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FRACTURE STRENGTH OF ENDODONTICALLY TREATED TEETH RESTORED WITH ENDOCROWN RESTORATIONS WITH /WITHOUT RESIN COMPOSITE BASE MATERIALS – AN IN VITRO STUDY

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ABSTRACT

Objective: To compare the effect of using resin composite base materials on fracture strength of endodontically treated premolar teeth restored with endocrown restorations.

Materials and Methods: A total of 60 sound maxillary first premolars with standardized MOD cavities with endodontic treatment were selected for this study, except for intact control. They were randomly divided into six groups (n=10); G1: sound premolars (negative control); G2: unrestored teeth (positive control); G3: MOD cavities with endocrown restorations. G4: MOD cavities with nanohybrid composite base and endocrown ; G5: MOD cavities with sonicfill bulk fill composite base and endocrown ; G6: MOD cavities with bulk fill flowable composite base and endocrown. Vita Enamic hybrid ceramic was used to fabricate the overlay restorations. All samples were subjected to thermocycling between 5C° to 55C° in water bath for a total of 2000 cycle with 10 seconds dwell time. Then specimens were individually mounted on a computer-controlled material testing machine (Instron 3345) with a load cell of 5 kN and the maximum load to produce fracture in Newton (N) was recorded.

Statistical analysis: Analysis of variance (ANOVA) and Kolmogorov Smirnov and Shapiro-Wilk tests was performed .

Results: Fracture strength of restored teeth was increased compared to unrestored teeth. The fracture strength of G6 (bulk fill flowable) was significantly higher than the fracture strength of G5,G4,G3 and not significantly different from G1(intact teeth).

Conclusion: The use of resin composite base material significantly increased the fracture strength of endodontically treated premolars with endocrown restorations.

KEYWORDS: Endocrown, Overlay; Resin composite; Fracture strength.

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INTRODUCTION

Restoration of endodontically treated teeth has been a challenging restorative procedure as result of compromised biomechanical properties.[1] Loss of structural integrity results from caries, trauma, endodontic and restorative procedures makes them more vulnerable to fracture. [2] Endodontic treatment is generally associated with reductions in both the resilience and fracture resistance of the treated teeth. Moreover, the depth and design of an endodontic access cavity compromises the strength of a tooth, resulting in an increased susceptibility to fractures.[3,4] Mesioocclusodistal (MOD) preparations generally are more liable to cuspal fracture due to extended cavity size.

The decision of restorative technique would depend mainly on remaining tooth structure to assure function and prevent fracture. A reinforcing ferrule design for the restoration is commonly recommended after endodontic treatment to reduce fracture susceptibility using complete crowns that cover all cusps. [5,6] Composite resin restorations or adhesive ceramic inlays that provide internal reinforcement of teeth without occlusal coverage have been advocated. [7,8] These techniques do not guarantee a full restoration of the fracture toughness of a sound tooth. Moreover, several studies in the literature have reported that the application of the posts causes weakening of the roots, in addition to the perforation risk during the preparation of the post space. [9,10] However, as the structural strength of the tooth with extensive loss of tooth structure restored with conventional restorations is poor, endocrowns became an alternative option for post-core systems.[11,12]

Endocrowns, defined as “bonded overlay restorations,” are anchored macro-mechanically to the internal portion of the pulp chamber walls and on the cavity margins whereas micromechanical retention is provided by the use of adhesive cementation. [13] In parallel with the developments and improvements in CAD/CAM, new and varied ceramic materials with different physical, mechanical and aesthetic properties are continually being developed. However, dentists have to consider the biomechanical behavior of these materials in order to make a well-informed decision. [14] It has been reported that several factors play an important role on the longevity of ceramic restorations, such as the strength, thickness, compatibility of the modulus of elasticity of the ceramics and tooth, and the adaptation of the restorations to the interfacial bonding surface.[15]

Endocrown restorations showed higher fracture strength values than conventional restoration in anterior and posterior areas.[12] The survival rate of premolar endocrown were stated 68.8% compared to 94.6% survival rate observed for classical crowns. [16] This was attributed to the accumulation of stresses at the interfaces of different materials with different modulus of elasticity which may cause increases fracture risk.

