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Dentistry

EVALUATION OF FRACTURE RESISTANCE IN MAXILLARY PREMOLAR TEETH RESTORED WITH FLOWABLE RESIN-BASED COMPOSITES AS LINER UNDER PACKABLE COMPOSITE – AN IN VITRO STUDY

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ABSTRACT **Objective(s):** To evaluate the effect of different flowable liners on fracture resistance in maxillary premolars restored with bulk fill composite. **Materials and Methods:** 72 extracted human maxillary premolar teeth were collected. The cavities (n=12) were prepared and randomly divided into 5 groups. Group I was positive control, Group II was negetive control, group III, IV, V were lined with Neospectra ST, Tetric N Ceram, and Filtek 3M liners respectively and all of them were further restored using Tetric N Ceram bulk fill composite. Group IV was only Tetric N-Ceram bulk fill packable composite. Fracture resistance were recorded using a universal testing machine. **Results:** Fracture resistance was the least for group 4 in which Tetric N-flow liner was used followed by tetric N-ceram packable composite. **Conclusion(s):** In this study, application of liner did not significantly improve fracture resistance, however considering the other advantages of liner application such as reduction of cuspal deflection, adaptation and stress distribution.

KEYWORDS : Fracture resistance, Filtek 3M, Neospectra ST and Tetric N Ceram

INTRODUCTION

Current research has evaluated topics associated with the weakening of the tooth structure when performing mesial-occlusal-distal preparations (MOD) and also topics regarding the effect of adhesive restorations in strengthening the remaining dental tissue.[1,2,3,4] Furthermore, when a significant amount of the dental structure is lost, there is an increase in fragility and susceptibility to fracture.[5,6]

MOD (mesial-occlusal-distal preparations) cavity preparations involve a substantial amount of tooth removal and constitute a potential weakness over the long term in the event of any degradation of the composite-tooth interface. According to Soares *et al*.[5] a wedging effect occurs between the palatal and buccal cusps, leading to a reduction of fracture resistance and a higher occurrence of catastrophic fracture in case of application of load on a heavily restored tooth. It has been stated that the amount of tooth tissue removed affects the strength of the tooth, particularly in relation to the width of the occlusal section of the preparation.

The compression fracture test with the help of universal testing machine is a method used to assess the maximum resistance of a restored tooth and can be performed to quantify the influence of different factors involved in restorative procedures. The compression test usually produces loads that exceed the load limit exerted by the normal movements of the oral cavity. Nevertheless, the test reproduces some real situations, such as when an individual chews a solid material of reduced dimensions, in which the force is distributed over the occlusal surfaces of the posterior teeth.[6]

Despite the difficulties related to applying direct composites in posterior teeth, it has been determined that the development of bonding and restorative systems has contributed to the longevity of restored teeth.[7] However, the clinical consequences of polymerization shrinkage represent the main reason for replacing resin-composite restorations, which explains why polymerization shrinkage is regarded as the main limitation of current resin composites.[8]The curing polymerization stress can form enamel microcracks and fracture in direct composite restorations with a high C factor such as extensive Class I and mesio-occluso-distal (MOD) Class II cavities[9,10].

Flowable composites were produced as an intermediate thin layer suggesting to absorb the shrinkage stress. This material presents higher flow, low viscosity, greater elasticity, and less filler loading in their formulation[11,12], besides providing easier insertion into a cavity and better marginal adaptation. It was reported that flowable bulk-fill composites had better marginal seals compared to packable bulk-fill composites[13] So, these materials are practically placed in cavities with a small size or complicated design.[14]

Hence, this study was performed to evaluate the fracture resistance of maxillary premolars with MOD cavities that were filled with nanohybrid resin composites lined with three different nano flowable resin composites.

MATERIALS AND METHODS:

Ethical approval was obtained from the institutional Ethics Committee, M.P. Shah Govt. Medical College and Guru Gobind singh Hospital, Jamnagar (Ref. No.72/02/2022). A total of 72 sound-extracted maxillary premolars were collected for this study. For standardization, teeth with the following crown dimensions were included: 11mm bucco-lingual distance and 9 mm mesiodistal distance. The collected premolars were checked under 10x stereomicroscope for any cracks, developmental defects, caries and were discarded if found any. Selected premolars were carefully cleaned with an ultrasonic scaler, and disinfected with 0.2% sodium azide solution for 48 hrs. Then they were stored in normal saline at room temperature, until the time of test to prevent dehydration. The teeth were divided into 6 groups of 12 teeth in each group. In this study, 3 flowable lining materials were used.

