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Fracture resistance of premolar teeth with class II preparations restored with light cured composite with beta quartz inserts, light cured' composite and silver amalgam in comparison with intact unrestored teeth

- An in vitro study

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ABSTRACT

An vitro study was designed to evaluate the fracture resistance of maxillary premolars with class II disto occlusal preparations restored with light cured composite with beta quartz inserts, light cured composites layered incrementally and silver amalgam in comparison with intact and unrestored teeth. Sixty freshly extracted maxillary premolars were randomly divided into 6 groups of 10 teeth each. All the 60 specimens were then subjected to a compressive load in an Universal Testing Machine (Hounsfield). The loads required to fracture the teeth were recorded and the data obtained were subjected to statistical analysis and the following results were arrived, Teeth restored with light cured composite with beta quartz insert showed higher values than light cured composite placed in horizontal increments. The use of the megafiller increased the filler-resin ratio and reinforced the tooth. Composite with beta quartz inserts was more resistant to tooth fracture than silver amalgam.

Teeth restored with light cured composite incrementally placed in oblique layers

Produced a higher fracture resistance than any other group and showed the closest value to the intact teeth. This was followed in descending order by light cured composite with beta quartz inserts, silver amalgam and light cured composite placed in horizontal increments. As a class II restorative material silver amalgam exhibited greater fracture resistance than bulk composite resin placed in horizontal increments.

INTRODUCTION

For several years clinicians have recognized the importance of a conservative approach to cavity preparation with the view to maintain the strength of the tooth [4,11,14,19,27] and to reduce the incidence of fracture. Teeth weakened by restorative procedures should be reinforced by restorative materials to strengthen the remaining tooth structure. Amalgam does not bind the walls of the cusps together and does not strengthen the remaining tooth[10,15,16,19,21,29]. The advantages of bonded restoration is the conservation of tooth structure as well as tooth reinforcement. Resin bonded restorations replace the tooth's rigidity which is lost after cavity preparation, and provide splinting of cusp [18,30]. The clinical performance of newer dental composites has been significantly improved over the past decade by incorporation of high concentrations of finely ground fillers to provide adequate strength and excellent wear resistance. However these exhibits polymerization shrinkage, to negate the influence marginal sealing[8].

To reduce polymerization shrinkage preformed tooth colored, glass ceramic inserts of beta quartz which possess good strength and esthetic properties are used as mega fillers. They are designed to fit Class I, Class II and Class III cavity preparations and are available in standardized shapes and sizes. By bulk replacement of the composite resin, these inserts increase the filler-resin ratio of the restorative material[9]. The reduction in resin bulk, therefore results in lesser polymerization shrinkage stresses and also lesser termal expansion since inserts have a coefficient of thermal expansion lower than that of tooth structure[3,7].

MATERIALS AND METHODS

Sixty non-carious, unrestored human maxillary premolar teeth extracted for orthodontic treatment were used as test specimens. Each of these test samples was mounted in a base of hard dental stone enclosed within a metal ring of 2cm diameter exposing only the crown portion. The stone investment was allowed to set for 24 hours. They were randomly divided into 6 groups of 10 teeth in each group and color coded for Identification (fig 1). Standardized class II disto-occlusal cavities were prepared on specimens of Group 2 to Group 6 and then restored with the following restorative materials (fig 2).

- Group 1 - Sound, unprepared teeth
- Group 2 - Disto-occlusal cavity prepared but unrestored
- Group 3 - Disto-occlusal cavity prepared and restored with light cure composite with beta quartz inserts.
- Group 4 - Disto-occlusal cavity prepared and restored with light cured composite incrementally placed in horizontal layers.
- Group 5 - Disto-occlusal cavity prepared and restored with light cured composite incrementally placed in alternating oblique layers.
- Group 6 - Disto-occlusal cavity prepared and restored with high copper silver amalgam.

Table I - Materials used in this study

Beta quartz glass ceramic inserts	Lee Pharmaceuticals, USA
Total Etch	Vivadent
Binding agent	Excite, Vivadent
Composite resin	Tetric Ceram
Silver amalgam	Solila alloy

In Group 3, the beta quartz 3 inserts (fig3) which are in the form of preformed inlays were tried into prepared cavity for a test fit. The L-shaped insert was used for the proximal box and a round cylinder insert was used for the remaining occlusal cavity. After etching a layer of dentin bonding agent was applied to the cavity and light cured for 20 seconds. A transparent celluloid matrix strip with a transparent matrix holder was applied and nearly half the volume of the cavity was filled with the composite restorative material. The L-shaped insert for the proximal box and round cylinder insert for the occlusal cavity were placed into the soft composite material. The composite restorative material was now packed to adapt uniformly to all surfaces of tooth and insert. The displaced composite restorative material was cut and removed. The restoration was then light cured for 40 seconds and the handle of the insert was cut and removed. The excess composite was contoured and finished to give a smooth surface.

