The influence of CAD/CAM ceramic and heat processed composite inlays on the fracture resistance of premolars (An in-vitro study)

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ABSTRACT

Background: The aim of this in-vitro study was to identify the influence of intracoronal indirect adhesive techniques (heat processed composite (SR Adoro) andcomputer-aided design / computer-assisted manufacturing (CAD/CAM) ceramic (e Max CAD) inlays)on the fracture resistance of maxillary first premolars and to identify the modes of fracture of all experimental groups.

Materials and Methods: Forty sound freshly extracted upper first premolar teeth were selected then mounted in acrylic blocks, the teeth were divided into four groupsas follow:Group (A): tenintact teeth (control group).Group (B): ten teeth prepared with standardized MOD inlay cavity but not restored. Group(C): ten teeth prepared with standardized MOD inlay cavity and restored with indirect heat processed composite (SR Adoro).Group (D): ten teeth prepared with standardized MOD inlay cavity and restored with CAD /CAM ceramic material (e max CAD).Fracture strength of the experimented teeth was measured by using universal testing machine (an axial compression test).Data were analyzed statistically by ANOVA and least significant difference tests.

Results:Group (D) restored with CAD/CAM ceramic inlays showed more resistance to fracture than teeth restored with SR Adoro composite inlays group (C), but the values are statistically not significant, using One way ANOVA test a highly significant differences ($P < 0.01$) were found among all groups.

Conclusions:All CAD/CAM ceramic inlays and 80% of heat processed compositeinlays survived maximum biting force for posterior single tooth, so these two types of inlays provide good reinforcement in an extensive MOD cavities in premolars,The fracture Mode of SR Adoro composite inlays seems to be 80% restorable while CAD/CAM ceramic inlays 90% of it are restorable type of fracture.

Key words: Fracture resistance,SR Adoro, CAD/CAM ceramic, inlays. (J Bagh Coll Dentistry 2012; 24(4):14-18).

INTRODUCTION

An ideal restorative material must be able to reinforce tooth structures and increase its fracture resistance in addition to aesthetic, biocompatibility, strength and marginal adaptation (1). Dental structure removed during cavity preparation has been associated with a progressive decrease in fracture resistance in teeth. Advances in new materials and the increasing demand for esthetic restorations have influenced the search for alternative materials to replace metallic restorations (2). The preparation configuration, technique and materials used for cementation, the restorative material type employed, may influence the fracture resistance of these restorations **(3)**. Indirect restorations have better physical properties than direct composite restorations because they are fabricated under relatively ideal laboratory conditions (4). The indirect composite restoration shows many advantages compared to direct technique such ascontrol of occlusal and proximal contact points, better marginal fit especially in the gingival wall, minimal shrinkage polymerization due to cement agents, good polishing and finishing possibilities, shorter clinical section and less contamination risk **(5)**.

Ceramic materials have superior esthetics, biocompatibility, resistance to wear, and similar coefficient of thermal expansion as that observed for dental enamel. It has been reported that sound molars fractured at a load of approximately 2500 N, and intact maxillary premolars fractured at a load of 1121 N. However, after preparation of MOD cavities, the fracture strength of teeth was reduced to approximately 54% of their original strength. The use of adhesive technology should restore at least some of this strength for enhancing reinforcement of the tooth (6). The aim of this in-vitro study was to identify the influence of intracoronal indirect adhesive techniques (heat processed composite (SR Adoro) andcomputer-aided design / computer-assisted manufacturing (CAD/CAM) ceramic (e Max CAD) inlays) on the fracture resistance of maxillary first premolars and to identify the modes of fracture of all experimental groups.

MATERIAL AND METHODS

Teeth selection criteria

Forty sound first premolar teeth extracted for orthodontic purposes. The teeth were stored in distilled water at room temperature within one month after extraction until use (7).Any calculus and soft tissue deposits were removed from the selected teeth by hand scaler.The teeth were mounted with their roots embedded in

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autopolymerized acrylic blocks with the cementoenamel junction (CEJ) 2 mm above the surface of the acrylic resin[4].To minimize bias in the study all the teeth that were used had regular occlusal anatomy, two separated roots and approximately comparable crown sizes[8], the buccolingual teeth dimensions were between **(8.9) & (9.6)mm** while mesiodistal dimensions were between **(6.5) & (7.4)mm**.

