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Fatigue Fracture Resistance of Different Materials Restoring Rest Seat Preparations in Removable Partial Dentures

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KEYWORDS

Heat-cured PMMA, Henna, Silver-nanoparticles, Surface properties , Surface hardness.

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ABSTRACT

Aim: This study aimed to compare the fatigue behavior of resin composite and dental amalgam restorative materials used below the occlusal rest of removable partial denture (RPD). **Subjects and methods:** Thirty extracted first maxillary molars were prepared with standard class II cavities and divided to three groups (n=10 per group). Group I and group II were filled with composite (Charisma Smart and Flitek Z250) respectively and group III was filled with amalgam (Dispersalloy). After 24 hours, 30 standard saucer shaped rest seats were prepared. The samples were stored in distilled water for 14 days prior to testing. Fatigue resistance test was evaluated by the step-test method on a computer controlled materials testing machine. One way ANOVA followed by pair-wise Tukey's post-hoc tests was used to determine the significance between groups**.** **Results:** The difference between groups was statistically non-significant as indicated by the one way ANOVA followed by pair-wise Tukey's post-hoc multiple comparison tests (p=8910>0.05). **Conclusion:** There was insignificant difference in the fatigue fracture resistances between the tested groups.

INTRODUCTION

The occlusal rest has main role in removable partial denture support. It also aids in directing forces with the long axis of abutment tooth that help in preservation of abutment periodontal health [(1)].

Rest seat form and inclination grossly affect appropriate rest function to avoid deterioration of abutments and supporting structures. Moreover, the rest seat material is considered essential requirement to maintain positive supportive foundation which finally preserve abutments and / or supporting periodontium [(2)]**.**

In selection of rest seat materials, the mechanical properties especially fatigue resistance and modulus of elasticity should be considered in order to withstand the masticatory load which normally ranges between (65-235) N [(3- 5)] .

Recently, resin based composite is widely used in posterior teeth. This could be attributed to its better esthetic quality with a minimum intervention, improved mechanical and physical properties, ease of use and no release of mercury as occurred with dental amalgam [3, 6, 7] .

Many researches had reported that the fatigue fracture strength of posterior composite is comparable to that of dental amalgam and the occlusal loads had a lesser effect on the restoration of composite than amalgam alloy. The composite acts as an absorbent of masticatory forces so it could be used instead of amalgam alloy [5, 8, 9, 10] .

Mechanical properties of composite showed lower tensile than compressive strength. This makes importance to exclude possibility of failure if it is used in stress bearing areas as in case of removable partial denture rests [11, 12].

Few studies were published concerning which material could be safely used under removable partial denture rests. Therefore, this research is formulated to assess and compare the fatigue fracture resistance of two resin composites with a dental amalgam which are widely used under removable partial denture rests.

Our research hypothesis was that there is a significant difference between fatigue behavior of composites and amalgam under the rest of removable partial denture.

MATERIALAND METHODS

Thirty freshly extracted permanent first maxillary molars were collected. All teeth were free from caries, restorations or crazing. The teeth were disinfected with 5.25% sodium hypochlorite for 24 hours and stored in distilled water for another 24 hours, then were molded in acrylic resin mold up to 2 mm below cemento-enamel junction. By using a bur number 245, standard class II occluso-mesial (OM) cavities were prepared for amalgam and composite with an isthmus width one- third of the inter-cuspal distance and a depth of 3.0 and width of 5.5 mm, The Class- II OM cavities were prepared in all 30 teeth. Extracted teeth were divided randomly into three groups of (n=10) according to the type of filling material used. The materials used in this study are presented in (Table 1).

Group I and group II were filled with resin composites; (Charisma Smart and Filtek Z250) respectively. To fill the first and second groups with composite, the 37% phosphoric acid gel was used for etching the teeth and the recommended dental adhesive for each composite material was applied to the walls and cured by using E-Morlit led curing unit (Apoza Enterprise.Co LTD, New Taipei City of Taiwan, R.O.C.). The resin was introduced in horizontal incremental layering and cured in occlusal, mesial and distal directions (800 w/ cm^2). The curing time for each part was 20s.

The procedures followed the recommendation of the manufacturers. The restoration surfaces were finished and polished using silicon carbide paper 1000 grit to remove any cracks at their edges.

Group III received a class II amalgam restoration (high copper, lathe-cut and spherical particles admixed type amalgam) (Dispersalloy) Zn-free which was triturated using Wig-Bug amalgamator (Model 2, SDI Manufacturing Co., Victoria, SE, Australia) according to the manufacturers' instructions. A maximum condensation stress was produced by repeated load applied by the hand.

After twenty-four hours, 30 standard rest seats were prepared with a triangular external outline form with the floor of the rest resembling a saucer shape by using high speed round bur. All tested molars were stored in 37^{o}C distilled water for two weeks.