Group 1 – Positive control group (Intact teeth)

Group 2 – Negative control group (Prepared teeth without restoration)

Group 3 - Neospectra ST Flowable liner with Tetric N Ceram bulk fill packable composite

Group 4 - Tetric N Ceram Flowable liner with Tetric N Ceram bulk fill packable composite

Group 5 -Filtek 3M Flowable liner with Tetric N Ceram bulk fill packable composite

Group 6 - Tetric N Ceram bulk fill packable composite

Two-step etch and rinse adhesive system (Tetric N- Ceram) and Tetric N- Ceram bull fill packable composite restorative system were used.

Fig. 1 Materials used for study

Tooth preparation:
A non-retentive MOD slot cavity were prepared, with dimensions of 4±0.3 millimeters in depth (without axial wall) and 2±0.3 millimeters in facio-lingual width following the conventional outline form. Each cavity was prepared using carbide bur No.245. The bur was changed after every 5 preparations. A graduated periodontal probe was used to check the depth of the cavity. For mounting the prepared teeth, polyvinylchloride (PVC) retention tubes in a diameter of three centimeters were used. The roots of each tooth were positioned at the center of the tube, with the long axis parallel to the sides of PVC tube. Each tube was filled with acrylic resin in the dough stage, leaving the crown and two millimeters of the root below the cementoenamel junction uncovered. In Positive control group, no tooth preparation was performed. In negative control group, teeth were prepared according to above dimensions mentioned but were not restored with any of the material.

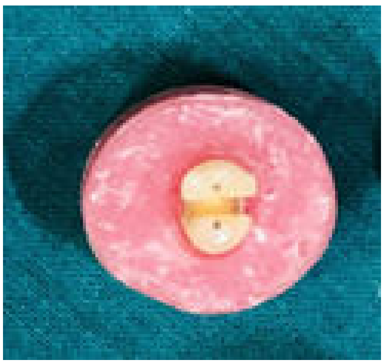


Fig. 2 Tooth preparation

Restorative procedure:
Etching and rinsing – 37 % phosphoric acid etching for 30 sec followed by rinsing for 30 sec followed by air drying.

Application of bonding agent – for 10 sec followed by blot air dry and curing for 20 sec.

Application of flowable composite namely Neospectra ST in group 3(12), Tetric N Ceram in group 4 (12) and Filtek 3M (12) in group 4 in thickness of 2 mm.

A 2 mm layer of Tetric N Ceram bulk fill packable composite were placed following placement of flowable composite.

Both the composite segments were cured using blue phase light (800 mW/cm^2) for 40 sec each. The teeth were then immersed in distilled water at room temperature (23±1°C) until further use.

Fracture resistance test:
The restored specimen of all the 6 groups were placed in a universal testing machine with the long axis of the roots parallel to the load direction. A stainless-steel ball (4 mm diameter) was used to load the specimens until fracture, with a crosshead speed of 1 mm/min. The loading site was the central fissure and the ball contacted to occlusal surface of the restorations and the buccal and palatal cusps of the teeth, while the mean loads were recorded in Newtons.

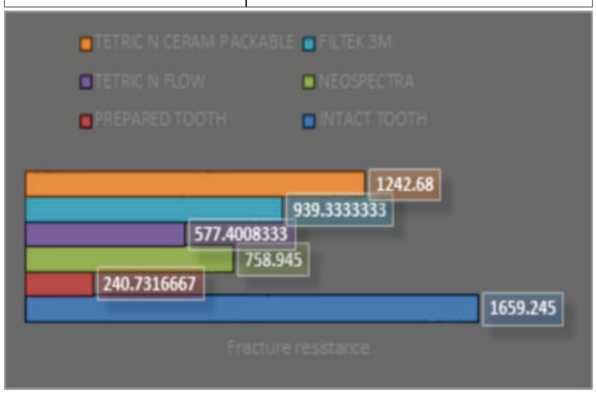
Figure.3- Universal testing machine

The failure modes (adhesive, cohesive, or mixed) were evaluated and assessed using standard criteria at a magnification of 20× in a stereo microscope. Fractures were identified as 'Restorable' if they were limited to the above the cementoenamel junction and included retention failures and 'Non-restorable' if the fractures extended below the cementoenamel junction.

RESULTS:-
The mean fracture resistance of all the groups is mentioned in table 1 and graph 1. Load needed to fracture experimental groups (group 3,4,5) in which liners were applied showed lesser value than samples restored with packable tetric N ceram bulk fill composite. Fracture resistance of all experimental groups shown to have a lesser value than the intact tooth and greater than the prepared tooth.

Table 1 – Mean fracture resistance of all groups

GROUPS	MEAN FRACTURE RESISTANCE
GROUP 1	1659.245
GROUP 2	240.7317
GROUP 3	758.945
GROUP 4	577.4008
GROUP 5	939.3333
GROUP 6	1242.68



Graph 1 - Mean fracture resistance of all groups

Among all the groups compared, a mean value of fracture resistance was the least for group 4 in which tetric N-flow liner was used followed by tetric N-ceram packable composite. Followed by that group 3 (neospectra ST) has mean fracture resistance of 758.94 and filtek 3M has 939.33. This values suggested better fracture resistance of filtek 3M liner group.