Samples grouping

The experimental teeth were divided into 4 groups, ten teeth each as follow

Group (A): ten intact teeth (control group).

Group (B): ten teeth prepared with mesio-occlusal-distal MOD inlay cavity but not restored.

Group (C): ten teeth prepared with MOD inlay cavity and restored with indirect heat processed composite (SR Adoro ,vivadent/ivoclar, Liechtenstein).

Group (D): ten teeth prepared with MOD inlay cavity and restored with CAD /CAM ceramic material (IPSe. max CAD,vivadent/ivoclar, Liechtenstein).

Cavity preparation

Each tooth in group B, C, and D was subjected to standardized (MOD) inlay cavity, with a water-cooled high-speed hand piece(W&H) attached to a modified dental surveyor **[4]**. Cavity depth was 2mm, the width was 2mm using straight fissure diamond bur (no.56835KR.314.014) forming parallel walls then using round end tapered diamond bur (no.8845KR.314.018) forming diverge walls in 10^0 degree occlusally, the axial wall was 2mm in depth and gingival seat was 1mm in width, all walls were flared, the internal line angle were rounded, all cavity dimensions were measured using digital caliper.

Study model fabrication

Impressions of the prepared teeth in group C & group D were taken with light and heavy body addition silicone impression material (putty) (Zhermack, Italy) in an individual plastic tray [9]. Impression poured after half an hour with stone material (navy blue, zhermack, Italy) according to the manufacturer recommendations to fabricate the master models for the prepared teeth.

Inlay fabrication

<u>Group (C) indirect composite inlay fabrication:</u>

SR Adoro indirect composite material was fabricated on a master model; all steps were made according to the manufacturer instructions as follow:

SR Adoro Model Separator is applied in two thin coats.The liner **(050-500)** was applied into the cavity walls and cavity floor in a thin coat and each segment were cured for 20 seconds, using a Quick curing light (Guilin Woodpecker , China)**.**Layering technique started with the first layer that was adapted firmly and cured for 20 seconds. The process of building up the cavity began with Dentin materials; adequate space was provided for the subsequent application of incisal material.After the layering procedure has been completed, SR Gel was applied on the restoration outer surface ensuring that all areas are fully covered. After that, the restoration was placed it in the Lumamat 100 furnacefor 25 minute and in 104 ^{0}C. Programs (P3) was used for polymerizing/tempering metal-free restoration (inlay) according to manufacturer instructions. Then the restoration carefully removed from the model. The restoration was finished with crosscut tungsten carbide burs and fine diamonds. The occlusal surface and proximal ridges were polished by using polishing pastewith polishing disc**.**After polishing all inlays were placed in the teeth and stored in distilled water in laboratory plastic tubes prior to cementation**.**

<u>Group (D) CAD/CAM ceramic inlay fabrication:</u>

A CAD/CAM device (Cerec inLab MC XL, Germany) scanner, milling machine and software (version 3.10) were used to fabricate CAD/CAM ceramic inlays. Each specimen model was scanned with InEos Scanner; IPS Contrast Spray Lab side (cerecoptsispray**)** was sprayed on the model,the scanning device converts the shape of the prepared teeth into three dimensional units of information**[10].**The digital impression was performed as Follow: opening the main page of the program then the type of tooth was determined by marking on the upper first premolar. The three dimensional picture finished by obtaining eight shot of the study model on the scanner.The whole margins of the cavity were marked accurately on the digital image then restoration was filled the scanned tooth cavity in the software. After designing e max CAD ceramic block was inserted in the milling machine in which it would start to fabricate inlay restoration.Finishedinlay was glazed and inserted in the Ivoclar Vivadent ceramic Furnaces (Programat P500)[11].

Adhesive Cementation

Cementation of inlays of both group (C &D) has been made using Variolink N cementaccording manufacturer instructions.

Axial Compression Test

After one week the specimens mounted in a universal testing machine and subjected to axial compression load using a round end steel device (8-mm in diameter) running at cross head speed of 0.5 mm/min.