In Group 4, after the application of etchant and bonding agent, composite resin was placed in several horizontal layers and incrementally cured. In Group 5, composite resin was placed after etching and application of bonding agent in alternate oblique layers and incrementally cured and finished as described for Group 3. In Group 6, the teeth were restored with high copper silver amalgam and polished after 24 hours.

Each of the color coded samples was then subjected to a compressive load of a cross-head speed of

Fig 1: Six groups of color coded test specimens

Fig 2: Restorative materials used in the study

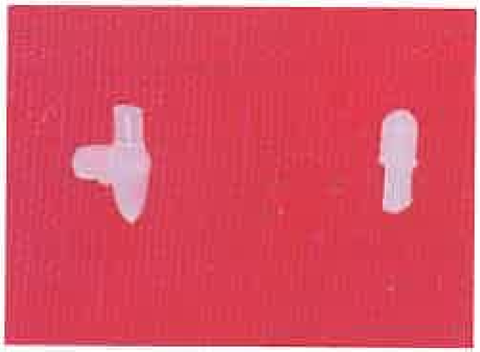


Fig 3: Beta quartz glass ceramic inserts

Fig 4: group 1 and 2 split the tooth through pulpal floor extending into root

Fig 5: Most of the fractures involved the palatal cusp in group 1

Fig 6: With beta quartz inserts fracture separated cusps with restoration being intact

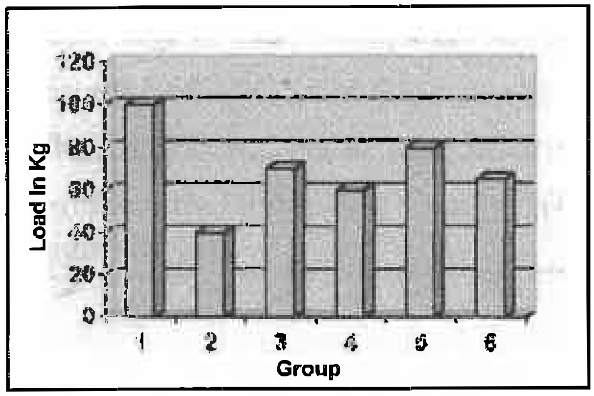
Fig 7: Fractures occurred through amalgam restoration leading to dislodgement or fracture of restoration itself

0.lmm per second (0.23 inch/min) to the point of fracture for each specimen test in an Universal Testing Machine (Hounsfield). The loads required to fracture the teeth were graphically recorded in kilograms (Kgs) and the data obtained were subjected to statistical analysis.

Table II - Mean and SD of compressive load required to fracture ten test specimens in the six different groups

Test group	n	Mean	Standard deviation
Group 1	10	104.65	13.59
Group 2	10	48.88	6.25
Group 3	10	73.62	15.52
Group 4	10	63.46	7.98
Group 5	10	84.05	14.03
Group 6	10	71.94	6.96

Mean Load required to fracture specimens in Group 1 to 6



Group 1 - Intact teeth

Group 2 - Prepared, unrestored teeth

Group 3-6 - Teeth restored with light cured composite with beta quartz insert (Gr.3), light cured Composite placed in horizontal increments (Gr.4), light cured composite placed in oblique increments (Gr.5) and high copper silver amalgam (Gr. 6)

Table III - Results of one-way ANOV A to compare the mean compressive load in the six different study groups

Source of variation	Df	Sum of squares	Mean sum of squares	F. ratio	P.value
Between Groups	5	17860.2	3572.0	27.71	< 0.0001
Within groups	54	6961.8	128.9		
Total	59	24821.9			

RESULTS

The results are presented in Tables II and III. The mean compressive load in Group1 (104.65 ± 13.59) was significantly higher than Groups 2,3,4,5 and 6 (P<0.05). Similarly the mean compressive load in Group 5 (84.05 ± 14.03) was significantly higher than Groups 2 & 4 (P<0.05). Also, the mean compressive load in Group 3(73.62 ± 15.52) and Group 6(71.94 ± 6.96) was significantly higher than Group 2 (48.88 ±6.25) P<0.05 was considered as the level of significance.

