aiming to Comparatively assess the fracture resistance of microhybrid, fiber reinforced and nanohybrid composite resins used in restoring class2 MOD preparation of maxillary premolars used in the study.

**Selection of samples:** 180 freshly extracted human maxillary premolar used in the study.

**Inclusion criteria:**
- Freshly extracted
- Intact
- Non carious
- Extracted for orthodontic reason

**Exclusion criteria**
- Teeth with caries
- Fracture
- Previous restorations
- Endodontically treated tooth

**List of materials**

1. Fiber-reinforced composite(ever-x posterior)
2. Nano hybrid composite (3M)
3. Microhybrid composite(Filtek™ Z250 Universal Restorative)
4. Etchant (3M ESPE Scotchbond™ Universal)
5. Bonding agent(3M ESPE Adper)
6. Normal saline solution 0.9%

**List of instruments**

1. Aiotar handpiece (NSK , Japan)
2. 245 tungsten carbide bur
3. Curing light (3M ESPE)
4. Universal testing machine
5. Digital vernier caliper

**METHODOLOGY**

180 recently extracted maxillary premolars collected by purposive sampling technique were used. Teeth cleaned off tissue fragments, visible debris using ultrasonic scaler and stored in 0.9% saline. For all specimens class 2 cavities (MOD) with standardization was prepared.

For all the specimens prepare class 2 cavities (MOD) with

- 2.0 mm pulpal depth
- 1.5 mm gingival depth
- 2.0 mm axial height

Parallel proximal walls with 3.0 mm bucco lingual width and occlusal isthmus width one third of intercuspal distance. A single periodontal probe was used as a guide. No bevel was performed except axiopulpal line angles. A single bur (#245) was used to cut four teeth only.

After the preparation of each tooth, the cavity was dried using gentle air blast and a matrix in a tofflemire matrix retainer used. Phosphoric acid etchant gel 37% was applied to the enamel and dentin (figure 9), and left for15seconds. After that it was washed with water spray for 10 seconds and air dried by oil free compressed air. Excess water was removed without overdrying the dentin. 3M Adper bonding agent was applied to the etched enamel and dentin using a disposable applicator tip (figure 10) for 20 seconds. The excess was gently air thinned for 5seconds until a uniform glossy appearance was obtained. Then bonding agent was light cured (figure 11), for 10seconds with a light curing unit (3M ESPE Elipar™ 2500 Halogen curing light). In all the specimens, composites was filled into the cavity using incremental technique as per the group divided and cured using the light curing unit (3M ESPE Elipar™ 2500Halogen curing light).

MOD cavities was restored with composites as follows:

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>Microhybrid</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>Nanohybrid</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>Fiber reinforced</td>
</tr>
</tbody>
</table>

All the groups consisted of 60 samples each

**Sample Analysis**

All the samples were mounted in an acrylic block (3×3×3) cm at CEJ using auto polymerized acrylic resin, with long axis perpendicular to base of block. All the specimens were subjected to compressive axial loading in universal testing machine.

A 1.94mm diameter metal bar was applied on buccal and lingual cusps of teeth. Cross head speed was 5mm/min until fracture happened. The force at which the tooth fractured was calculated in Newton as the fracture resistance. Statistical
analysis was performed using ANOVA test and results were obtained.

RESULT

Among the three different composite restorations, fiber reinforced composites showed much higher fracture resistance when compared to nanohybrid and microhybrid composites. Fiber reinforced composites had a mean fracture resistance of 1551.6683N. Nanohybrid and Microhybrid had a mean fracture resistance of 1066.88N and 768.67N respectively.

DISCUSSION

Transfer of stress is different in intact and restored tooth. Any force on the restoration produces compression, tension or shear along the tooth/restoration interface. To judge the failure risk of restored premolars by their load bearing capacity determined in an invitro setting it is important to consider what forces can be expected in actual clinical situations.

Restorations in posterior areas are subjected to functional loading. Compressive strength is important because of the forces acting while chewing. It is one of the strength of material in different force conditions, increased value represents increased strength of the material.

Sound teeth rarely fracture from masticatory stresses, but cusp fracture may occur in teeth with cavity preparations and restorations. A cavity preparation significantly weakens the remaining tooth structure. undermining weakened marginal ridges of molar teeth during cavity preparation include extension of occlusal cavity into the corresponding proximal surface. Class II cavities may induce caries recurrence at the gingival area, weakening of the tooth structure, in addition to periodontal problems.

The major predictors for marginal deterioration are shrinkage and micro leakage. Composites are subjected to polymerization shrinkage that occurs due to affiliation of resin molecules with one another and formation of chemical bonds which reduce the materials bulk. Shrinkage of composite results in stresses, cuspal deflection which in turn lead to enamel cracks, hypersensitivity, marginal degradation, microleakage.