The use of resin composite liners or base material with a low modulus of elasticity as the first increment has become increasingly accepted over the past few years. [17] Generally positive effects have been reported for the use of flowable composites as stress-breaker intermediate layer. Moreover, the addition of polymerization modulator as the stress decreasing resin (SDR) in bulk-fill flowable materials results in polymerization stress values up to 60-70% less than methacrylate and nano-hybrid flowable composites. [18,19] In addition, lower fracture rates and marginal adaptation were also reported for bulk-fill composites. [20] Nanohybrid composite resin reported an acceptable fracture resistance value. The high filler loading enables nanocomposites to report both good physical and mechanical properties with reinforcement of tooth structure. [21]

Although some literatures were comparing the fracture resistance of different endocrown restorative materials, there is no data about the effect using resin composite as base material with endocrown restorations. Therefore, the aim of this study was to evaluate the effects of different restorative protocols on fracture resistance of endocrown restoration The null hypothesis of this study was that the various resin composite base materials would not affect the fracture strength of endodontically treated teeth restored with endocrowns.

METHODOLOGY

Sample selection

A total of sixty recently extracted intact, crack and caries-free human maxillary first premolars, extracted for periodontal reasons, were selected for this study. The teeth were examined for being approximately homogeneous in anatomic crown length, mesiodistal and buccolingual dimensions. For the purpose of standardization, the teeth were selected with approximate similarity in crown size, length and shape. They were of average dimensions (7 ± 0.5 mm) mesio-distal width, and of bucco-lingual width (8mm ± 0.5mm). All dimensional measurements were taken at the proximal cemen-toenamel junction (C.E.J) level using a digital caliper. Any premolars with other dimensions than formally stated were excluded. These measurements were used in the distribution of the teeth among the different groups to provide uniformity of tooth size in each group. All gingival remnants were removed; the crowns were cleaned and scaled with hand instrument and polished with a rotating brush and pumice. Then the collected teeth were stored in saline solution at room temperature from the day of extraction until the time of testing, to keep them hydrated and prevent cracking during preparation.

Sample grouping

The teeth were randomly divided into six groups (10 each) according to the restorative materials applied. The materials for the restorative procedures are listed in Table 1.

Group 1: sound premolars without endodontic treatment or cavity preparation as negative control.

Group 2: endodontic treatment and cavity preparation but without restoration as positive control.

Group 3: endodontic treatment and the prepared cavity was restored with ceramic overlay extending into the prepared pulp chamber (endocrown)

Group 4: endodontic treatment and the prepared pulp chamber was restored with nanohybrid composite then the occlusal part was restored with ceramic overlay.

Group 5: endodontic treatment and the prepared pulp chamber was restored with sonicfill bulk fill composite then the occlusal part was restored with ceramic overlay.

Group 6: endodontic treatment and the prepared pulp chamber was restored with bulk fill flowable composite then the occlusal part was restored with ceramic overlay.

Samples preparation

Fabrication of mold and centralizing device:

Specially designed cylindrical Teflon mold formers having 2cm length and 2cm internal diameters were fabricated. Its cylindrical tube used for holding of the epoxy resin and the tooth inside it. Accurate centralization of the teeth in the epoxy resin was done using a specially designed centralizing metal device for standard placement.

Periodontal ligament simulation and Mounting of the teeth

For periodontium simulation, the roots of all teeth were dipped in melted set up wax **(Cavex, Holland B.V)** to a depth of 2mm away from cemento-enamel junction to form a uniform coat of about 0.3 mm around root. After wax setting, each tooth is casted in self-cure acrylic resin cylindrical block (Acrostone, Egypt). Each tooth was embedded in the acrylic while it was in soft dough stage and the tooth was pressed in the acrylic till all root is embedded except for 2mm apical to cemento-enamel junction

