Cusp resistance to fracture of posterior teeth restored with fluoride release restorative materials

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ABSTRACT

The aim of this study is to investigate the effect of different fluoride release restorative materials (resin modified glass ionomer, composite resin and conventional type of glass ionomer) on fracture resis-tance of the restored teeth.

Forty recently extracted human maxillary premolar teeth were used in this study. The teeth were mounted in acrylic resin inside a plastic ring by the use of a surveyor.

The specimen randomly divided into five groups: Group A: Five intact teeth; Group B: Five teeth prepared but not restored; Group C: Ten teeth restored with resin modified glass ionomer (Vitremer); Group D: Ten teeth restored with composite resin (Tetric); and Group E: Ten teeth restored with conventional type of glass ionomer (Ionofil).

Class II mesio–occluso–distal cavity preparation was made for the teeth of Groups B through E.

The specimens were thermocycled (5 ºC to 55 ºC) for 100 cycles, stored for one week at 37 ºC in distilled water and then fractured by occlusal force.

The statistical analysis of the results showed that resin modified glass ionomer and composite resin significantly increase the resistance of prepared teeth to fracture.

Key Words: Tooth fracture, composite resin, glass ionomer.

الخلاصة

إن الغرض من هذه الدراسة هو تقويم تأثير الأنواع المختلفة والمحررة للفلورايد من مواد الحشوة (الحشوة المزججة مع الراتنج والراتنج المركب والحشوة المزججة التقليدية) على مقاومة كسر الأسنان المحشوة.

تم إجراء هذه الدراسة باستخدام أربعون من الأسنان السليمة والمقلوعة حديثاً وتم تثبيت الأسنان في مادة الأكريلك داخل حلقة بلاستيكية وباستخدام جهاز التخطيط.

قُسِّمت العينات بصورة عشوائية إلى خمس مجاميع: المجموعة "أ": خمس أسنان سليمة، المجموعة "ب": خمس أسنان مُحَضَّرة ولكن غير محشية، المجموعة "ج": عشر أسنان تلقت حشوة من نوع الحشوة المزججة مع الراتنج (Vitremer)، المجموعة "د": عشر أسنان تلقت حشوة من نوع الراتنج المركب (Tetric)، والمجموعة "هـ": عشر أسنان تلقت حشوة من نوع الحشوة المزججة التقليدية (Ionofil).

تم عمل حفرة من الصنف الثاني للأسنان في المجموعة الثانية والى المجموعة الخامسة، بعد ذلك خضعت العينات لعملية التدوير الحراري (٥–٥٥) درجة مئوية لمدة ١٠٠ مرة وحُفظت في الماء المقطر بدرجة حرارة ٣٧ درجة مئوية لمدة أسبوع واحد، ثم كُسِّرت بواسطة تسليط قوة.

أظهرت نتائج التحليل الإحصائي أن الحشوة المزججة مع الراتنج والراتنج المركب لهما تأثير معنوي في زيادة مقاومة كسر الأسنان المُحَضَّرة.

INTRODUCTION

Any preparation appears to decrease a tooth's resistance to fracture.[1, 2] Conservative preparation design may affect fracture pattern and enhance option for subsequent restoration.[3]

Amalgam has been used to restore tooth structure for years. the mechanical, physical and biological properties of amalgam are well established, but the success of this material is largely determined by strict adherence to the proper essentials of cavity design.[4] Large amounts of tooth preparation were required for proper retention and strength in amalgam restoration, even in teeth with minimal

decay. More recently, a technique for bonding amalgam to tooth structure with an adhesive resin liner demonstrated strength similar to that of bonded composite resin.[5–7] The addition of fluoride to amalgam will decrease in compressive strength of amalgam, particularly at high fluoride concentration.[8] So introduce other materials which release fluoride like tooth coloured restorative material (composite resin and glass ionomer).

Composite resin can be used for restoration of posterior teeth only in certain conditions such as when esthetics is the primary concern of the patient, in Class I and Class II cavities that are not subjected to high stress.[9–11]

The introduction of glass ionomer cements has increased the bond strength to tooth structure by mean of chemical bonds.[12, 13]

Light cured resin modified glass ionomer has recently developed in the market. It has better properties than conventional glass ionomer cement. Generally, they have the advantages of good adhesion to the tooth structure, esthetics, fluoride release and rapid hardening by visible light.[14, 15]

The aim of this study is to evaluate the relative effect of different fluoride release restorative materials (resin modified glass ionomer, composite resin and conventional type of glass ionomer) on fracture resistance of posterior teeth.

MATERIALS AND METHODS

Forty maxillary premolar teeth extracted for orthodontic purposes were collected and stored in distilled water until used. The teeth were caries free. They were scaled and cleaned with non fluoridated pumice (Quayle Dental, England), then examined by fiberoptic light to exclude the cracked teeth.