Choosing a suitable resin based composite for a restoration in modern dentistry requires balancing a large number of requirements. This requires functional properties, including enhanced longevity of the restoratives by excellent mechanical properties like high strength, surface hardness, fracture toughness, optimized modulus of elasticity, low wear, low polymerization shrinkage etc.

Dental composites are composed of three different materials: the organic matrix; the inorganic matrix (filler) and an organosilane (coupling agent).

There are a few factors which can influence the result of fracture resistance studies. These include the tooth mounting method, type of load application device and cross head speed. During fracture strength testing, the point of contact between the loading bar and the occlusal surface of the teeth may differ from one sample to other. It was concluded that the best method to measure the fracture resistance of premolars was to use a cylinder of a defined diameter.

The hardness of the resin composite is influenced by its constitution, which included the type and matrix composition and the amount and particle shapes. Filler shape and size influences the inorganic content rise: spherical particles of regular size are responsible for this increase. A greater percentage of inorganic filler may improve the mechanical, physical and chemical properties of restorative resin based material.

A number of studies assessed the effect of fiber re-inforced composite on the strength of the posterior teeth and reported different results depending on the type of fiber used, different techniques of fiber insertion and various testing methods.

In the current study, MOD cavity design was prepared in premolar teeth as it would weaken the remaining tooth structure and favour cuspal fracture. The findings of the current study were similar to that of previous studies. The most traditional dental composites for restoration are hybrid and microfilled types. They offer intermediate esthetic properties but excellent mechanical properties due to the filler content with different average particle sizes. Microfilled composites were launched to overcome the problems of poor esthetic properties. Unfortunately the mechanical properties were low. Based on nano scale bulk technology new classes of dental composites, so called nano composites, have been developed.

Nano composites, that is nano filled and nano hybrid possess similar resin matrix composition but differ in their filler particle type, size and distribution. Nanofilled composites consists of nanometer particle size throughout the resin matrix, whereas nanohybrids combines nanometer sized particles with more conventional filler technology.

As compared to conventional composites, nano composites possess a greater elastic modulus and higher flexural, tensile and impact strengths, along with improved abrasion resistance. Greater filler loading also consequently reduces the composite resin by increasing hardness and fracture resistance by reducing the viscosity.

In one of the studies, they stated that the number of cycles shows the durability of the composites. The number of cycles is the function of chewing and biting action by a human. The more are the number of cycles, the longer a composite work properly.

According to the results obtained from this current study, fiber reinforced composite had more fracture resistance when compared to micro hybrid and nano hybrid composites. These findings were similar to that of previous studies were they compared mechanical properties of fiber reinforced composite with bulk filling composites.

This may be explained as, stress transfer from the polymer matrix to fibers is necessary for a fiber to be effective in polymer reinforcement. This is achieved if the fibers have an equal or greater length than the critical fiber length. Fiber critical length depends on factors such as shear strength of the matrix, strength of the interfacial bonds and the tensile strength of the fiber.

Fibers are used to improve flexural strength of composite resins. The orientation of fiber layer affects flexural strength of

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conclusion

Fiber reinforced composites have elastic modulus very close to dentin, which might act as a stress breaker between the composite resin and dentin.\[11\]

Other possible explanations could be the properties of the fiber itself, chemical bonding between the resin and the fiber and also the presence leno weave which increases crack resistance and deflection as well as resistance to shifting within the matrix.\[5\]

The fiber functions as a crack stopper by supporting the surface composite layer. Polyethylene fiber is believed to create a change in stress dynamics at restoration/adhesive interface. Also fibers replace a part of composite, resulting in a decrease in overall volumetric contraction of the composite and blunt the crack and can act as a barrier to crack propagation and decreasing the shrinkage stress.\[29\]

In the result fiber reinforced composite shows more cohesive type of failure on the tooth structure. Which may be due to the presence of short E-glass fibers that acted as crack stopper and hence the propagation of the fracture. Nanohybrid composites showed more mixed type of failure. It may be because of the presence of nanoclusters which would have resulted in decreased conversion rate.\[2\]

In this study though every effort has been made to standardize the tooth size, cavity preparation, tooth morphology, the changes occurring with age, effect of the periodontal ligament, the complex chewing patterns etc are difficult to simulate. Therefore, further long term studies are needed to evaluate the result.

CONCLUSION

Remarks

Fiber reinforced composites can be a material of choice for restoration of large class II cavities. Nanohybrid composites also showed good results of fracture resistance but comparatively lesser than that of fiber reinforced composites. Micro hybrid composites showed least value of fracture resistance.

Limitations of the study

The changes occurring with age, effect of the periodontal ligament, the complex chewing patterns etc are difficult to simulate.

Clinical applications

Posterior teeth has to have restorations with high fracture resistance values so that it can withstand the masticatory load. Based on the result of this study fiber reinforced composites can be used in higher stress bearing areas like posterior teeth.

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