TABLE (1): Name and product details of the materials used

Material	Specifications	Composition	Manufacturer	Lot number
Ceram x-SpherTEC	Nanohybrid composite material	Matrix: (methacrylate-, acid-modified methacrylate-, inorganic polycondensate- or epoxide based) modified version of the polysiloxane. it is combined with a well-established *poly*-urethane-methacrylate as well as bis-EMA and TEGDMA. **Fillers:** 77-79 weight-% total (59-61% by volume)	*DENTSPLY sirona, Konstanz, Germany*	
SonicFill™	Nanohybrid bulkfill composite material	**Matrix**: Glass, oxide, chemicals (10–30%), 3-trimethoxysilylpropyl methacrylate (10–30%), silicon dioxide (5–10%), ethoxylatedbisphenol A dimethacrylate (1–5%), bisphenol A bis(2-hydroxy-3- methacryloxypropyl) ether (1–5%), and TEGDMA (1–5%) **Filler:** 83.5 % by weight	Kerr™ Corporation, West Collins, Orange, CA	5116395
SureFil™ SDR flow [Smart Dentin Replacement] (Universal Shade)	Visible light cured bulk-fill flowable base resin composite	**Matrix:** • SDR™ patented UDMA resin, • TEGDMA • DMA resin, • Di-functional diluents. • EBPADMA • Triethyleneglycol dimethacrylate **Filler:** • Barium and Strontium. • Fluoroalumino-silicate glasses. (68% by wt., 45% by vol.)	*DENTSPLY sirona, Konstanz, Germany*	#1206000598
Vita Enamic	Resin nano hybrid ceramic	**Composition of the ceramic part (86 wt% / 75 vol%)** Silicon dioxide **SiO_2** (58 – 63%) - Aluminum oxide **Al_2O_3** (20 – 23%) - Sodium oxide **Na_2O** (9 – 11%) - Potassium oxide **K_2O** (4 – 6%) - Boron trioxide **B_2O_3** (0.5 – 2%) - Zirconium dioxide **ZrO_2** < 1 - Calcium oxide **CaO** < 1 **Composition of the polymer part (14 wt% / 25 vol%** UDMA(urethanedimethacrylate) & TEGDMA (triethylene glycol dimethacrylate)	VITA Zahnfabrik H. Bad Säckingen · Germany[1*]	

with the long axis of the tooth perpendicular to the base of the block. The cylinder Teflon mold was seated into the stainless steel base of centralizing advice, and then applying separating medium on walls of the mold .The crown of each tooth was clamped by the crown holder. The tooth was centralized guided by the centralizing depression in the stainless steel base. When the axis of the tooth was positioned correctly, acrylic was poured inside the mold until it completely filled it. The acrylic was left to harden then pushed with the tooth outside the mold**.** After acrylic setting the block was removed from the mold and checked carefully. Then the teeth were removed from the casted acrylic block, wax spacer was removed and light body poly-vinyle siloxane material (Speedex, Coltene Whaldent AG, Attstatten, Switzerland) was injected in the space between mold and root and teeth were re-inserted in the mold. This simulated the periodontal ligaments. The specimens were stored in distilled water in 37°C temperature for 24 hours before testing.

Standardized Tooth Preparation

Silicone putty impressions were done on all of the teeth samples before their preparation. These impressions were used as templates to evaluate the amount of tooth reduction. The premolar overlay preparation involved a mesio-occluso-distal cavity with both buccal and lingual cusps covered. Overlay preparation procedures were performed in accordance with general principles for ceramic overlay restorations. Because the Freehand preparation of teeth can result in a variable depth of preparation, so in order to standardize the preparation to receive overlay restoration, the teeth were prepared by computer numerically controlled CNC milling machine. This device is characterized by 5-axes simultaneous processing, with water coolants to prevent tooth overheating or burns during preparation and cracking. Preparation of the occlusal cavity was started in the central fossa of the occlusal surface to a depth of 3mm. Then the cavity was extended mesially and distally to the mesial and distal fossae. The preparation was extended 1.5mm beyond the central groove in the buccal direction and 1.5mm in the lingual direction. The bucco-lingual width was 3mm which corresponded to 1/3 of the inter-cuspal width. Proximal Box-shaped cavity with 6-degrees divergence. The width of the gingival seat was 1.5mm mesiodistally and the height of the axial wall was 2mm. The gingival seat was kept 1mm above the cervical line. The bucco-lingual width of the proximal box was 4mm cervically and 5mm Occlusally. The buccal and ligual cusps were reduced 2mm to be flat without any inclinations. To check the amount of reduction for each tooth, a silicone index that was fabricated prior to tooth preparation of all teeth and Provisional restorations were fabricated for each preparation and their thickness was measured using a caliper to verify standard amount of reduction.