Specimens were mounted in an autopolymerizing resin base. The procedure for mounting the teeth was done as follows:

A clip of flexible wire was adapted to the mesial and distal surfaces at the cementoenamel junction holding the tooth with the long axis of the tooth perpendicular to the plane of the base of surveyor (Quayle Dental MF, England). Then the wire, with the tooth, stuck to the ring by sticky wax. A thin mix of resin was poured into the ring, embedding the root. The level of resin on the root surface was brought to cementoenamel junction. The ring was immediately placed in a distilled water to aid in dissipation of the heat of reaction generated by the setting resin.

The specimens were then randomly divided into five test groups:

Group A: Five intact teeth.

Group B: Five teeth prepared but not restored.

Group C: Ten teeth prepared and restored with resin modified glass ionomer (Vitremer; 3M, Dental Product, St Paul, MN55144).

Group D: Ten teeth prepared and restored with composite resin (Tetric; Vivadent, Schaan / Liechtenstein).

Group E: Ten teeth prepared and restored with conventional type of glass ionomer (Ionofil; Voco, 27457, Coxhaven, Germany).

Regarding cavity preparation, Class II mesio–occluso–distal (MOD) cavities were prepared in specimens of groups B through E. The preparation were made by using parallel sided carbide fissure bur No. 014 adjusted in high speed handpiece with water coolant. The bur was replaced after each five preparations. A width of one fourth of intercuspal distance was chosen for the occlusal portion of the preparation and one third of the total bucco–lingual distance was used for the proximal boxes. The buccal and lingual walls were prepared parallel to each other. The depth of the cavity at the occlusal portion was 2 mm. The axial wall in the proximal box was prepared to depth of 1 mm; mesio-distal width of gingival floor was kept 2 mm. No retentive grooves were used on the buccal and lingual proximal walls. The surveyor was used in order to standardize the cavity preparation. The ring was fixed on the platform of the surveyor previously adjusted in a parallel plane with the base, a parallel sided fissure bur was passed through the parallel walls making them parallel to each other. The width of the occlusal and proximal portions was che-

cked using a digital vernier (Electronic digital vernier caliper, Lezaco, China).

The internal line angles of the cavity were rounded by using a round bur No. ¼ with a conventional speed handpiece.

The teeth of group C were treated with Vitremer primer for 30 seconds, then air dried with oil free air for 15 seconds and light cured for 20 seconds. After that the powder and liquid of Vitremer was mixed, filled and cured for 40 seconds. The restoration was done by one step because Vitremer restorative material is a dual cure.

The enamel margins and subsequently the dentin of teeth of group D were etched with 37% phosphoric acid gel for 15 seconds, then thoroughly rinse off acid with water for 15 seconds and the tooth surface was dried with oil free air for 10 seconds. Then the teeth were treated with Syntac single component for 20 seconds, then disperse the material to a thin layer with air free of oil until movement of the liquid is no longer visible, light cured for 20 seconds, then apply Tetric composite resin and adapted carefully with plastic instrument; ASH 6 to the level of pulpal floor and light cured for 40 seconds. This procedure was repeated for the occlusal portion. A matrix was used before each polymerization. The excess materials were removed by using silicone rubber finishing bur (Translux; Trans AG, Feidweisen, CH 9450, Germany).

The teeth of group E were cleaned with 3% hydrogen peroxide and then rinse carefully with water and dried. Ionofil powder and liquid was mixed according to the manufacturer's instructions and inserted into the cavity. Immediately upon removal of stripes, the filling has to be covered with varnish for protection from moisture. After setting after 6–7 minutes, the excess was removed with a sharp hatchet.

The specimens of five groups were thermocycled between 5 to 55 $\pm$ 2 ºC for 100 cycles and stored in distilled water for 1 week in an incubator at 37 ºC before testing.

Specimens were tested for resistance to fracture with a universal compressive machine (Engineering test equipment, Model CN 472, Soil test, USA). One metal rod approximately 5.5 mm in diameter was used in this study. The plunger contacted only the occlusal inclines of the facial and lingual cusps and not the restoration. The specimens were tested at a cross–head speed of 0.5 mm / minute. The forces which were necessary to fracture the teeth were recorded.

RESULTS

Table (1) presents the mean of forces in Kg required to fracture the specimens of the five groups. The values of group A represent the highest while the values of group B represent the lowest.

The mean and standard deviation of the force required to fracture the specimen of group A (150.4 $\pm$ 16.11 Kg), group B (47.6 $\pm$ 5.94 Kg), group C (80.1 $\pm$ 11.49 Kg), group D (78 $\pm$ 16.86 Kg) and group E (54 $\pm$ 10.64 Kg).

Table (1): Mean and standard deviation of tooth fracture

Group	Treatment	Mean Force $\pm$ SD (Kg)
A	Intact	150.4 $\pm$ 16.11
B	Prepared, Unrestored	47.6 $\pm$ 5.94
C	Restored with Vitremer Resin Modified Glass Ionomer	80.1 $\pm$ 11.49
D	Restored with Tetric Composite	78 $\pm$ 16.86
E	Restored with Ionofil Glass Ionomer	54 $\pm$ 10.64

SD: Standard deviation.

Statistical analysis of data by using analysis of variance revealed that there is significant difference ($p < 0.01$) between the five groups as shown in Table (2).