Table (1) *Materials used in this study.*

Material	Manufacturer	Type	Filler fraction (Wt%)	Composition
Chrisma Smart	Kulzer Gmbh, Hanau,Germany	Hybrid Composite	59	BIS-GMA Ba-Al-Fluoride glass, highly dispersive silicone dioxide
FiltekZ250	ESPE 3M, St. Paul, MN,USA	Hybrid Composite resin	82.60	BIS-GMA, TEGDMA, Silica Zirconia
Disperse alloy	Johnson & Johnson Dental Product,Co East Windsor, NJ, USA	Zn-free , Non $\gamma 2$	N/A	Ag, Sn, Cu

Fatigue Resistance Test

Fatigue resistance test of all groups (n=10) was measured by the step-test technique on a computer controlled materials testing machine (**Model 3345; Instron Industrial Products, Norwood, USA**) with a 5 kN load cell and the data was recorded using computer software (**Bluehill Lite; Instron Instruments**) in water filled chamber.

Samples were attached to the lower fixed part of the machine by tightening the screws. Fatigue resistance test was done by applying a compressive load occulsally at mesial marginal ridge using a metallic rod (1.6 mm diameter) attached to the upper movable part of the testing machine at a cross-head speed of 0.5 mm/sec. (Fig.1)

In the step-test, the specimen were subjected to a prescribed number of cycles with a sequence of increasing stress levels, until failure of the specimen occurred. To start a step test, a load level lower than the expected material fatigue failure is selected. The specimen is then tested at that load level until either failure occurs or the run-out at a previously set number of cycles is achieved. When failure occurs, the level of the load and the cycle numbers are registered. If run-out happened, the level of the load is increased by using a preselected stress increment and the same test is repeated at new load point.

Cyclic load was applied at 1.6 Hz frequency. Maximum number of cycles for each load step was set in 1,000 cycles. If the specimen survived the 1,000 cycles, the stress level was increased by a fixed load increment (100 N) in the same specimen. An individual loading protocol was established for each specimen on the results of previous studies [13].

An initial load of 200 N was applied, followed by successive steps of 100 N. The software was adjusted to record the load and the cycle numbers corresponded to the fracture of the specimen. The maximum fatigue load (LE) supported by each specimen was calculated according to the equation described by Nicholas [14] .

$$L_E = L_0 + \Delta L \left(\frac{N_{fail}}{N_{life}} \right)$$

The L_0 is the last maximum load which did not result in failure, ΔL mean a load step increase, N_{fail} is the cycles number at the failure load step ($L_0 + \Delta L$) while N_{life} defined life of cyclic fatigue (1,000 cycles).

Data analysis was performed in several steps. Initially, descriptive statistics for each group results. One way ANOVA followed by pair-wise Tukey's post-hoc tests were used to detect significance between groups. Statistical analysis was done by using Windows Graph Pad Prism4, Graph Pad Software, San Diego California USA. P values ≤0.05 are considered to be statistically significant in all tests.

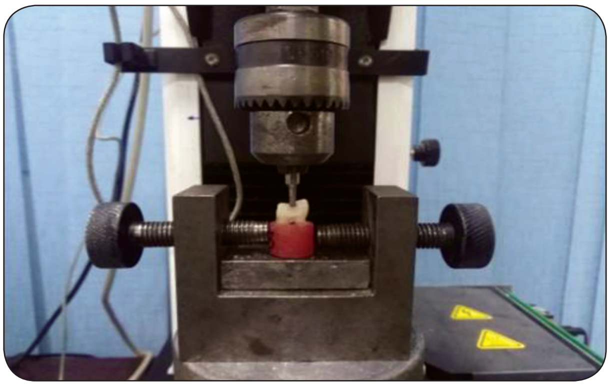

Fig. (1) Sample was secured to the lower fixed part of testing machine

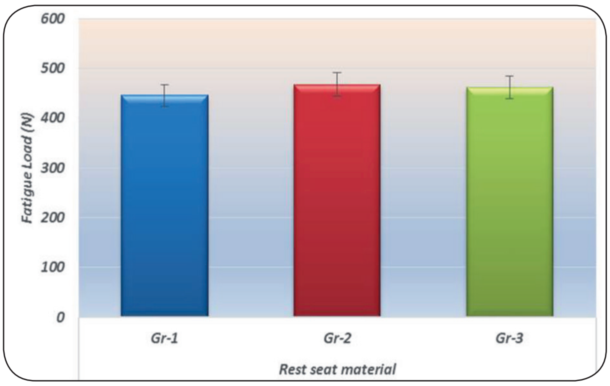

Fig. (2) Mean values of the fatigue fracture resistance of different restorative materials used in molar rest seats.

RESULTS

The fatigue fracture resistance of posterior composite and amalgam in molar teeth was compared and the values obtained from the samples are shown in (Table 2) and (Fig. 2)

It was found that, group II recorded the highest fatigue fracture resistance mean value (467.67± 128.04 N) followed by group III (461.9± 95.27 N) while group I reported the lowest mean value of fatigue fracture (445.2± 98.93 N).