Endodontic treatment

Endodontic access cavities were then prepared using a #2 round diamond bur (Mani, Utsunomiya, Japan). The teeth were selected with a minimal apical diameter corresponding to a size 15 K-file. The working length was determined using a size 15 K-file (Mani) and set as the initial apical file. All the canals were instrumented with K-files (Mani) to an apical size of 40 using a step-back technique. The coronal portion of each canal was enlarged with Gates Glidden burs (Mani) with size #3 to #1 in a slow-speed contra-angle handpiece. Irrigation was performed with 5.25% sodium hypochlorite between each file usage during cleaning and shaping and finally with distilled water. The canals were dried with paper points (DiaDent, Burnaby, BC, Canada) and obturated by cold lateral condensation with ISO standardized 2% gutta-percha (Densply Maillefer, Ballaigues, Switzerland) and AH Plus Root Canal Sealer (Dentsply Maillefer, Ballaigues, Switzerland). The gutta-percha was removed till the level of the canal orifice. The walls of the pulp chamber were prepared to provide occlusal divergence with 10 to 15^{o} using tapered abrasives with flat end.

Restoration of the pulp chamber of the prepared teeth

The application of all tested materials was performed in accordance with the manufacturer's instructions using their recommended adhesives of the same company. For all specimens the etch-and-rinse adhesive approach was used, applied according to the manufacturer's instructions. All cavities were etched using 37% phosphoric acid, rinsed with water for 10 seconds and dried with air for 5 seconds. Then, the adhesive was applied for all specimens according to the restoration material used and polymerized using LED light-curing unit (Elipar S10, 3M ESPE, St Paul, MN, USA) operating in standard mode at light intensity 1200 mW/cm^2. The pulp chamber of the endodontically treated teeth was restored as follows;

Group 3: the pulp chamber was left unrestored with direct restoration to be restored with the ceramic restoration in the form of endocrown.

Group 4: the pulp chamber was restored incrementally with Ceram-x-SpherTEC then the occlusal part was restored with ceramic overlay. The first increment was 2 mm thickness and applied horizontally to ensure maximum adaptation with the floor and cured for 20 seconds using the same light curing unit. Afterwards the second increment was applied and cured for another 20 seconds.

Group 5: the pulp chamber was restored with Sonicfill bulk fill composite then the occlusal part was restored with ceramic overlay. Mounting of the Sonicfill handpiece to the high-speed aerator was done, followed by placing the composite compule into the tip of the device. Then, the speed of composite ejection from the sonicfill handpiece was adjusted to speed 3. Upon activation of the handpiece, resin composite flowed into the pulp chamber in one increment. The tip of the compule was always at a lower level than the ejected composite material inside. After turning off the hand piece, composite was packed using ball burnisher and the excess material was removed before curing. Then, curing for 20 seconds was done according to the manufacturer's instructions with the same light curing unit.

Group 6: the pulp chamber was restored with SDR Bulkfill flowable, then the occlusal part was restored with ceramic overlay. The SDR® was supplied as pre-dosed injectable flowable resin composite compules. The compules were loaded into the composite applicator gun (DENTSPLY, De Trey, and Konstanz, Germany). After removal of the cap from the compule tip, the material was injected directly into the pulp chamber till filling it. The tip of the compule was immersed into the injected composite to avoid air bubbles. Then, curing for 20 seconds was done according to the manufacturer's instructions with the same light curing unit.

Fabrication of overlay ceramic restoration

Each prepared tooth was scanned using omnicam intraoral camera of CEREC system for taking the optical impression. The optical impression was checked to avoid incomplete image that would affect the final design. The margin was drawn and the final design was acquired and checked for any corrections. The ceramic overlay thickness was checked by the software in order to standardize the thickness of all samples. After successful design of the restoration; checking the margins, checking restoration uniformity and contour, all the parameters were met; the selected ceramic block (Vita Enamic hybrid ceramic) of the required size (12) was inserted in the spindle of the milling chamber of the CEREC milling machine and fixed with the set screw. The milling process was fully automated. After completion of the milling process, the overlay restoration was separated from the block and was checked over their corresponding prepared teeth. All ceramic specimens were polished according to the manufacturer's recommendations using vita enamic polishing kit of varying grit sizes, starting with the largest grit-sized tips and ending up with the smallest.