Statistical analysis: -
Comparison of group 1 with all the experimental groups was done using an unpaired t test which showed a statistically significant difference suggesting all the material has significantly lesser fracture resistance than a natural tooth. Only a comparison of a natural tooth with packable bulk fill composite (without liner) showed nonsignificant difference.

Table 2 Intergroup comparison with natural tooth

Comparison	P VALUE
Group 1vs Group 2	<0.001*
Group 1vs Group 3	<0.001*
Group 1vs Group 4	<0.001*
Group 1vs Group 5	<0.001*
Group 1vs Group 6	0.006798

Table3 intergroup comparison of all experimental groups

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Restorable	10(83.33%)	3(25%)	4(33.33%)	5(41.67%)	8(66.67%)	9(75%)
Non restorable	2(16.67%)	9(75%)	8(66.67%)	7(58.33%)	4(33.33%)	3(25%)

Intergroup comparison all experimental groups showed statistically significant difference except comparison of group 5 and 6 which has p value 0.05 which indicates tetric N ceram bulkfill packable composite and filtek 3M liner under Tetric N ceram has statistically insignificant difference in terms of fracture resistance of premolar tooth in restoration of MOD cavity preparation.

This result can be coded as group 1>group 6>group 5>group 3>group 4>group 2 for comparison of fracture resistance of premolar tooth with MOD cavity preparation.

Table 4 Percentages of restorable and non-restorableb sample

Figure 4 Restorable

Figure 5 Non restorable

DISCUSSION:-

The propensity of a particular restoration to fracture in the oral cavity is very difficult to measure since it is affected by many factors. These factors include the material composition and properties, cavity size, integrity of the tooth structure, and the effectiveness of bonding. Bulk-fill RBCs were developed to provide a faster restoration procedure and to minimize the possibility of void entrapment or contamination between the layers. 20

A higher failure load is accepted to be the criterion for better strength and durability characteristics of dental restorations.[15] Mondelli et al.[16] reported that maxillary premolars with MOD cavity preparations close to 2.5 mm deep presented only 36% of the fracture resistance recorded for that of sound premolars. That is related to the smaller remaining tooth structure following MOD cavity preparations, similar to the study of Burke et. al.[17] however in this study comparison of mean fracture resistance of negative control group and positive control group showed 85.5 % reduction of fracture resistance than intact tooth. As premolars are the component of load bearing areas during mastication, reestablishment or rehabilitation of the tooth preparation with restoration that can bear the masticatory forces is necessary.

An important characteristic of lining material is their ability to adequately resist compressive forces during restoration placement and later, during mastication. [15] for that reason effect of liner application underneath packable composite restoration was studied.

Stereomicroscope results show positive control group was highly restorable compared to other groups. In experimental groups filtek 3M shows more restorable fracture compared to other groups.

On the basis of above-mentioned result, it can be said that without liner, bulkfil packable composite has performed better which might be attributed to higher filler content. Prepolymerized fillers consist of organic resin and inorganic fillers that are cured and then milled or ground down, producing resin filler particles that are added to the nonpolymerized resin and inorganic fillers. They are usually added to increase filler loading.[22], One of the major limitations of these fillers is the weak bond between the prepolymerized particles and the clinically cured resin matrix that decreases the tensile strength of the composite. The poor integration between prepolymerized fillers and the resin matrix is related to the difficulty of silanization. This is due to a lack of active binding sites since they have already been cured.[21]

Result of this study coincides with study done by Al-Naheden et. Al.[19] who has concluded that the new high-viscosity bulk-fill composite restorations seem to have adequate fracture resistance.

Our result was contradicting to study done tugza toz et. Al.20 who has concluded that no difference of fracture resistance in packable bulk fill group and lined bulk fill group.

For evaluation of their capability to bear occlusal and masticatory force in individual, mean fracture resistance of all the groups can be compared with mean load applied during mastication as well as in parafunctional habit for male and female.

Maximal biting forces in normal occlusal in male and female is 793.80±129.78 and 522.60±147.99 respectively, in parafunction habit cases male and female force are1058.4±68.67 and 811.80±27.60 respectively[18]. These values are lesser than mean fracture resistance of all the experimental groups except group 4 which has a fracture resistance of 577.4N.

CONCLUSION:-

In this study, application of liner did not significantly improve fracture resistance, however considering the other advantages of liner application such as reduction of cuspal deflection, adaptation, stress distribution, bulk fill flowable composite liner along with bulk fill packable composite restorations are indicated in premolar tooth since it can bear masticatory load adequately and it should be used with caution in cases of parafunctional habits.

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