Modes of fracture

Fracture modes for each specimen were recorded, based on the degree of tooth structure and restoration damage, using a modified classification system proposed by Burke et al[12]: Type (I) isolated fracture of restoration (complete dislodgment of restoration), Type (II) fracture involving a small tooth portion**,** Type (III) fracture involving half of tooth, above the CEJ, Type (IV) fracture below the CEJ. Fracture modes I-III represented restorable, but mode IV – not restorable situations.

RESULTS

1-Fracture resistance values of all experimental groups

The descriptive statistics which represent the mean, standard deviation (±SD) with the maximum (Max) and minimum (Min) values of the fracture resistance in (KN) are shown in **(Table 1).** Sound teeth presented the highest mean value (1.7830), while unrestored teeth showed the lowest resistance to fracture (0.5850).

Table 1: Descriptive statistics of fracture resistance of each group in KN

Groups	Mean	±SD	Max	Min
Group A	1.7830	0.38701	2.59	1.31
Group B	.5850	.07678	0.70	0.45
Group C	.9110	.24242	1.3	0.6
Group D	.9690	.19267	1.31	0.67

One way ANOVA test detected statistically high significant differences among experimental groups **(Table2).**

Table 2: One-way ANOVA test of fracture resistance among all groups

	SS	DF	MS	F	P	Sig.
Between Groups	7.788	3	2.59	41.2	.000	HS
Within Groups	2.264	36	.063			
Total	10.05	39				

Teeth restored with CAD/CAM ceramic inlays presented more resistance to fracture than teeth restored with SR Adoro composite inlays but the values are not significant **(Figure 1).**

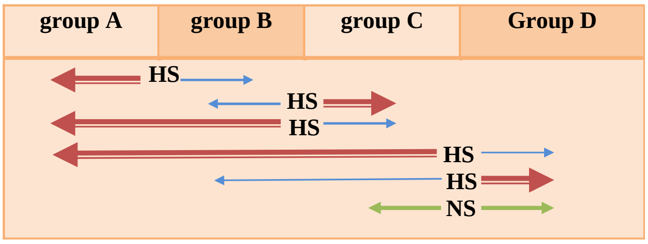

Figure 1: LSD between each two groups

2-Mode of fracture

As seen in **(Table 3)**:Control group had 50% (type II) fracture, while 50% of Unrestored teeth had (type IV),Heat processed composite inlays group had 80%of fractures restorable,20%not restorable, CAD/CAM ceramic inlays had 90% of fracture mode restorable ,10% not restorable.

Table 3: Modes of Fracture in each group used in the study

G	isolated fracture of inlay (type I)	fracture a small tooth portion (type II)	fracture half of tooth, above the C E J (type III)	Fracture below the CEJ (type IV)
A	0	5	3	2
B	0	1	4	5
C	1	4	3	2
D	3	4	2	1

DISCUSSION

Resistance to fracture is a critically important issue with teeth. Fracture can frequently occur in teeth that have been weakened by caries, large cavity preparations and reduction of dental structure as a result of erosion or abrasion. The fracture resistance of a filled tooth can be significantly affected by several factors, in particular cavity dimension and type of restorative materials [13].

Maxillary first premolars were used in this study for many reasons: they need esthetic restorations**;** under occlusal loading, the cuspids receive high tensions; their anatomy facilitates flexion and fracture **[14]** and these teeth are commonly employed, facilitating the comparison among studies **[2].**

Teeth with comparable sizes and shapes were selected by crown dimensions after measuring the buccolingual and mesiodistal widths to avoid the error in the experimental groups **[15]**. The specimens were stored in 100% relative humidity at 37°C until the test **[6].**

The experimented teeth were vertically embedded in autopolimerizing acrylic resin 2 mm below cement- enamel junction to simulate alveolar bone level [16].Teeth preparations were made with a standardized cavity preparation using high speed headpiece attached to a modified dental surveyorin order to avoid bias and methodological errors [17].

In this study a bonding system and a resin agent were used for cementation of the indirect restorations. This procedure increases tooth resistance compared to the use of non-adhesive conventional cements because it allows the formation of a single body between the restorative material and the dental structure **[15].**

Intact teeth were used as control group to observe the effect of the esthetic inlays and adhesive cementations on the fracture strength of the restored tooth in comparison to the intact teeth **[4].**Second group was prepared and not restored were used to determine the role of the ceramic and composite inlays in the reinforcement of the tooth after cavity preparation in comparison to the unrestored teeth.