Surface treatment of the ceramic overlay restoration

The inner surfaces of the ceramic restorations were etched using 9.8 % hydrofluoric acid gel according to the manufacturer instructions for 60 seconds. The ceramic restorations were then washed thoroughly with air/water spray for 30 seconds and then dried for 10 seconds using compressed air. Afterwards, the inner surface of the etched restorations were primed for resin using a silane coupling agent (**Monobond**-S) for 60 seconds, then air dried before cementation. Finally, single coat of the Universal adhesive (Prime and Bond active, DENTSPLY) was applied with agitation movement, air thinned with gentle air blast for 5 seconds and light cured using LED light curing unit for 20 seconds.

Surface treatment of prepared tooth

The prepared surfaces of all teeth samples was acid etched using 37 % phosphoric acid etching gel (etch and rinse approach) for 30 seconds for enamel margin and 10 seconds for dentin surfaces, rinsed by air/water for another 10 seconds, then dried with air spray for 5 seconds. Universal adhesive (Prime and Bond active, DENTSPLY) was applied for 20 seconds with a micro-brush on the etched surfaces of all teeth. The adhesive was thinned by air syringe and light cured using the same LED light curing unit for 20 seconds.

Cementation of the ceramic restoration

The base and catalyst paste of the Rely-x self-adhesive dual cure resin cement were dispended separately from the syringes on the mixing pad in a ratio of 1:1 and carefully mixed with spatula for 10 seconds to form a homogenous mix . A thin layer of cement was then applied on the fitting surface of the overlay restoration which was then placed in position with gentle finger pressure on the corresponding tooth and placed in the cementing device to standardize the static load applied during the restoration cementation. The excess cement was removed immediately with the micro-brush and the exposed margins were covered with glycerin gel as recommended by manufacturer as air block material to avoid oxygen inhibition of the cement and ensures the complete polymerization. The cement was then light cured with the same LED light curing unit for 20 seconds from the occlusal, lingual, mesial and distal directions each respectively. After complete polymerization, the glycerin was rinsed off with water.

Thermocycling:

All specimens were subjected to thermocycling between 5C° to 55C° in water bath for a total of 2000 cycle with 10 seconds dwell time at each bath using thermocycling device.

Fracture resistance testing

All specimens were individually mounted on a computer controlled materials testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a load cell of 5 kN and data were recorded using computer software (Instron® Bluehill Lite Software). The specimens were mounted and secured on the lower fixed compartment of the testing machine by tightening screws, to ensure that the loading steel rod with spherical tip of 6-mm diameter was positioned on the central occlusal surface of the ceramic overlays in such way the load applicator tip only touched the inclined planes of buccal and lingual cusps. The loading steel rod with spherical tip was attached to the upper movable compartment of the machine traveling at cross-head speed of 1mm/min. A layer of tin foil (1mm thickness) was placed between the loading tip and the occlusal surface of the overlay to achieve an even stress distribution and to minimize the transmission of local force peaks. The tip contacted the occlusal surface of the overlay restoration which was subjected to a slowly increasing vertical load (1mm/min) until the fracture occurred. The load at failure in Newtons was manifested by an audible crack and confirmed by a sharp drop of load-deflection curve.

The maximum load to produce fracture for each specimen in Newton (N) was recorded.

Statistical analysis.

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, data showed parametric (normal) distribution. One-way ANOVA followed by Tukey post hoc test was used to compare between more than two groups in non-related samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

The mean fracture resistance values obtained for each group are listed in Table 2 ,Figure 1. There was a statistically significant difference between all groups ($p<0.001$). A statistically significant difference was found between (G2) and each of (G3), (G4), (G5) and (G6) groups where ($p<0.001$). The highest mean value was found in (G1) followed by (G6), (G5), (G4) and (G3), while the least mean value was found in (G2) group. No statistically significant difference was found between (G1) and (G6) where (p=0.468).