DISCUSSION

A restored tooth tends to transfer stress differently than an intact tooth. Any force on the restoration produces compression, tension or shear along the tooth/ restoration interface. Since enamel is no longer continuous, its resistance is much lower. Therefore, most restorations are designed to distribute stresses onto sound dentin, rather than to enamel. Once in dentin, the stresses are resolved in a manner similar to a normal tooth. This study was designed to evaluate the fracture resistance of teeth of 6 groups of samples. Prepared but unrestored teeth (Group II) showed the least mean compressive load (48.88) as compared to intact teeth (104.65).

Segura and Riggins[28] did not find any appreciable difference in fracture resistance between composite resin with beta quartz insert and the composite resin group.

Contrarily Rada[26] in his study observed that beta quartz inserts improve restoration strength, minimize marginal contraction gaps and micro leakage and allows good proximal contacts and contours, as it reduces polymerization shrinkage. Kiremitci et al[1] also concluded that glass ceramic inserts improve the overall properties of resin composite restorations while maintaining a conservative and direct approach to restoration placement.

In this study it was shown that the mean compressive load of teeth restored with light cured composite with beta quartz glass ceramic inserts (73.62) was significantly higher than Group 2 (48.88). Significantly composite resin with beta quartz ceramic inserts exhibited an increase in fracture resistance of 10 kg as compared to bulk composite resins placed in horizontal increments. Similarly composite resin with beta quartz inserts showed higher fracture resistance than silver amalgam restorations.

It was observed that obliquely placed composite resin group showed much higher values (84.05) than the composite-resin placed in horizontal increments (63.46). Composite resin placed in oblique increments produced an interlocking and contributed to the overall strength of the restoration. It also helped to bind the walls of the prepared cavity and reinforced the tooth better. This concurs with the findings of Mc Cullock [22,23], Jensen[13] and Wieczkowski [32] who also reported that diagonal placement technique could significantly reduce the degree of cuspal fracture.

Silver amalgam was widely advocated for posterior teeth before the advent of composite resins. Amalgam exhibited well sealed margins due to the formation of corrosion products. This greatly helped to reduce micro-leakage. However, the discoloration exhibited by this material was shown to be a major disadvantage. Discoloration was also evident in the adjacent areas of the tooth. Hence for esthetic reasons amalgam was gradually replaced by tooth colored materials. However, it is questionable whether these tooth colored materials could bring about the desired mechanical properties of amalgam. As regards fracture resistance it was shown in this study that horizontal incremental layering of bulk composite resin (63.46) was inferior to amalgam restoration (71.94). However when composite resin was incorporated with beta quartz, it showed improvement in fracture resistance (73.62). Incrementally placed composite resins showed much greater fracture resistance than silver amalgam restorations (71.94).

This study investigated the role of these restorative materials in matching the strength of remaining tooth structure. It was observed that composite resin placed in oblique increments resisted the tooth better against fracture. This indicates that these resins could reinforce the tooth structure better. It was seen that the highest value obtained in-group 6 was comparable to the highest value of group 5. This means that in some instances silver amalgam was similar in strength to the composite resin placed in oblique increments. Silver amalgam, a time tested material which has been widely advocated as a posterior restorative material showed a mean compressive load significantly higher than composite placed in horizontal increments (63.46).

The several variations in morphology present among teeth in an invitro study should be considered. These include the angulation of cuspal inclines to force application, thickness of enamel and other inherent weaknesses present in the tooth. Variations could have also existed in the bulk of the remaining tooth structure after preparation. Besides these variations- the forces generated intra-orally during function vary in magnitude, speed of application and direction. While the forces applied to the teeth in this study were at constant direction and speed and they were increased continually until fracture. Further the masticatory forces could not be duplicated laboratory. This study was only intended to determine fracture resistance of teeth restored with different materials within a known parameter of speed and direction of application for evaluating the role of individual restorative materials and their contribution to the overall strength of the tooth.

The advent of composite resins brought about several advantages such as tooth reinforcement and improved bonding. This study indicated that light cured posterior composites placed in oblique increments helped to match the strength of remaining tooth structure and was the only group, which showed nearest value to the unprepared teeth.

Each group had a peculiar pattern of tooth fracture when the load was applied. In Groups 1 and 2 fractures generally separated one cusp at its base near the CEJ or split the tooth through the pulpal floor extending into the root (fig 4). Most of the fractures involved the palatal cusp in group 1(fig 5); In Group 3 with beta quartz inserts fracture separated the cusps with the restoration being intact (fig 6). In group 4 and 5, a fracture separating one cusp was seen. Fractures splitting the tooth were rare. In Group 6 70%of the fractures occurred through the amalgam restoration leading to dislodgement or fracture of the restoration itself (fig 7). In the remaining 30% the filling was intact. The fractures occurring in Group 6 could be related to bulk fractures of silver amalgam which occur in clinical situations.

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