Fracture resistance among all experimental groups

There was a highly significant difference among all experimental groups (Table 2).

Control group have the higher fracture mean value it is (1.7830) KN, this comes in agreement withprevious studies [18, 4,7, 2].The statistical analysis using ANOVA test (Table 2) showed highly significant difference with other three groups,due to the presence of the palatal and buccal cusps with intact mesial and distal ridges which forms a continuous circle of dental structure, reinforcing and maintaining tooth integrity [15].

Prepared unrestored teeth group showed the least fracture resistance mean value among the experimental groups (0.5850) KN and the differences were statistically highly significant with other groups (Figure1), this comes in agreement with previous studies [20, 7, 21, 17], the explanation is based on that the teeth with large MOD cavities are severely weakened due to the loss of reinforcing structures, such as the marginal edging, and become more susceptible to fractures [4].

Heat processed composite inlays group (SR Adoro composite) presented higher fracture strength mean value (0.9110) KNand the differences were statistically highly significant in comparison to the unrestored teeth (Figure 1) ,this comes in agreement with Dalpino *et al*, St-Georges *et al*, Sun *et al* [19,4,21];this could be due to the homogeneous structure with high loading of inorganic microfillers that resulted from carefully adjustment of the inorganic microfillers combined with (UDMA) matrix in which this provide the material with excellent mechanical & physical properties. Also composite with a high loading of inorganic microfillers allows for high physical strength. This composite material has shown a greater capacity to absorb compressive loading forces and reduce the impact forces to the underlying tooth structure **[22].**

CAD/CAM Ceramic inlays group has greater fracture resistance mean value (0.9690) kN than that of unrestored teeth and the differences were statistically highly significant in comparison to the unrestored teeth (Figure 1) ,this come in agreement with Soares *et al*, Jacinta *et al*, Ragauska *et al* [3,7,6]; the main explanation is based on that the conventional ceramic inlays fail predominantly as a result of crack propagation from material flaws leading to fracture, Internal material flaws are minimized by industrial production of indirect glass-ceramic materials or ceramic blocks designed for (CAD/CAM) in which it provides an impressive homogeneity of the material using an innovative process & excellent fit of the restoration with maximum inherent strength and this helps in prevention of crack propagation in the material thereby reducing the chances of fracture of restorations or teeth **[23]**

Heat processed composite inlays have lower fracture strength mean value than CAD/CAM ceramic inlays but the difference is statistically not significant,this comes in agreement withprevious studies[18,3,24],the explanation is according to the study of Subramaniam and Kankaria which demonstrated that SR Adoroexibits physical and aesthetic properties of ceramic but is less expensive& they discuss the possibility of using SR Adoro as an appropriate option for replacing indirect restorations with higher aesthetic and functional requirements [25].The non significant difference between two inlays groups disagree with Soares *et al* [3]as they used in their study another types of indirect composite resin and ceramic inlays.

It was found clinically that maximum biting force was approximately 725 N for posterior single tooth, the fracture loads in this study exceeded maximal biting forces, but it can represent some overloading situations for example bruxism or traumatic occlusion [6].In this investigation all ceramic inlay restorations and 80% of indirect composites survived this force so that these two types of inlays considered to be reinforcing an extensive MOD cavities in premolars [4].

Modes of fracture

The analysis of failure patterns demonstrated that if failure occurred in the restorations is better in the clinical situation, because the restoration could be replaced, while tooth failure may impair the prognosis.

Indirect Composite inlays fracture patterns (Table3) has only 10% (type I) and the other 90% (type II, III, IV) found to be involve the fracture with tooth structure this is due to: polymer materials accumulate and transmit tensions that exceed the dental structure intrinsic resistance, resulting in whole group fracture [(3)]. 80%of the specimen was restorable fracture pattern.

CAD/CAM Ceramic fracture patterns (Table 3) showed that 30% is (type I) this characterizes the material friability with limits below dental structure resistance this is due to ceramic's brittle nature: it has high elastic modulus and tends to concentrate stress inside the body of restoration [(6)].CAD/CAM ceramic inlays group has only one specimen with fracture below the CEJ so it is considered to have the most restorable fracture pattern.

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