TABLE (2): The mean, standard deviation (SD) values of different Endo-Crown protocols.

Variables	Endo-Crown protocols	
	Mean	SD
G1 (Sound)	992.84 [a]	117.17
G2 (Endodontic, cavity without restoration)	459.52 [d]	90.66
G3 (Endodontic, ceramic overlay)	659.57 [c]	79.91
G4 (Endodontic, nanohybrid composite, ceramic overlay)	749.27 [bc]	70.03
G5 (Endodontic, sonic-fill bulk fill composite, ceramic overlay)	805.99 [b]	67.15
G6 (Endodontic, bulk fill flowable composite, ceramic overlay)	925.55 [a]	61.12
p-value	<0.001*	

Means with different letters in the same column indicates for statistically significant difference. *; significant (p<0.05) ns; non-significant (p>0.05)

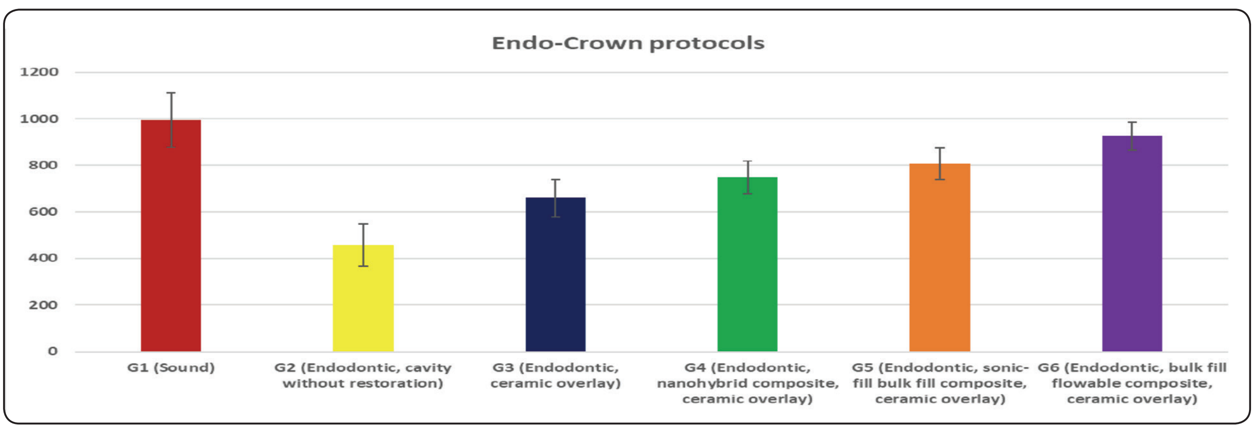

Fig. (1): Bar chart representing different endo-crown protocols

DISCUSSION

The goal of restorative dentistry is to replace the lost dental tissue with material whose mechanical and physical properties are similar to a natural tooth. Endocrown restorations have been increasingly used for restoration endodontically treated teeth with severe crown damages. It has been reported that several factors play an important role on the performance and longevity of endocrown, such as the preparation depth, strength and thickness of the ceramic, [22] compatibility of the modulus of elasticity of the ceramics and tooth structure, and the adaptability of the restorations to the bonding surface [15].

In this study, we aimed to evaluate the effect of resin composite materials used to fill the pulp chamber on fracture strength of endodontically treated teeth restored with endocrown restorations. The fracture resistances were compared with both positive and negative control endodontically-treated premolars. The null hypothesis was rejected, because composite base restoration did affect the fracture strength, such that the highest fracture strength values were obtained with SDR bulkfill flowable composite group.