The difference between groups was statistically insignificant as indicated by one way ANOVA followed by pair-wise Tukey's post-hoc multiple comparison tests (p=8910>0.05).

Table (2) *Results of fatigue fracture resistance (Mean± SD) of rest seat·s restorative materials*

Variable		Fatigue fracture resistance		95% CI	
		Mean	SD	Lower	Upper
Rest seat material	Group 1	445.20[a]	98.93	374.43	515.97
	Group 2	467.67[a]	128.04	376.08	559.26
	Group 3	461.9[a]	95.27	393.76	530.03
ANOVA	P value	0.8910 ns			

*CI ; the confidence intervalsdifferent letters in same column indicating statistical significant (Tukey's p<0.05) *; significant (p<0.05)ns; non-significant (p>0.05)*

DISCUSSION

The Fatigue property is the material resistance to cyclic loading when the applied load is less than its yield strength. On applying a cyclic loading below the yield strength of the material, the internal coherence may change as occurs during mastication which results in fatigue and failure of the material. Such properties have estimated the longevity of the filling materials under simulated clinical conditions[11].

The main causes of tooth fracture and failure of restorative materials have been occurred as high forces produced by occluding on a hard material or uncontrolled occlusion of opposing teeth [15]. So repeated loading was used in this research to measure the fatigue resistance of different restorations.

Cyclic fatigue resistance of two different composites and a non γ2 dental amalgam were studied at the area of rest seat to support a removable partial denture. The results showed that the Filtek composite revealed the highest fatigue fracture resistance followed by lathe-cut high copper non γ2 amalgam and the least fatigue value was recorded by Chrisma Smart resin but the differences was insignificant (p>0.05) so our hypothesis was rejected. These results agreed with previous studies[16, 17].

Many researchers reported that Filtek composite was the most resistant material. Although the high-copper disperse amalgam alloy has more resistance to the marginal breakdown and propagation of the fatigue crack, it still more sensitive to fatigue than the composite. So composites could be used as an alternative to amalgam in the molars with regard to fracture resistance [18- 20].

Several studies have suggested that the teeth restored by the composite were less susceptible to masticatory force due to reinforcement of the cusp accomplished by enamel and dentin bonding which distribute the stress along the bonding junction. Therefore the fracture resistance increased and the occlusal force had a limited influence on the composite resin filling material [21, 22].

In present study the different values of fatigue resistance of two resin materials may be due to the different fillers content of the two materials, Filtek had 82.60 % wt and Chrisma ceram had 59% wt. Resins with higher filler contents tended to improve fatigue resistance [15, 23, 24].

Another theory was reported by Lindberg et al[25], they concluded that increasing the filler contents are referred to increased light scattering at the filler particles which leads to monomer cross-linking changes and a low depth degree of conversion which could be considered an important cause for the difference between Filtek and Chrisma resins.

Other important factors as wear resistance and rest seat size have to be considered so further studies are recommended.

CONCLUSIONS

Based on the findings of this in vitro study, it could be concluded that, there was insignificant difference in the fatigue fracture resistances provided by the resin composite restorative materials compared to dental amalgam.

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مقاومة الكسر لمواد مختلفة تستخدم اسفل المساند الاطباقية في الاطقم الجزئية المتحركة

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الملخص:

الهدف: مقارنة مقاومة الكسر ثلاثة انواع من حشو الأسنان المستخدمة أسفل المساند الاطباقية للاطقم الجزئية.

المواد والأساليب : تم اختيار 30 ضرس لعمل هذا البحث وتقسيمها الي ثلاثة مجموعات عشرة لكل مجموعة. تم عمل تجويف من التصنيف الثاني في جميع الضروس. المجموعة (الأولي و الثانية) تم حشوها بنوعين مختلفين من بالرنتج المركب (الاسمارت والفليتك الكومبوزيت). المجموعة (الثالثة) تم استخدام حشو الملغم فيها. بعد 24 ساعة تم تحضير تجويف موحد في جميع الأسطح الطاحنة للضروس اسفل المساند الاطباقية. تم وضع جميع العيانات في ماء مقطر لمدة 14 يوم قبل اجراء الاختبارات. تم استخدام آلة اختبار INSTRON لقياس مقدار مقاومة الكسر وقد تم تحليل جميع البيانات إحصائيا من خلال طريقة واحدة ، توكي آخر اختبار مخصص وعينة اختبار الاقتران.

النتائج: لم يكن هناك فرق ذي دلالة إحصائية بين جميع المجموعات .

الخلاصة : بالرغم من عدم وجود فرق معتد به إحصائياً بين جميع المجموعات المختبرة إلا ان مقاومة الكسر كان اعلي في حالة العينات التي تم استخدام مادة الفليتك الكومبوزيت (المجموعة الثانية) مادة للحشو

الكلمات المفتاحية: الاطقم الجزئية المتحركة. المسند. مقاومة الكسر. مواد حشو الاسنان