Further analysis of data was needed to examine the differences between different pairs of groups and this done by applying the student's t–test to compare between each pair of groups (Table 3). The analysis included:

Significant difference between the values of force required to fracture intact teeth (group A) and the other four groups.

Significant difference was found between the values of force required to fracture teeth restored with Vitremer (group C) and the values of teeth prepared but not restored (group B). Also a significant difference was found between the values of teeth restored with Vitremer (group C) and the values of teeth restored with Ionofil (group E).

Significant difference was found between the values of force required to fracture teeth restored with Tetric composite resin (group D) and the values of teeth prepared but not restored (group B). Also a significant difference was found between the values of force required to fracture teeth restored with Tetric composite resin (group D) and the values of teeth restored with Ionofil (group E).

No significant difference was found between the values of teeth restored with Ionofil (group E) and the values of teeth prepared but unrestored (group B).

No significant difference was found between the values of teeth restored with Vitremer (group C) and the values of teeth restored with Tetric composite (group D).

Table (2): Analysis of variance (ANOVA) of all the five groups

Source of Variation	SS	d.f	MS	F–value
Between Groups	67113.7	4	16778.4	70.349
Within Groups	10732.7	45	238.5	
Total	77846.4	49		

SS: Sum of squares.
d.f: Degree of freedom.
MS: Mean squares.

Table (3): t–test of the differences between different pairs of groups

Group	Significant Difference at $p < 0.01$	Group	No Significant Difference at $p < 0.01$
A & B	t = 18.749	**E & B**	t = 1.450
A & C	t = 10.361	**C & D**	t = 0.597
A & D	t = 11.867		
A & E	t = 16.418		
C & B	t = 7.401		
C & E	t = 4.744		
D & B	t = 5.131		
D & E	t = 3.963		

Group A: Intact;
Group B: Prepared, unrestored;
Group C: Restored with Vitremer resin modified glass ionomer;
Group D: Restored with Tetric composite;
Group E: Restored with Ionofil glass ionomer.

Table (4) presents the number of teeth fractured by each specific type of the fracture. Cusps of intact teeth (group A) fractured at the base of the cusp. Teeth prepared but unrestored (group B) fractured at the base of the cusp or split at the pulpal floor. Teeth restored with Vitremer (group C) fractured mostly in a combination type of fracture through the bulk of restoration and fracture at the tooth resto-

ration interface. Teeth restored with Tetric composite (group D) mostly fractured at tooth restoration interface. Teeth restored with Ionofil fractured always through the bulk of the restoration.

Table (4): Modes of failure of the groups of the experiment

Mode of Failure	Groups				
	A	B	C	D	E
Adhesive Failure			2	7	1
Cohesive Failure					8
Combined Adhesive / Cohesive			8	3	1
Fracture Through the Pulpal Floor		1			
Fracture at the Base of Cusp	5	4	10	10	10

Group A: Intact;
Group B: Prepared, unrestored;
Group C: Restored with Vitremer resin modified glass ionomer;
Group D: Restored with Tetric composite;
Group E: Restored with Ionofil glass ionomer.

DISCUSSION

In this study MOD cavity preparation was used because it causes more weakening to the tooth structure than MO or DO preparations.

The results of this study indicate that the cavity preparation reduced the strength of prepared teeth when compared with sound unprepared teeth.

In this study, different types of restorative materials produced different results. It was found that the Vitremer resin modified glass ionomer and Tetric composite resin were significantly stronger than either unrestored prepared teeth or restored with Ionofil which is a conventional type of glass ionomer.

Resin modified glass ionomer contain resin component. This modification over the conventional glass ionomer cement im-proves the adherence to enamel and dentin.[16, 17] This property strengthen the tooth–material interface and this mean it is more difficult to cause failure at tooth–material interface. In addition to that, the resin component improves the flexural strength of glass ionomer.[18, 19] This property means more difficult to cause failure within the material, so that the resin modified glass ionomer has great potential as a cusp reinforcing material. This finding was in agreement with Marcherson and Smith.[20]

Teeth restored with Tetric composite resin significantly produce greater fracture resistance than either teeth prepared unrestored or restored with Ionofil glass ionomer. This may be due to the bonding agent used in this study that developed micromechanical retention with etched enamel.[21] This result has come in agreement with other studies.[22, 23]

In this study, teeth restored with conventional type of glass ionomer significantly need less force to fracture compared to Vitremer resin modified glass ionomer and Tetric composite, but showed no significant difference than prepared unrestored teeth. This finding has come in agreement with Chakmakchi's study.[23] In spite of the adhesive property of glass ionomer to the tooth structure but the flexural strengths are insufficient.[24] So, most of failure occurred within the material because the bond strength to the tooth structure exceed its cohesive strength.[23]

CONCLUSIONS

It was concluded that the sound unprepared tooth significantly stronger than the teeth restored with resin modified glass ionomer, composite resin and conventional type of glass ionomer. Also, the resin modified glass ionomer and composite resin were considered to be as a tooth reinforcing materials.

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