Premolars were selected due to their increased susceptibility to fracture following endodontic treatment compared to molars as result of an increase in cuspal deflection and tooth fragility under occlusal forces. [23] In addition, it has been reported that large restorations result in higher stress in the tooth itself rather than at tooth restoration interface which could result in cracking or even fracture from excessive flexural fatigues. [24] Thus, in this study, maxillary first premolars were used to compare the fracture resistance of different base materials regard to mechanical occlusal loading. Taking into consideration the results of previous study which concluded that greater stresses detected in designs with 1 mm buccal reduction than in 1.5-2mmm designs, so reduction of height of buccal cusp was chosen to be 2mm. Periodontal ligament simulation prior to the fracture strength analysis of endocrown was performed in order to simulate the real tooth behavior against masticatory forces. Soares et al. concluded that periodontal ligament behaved as stress absorber thus affecting both the fracture resistance and fracture modes. [25]

To standardize the parameters, Vita Enamic was used for fabrication of endocrown restorations for all groups. It is a hybrid ceramics which is formed by a combination of two penetrated phases with higher flexural strength than single phase materials. [26] The elastic modulus value is 30 GPa which is similar to the elastic properties of teeth. [27] Moreover, hardness value of hybrid ceramics was lower compared to silica-based ceramics thus resulting in less wear than traditional ceramics.[28]

The samples were subjected to thermal cycling treatment to simulate the situation in the oral cavity undergoing continuous thermal changes. Thermocycling is considered a valuable in vitro method to evaluate the results of temperature changes during mastication on dental materials in a short time. A compression force was applied to the specimens in the present study until breakage occurred thus determining the maximum loads that lead to fracture. A steel ball of 6 mm diameter was used based on its ability to contact the buccal cusp, the palatal cusp, and the restorations with equal distance.

Cuspal deflection influenced by two main categories of factors, the geometric properties and restorative material itself.[29] An important mechanical property for resin composite materials is fracture toughness, which indicates the relative resistance to surface crack propagation or inherent flaws in inside the materials. It was also known that the cuspal displacement was affected by the modulus of elasticity of the restorative materials.[30] The other category of factors includes clinical factors such as the use of cavity liner, restorative and polymerization techniques. It has also been reported that the use of flowable composites as an intermediary material reduces cuspal flexure according to elastic cavity wall concept. [31] In this study, the fracture strength of endodontically treated premolars restored with a nanohybrid and bulk-fill rein composites was evaluated. Today's nano technology made small modifications on resin composites to have superior mechanical properties such as increased elastic modulus and improved adaptation techniques. Sphere TEC allows the production of pre-polymerized fillers with a high filler loading using primary particles which are smaller than 1 μm thus supporting mechanical strength and reducing polymerization shrinkage. Moreover, acceptable clinical results were reported for bulk-fill materials regarding good surface characteristics, marginal adaptation and low fracture rates. [32] The bulk-fill flowable liners combine the advantage of adequate mechanical properties with low stress and shrinkage values which is important particularly in restoration of endodontically treated teeth. [33]

Intact teeth showed the highest fracture resistance values, which is consistent with previous studies reporting that lower resistance to fracture was found with restored teeth. [34,35] Reeh and Messer, reported that the access of endodontic treatment within intact teeth reduces fracture resistance and when it was combined with a MOD cavity preparation, the resistance was significantly reduced. [36] The results also showed that, fracture strength of restored teeth was increased compared to unrestored teeth. This could be attributed to the cantilever beam theory proposed by Hood in which the placement of 4mm increment significantly reduces the length of cusp height thus splinting the cusps together and reduces deformation under occlusal loading.[37]

The use of bulk flow flowable composite base (SDR) has significantly improved the fracture strength values of endodontically treated teeth compared to Sonic fill bulk fill, nanohybrid and unrestored teeth and not significantly different from intact teeth. Superior handling and significantly improved physical properties of Ceram-X SphereTEC are a direct result of a novel filler system . The improved resistance to micro crack propagation in Cram-X was attributed to strengthening effect of the nano – ceramic particles which can be best described as inorganic-organic hybrid particles. The inorganic siloxane part provides strength and the organic methacrylic part makes the particles both compatible and polymerizable with the resin matrix.

Considering bulk fill placement technique, it has been demonstrated that Sonicfill system and SDR showed greater fracture strength values. This could be attributed to better internal adaptation than conventional composites in high C-factor cavities. [38] The low viscosity of both Sonicfill system and SDR, which facilitates plastic flow during the early phases of polymerization could be responsible for the greater fracture strength values obtained by these materials. [39] Regarding Sonicfill system, the results can be explained by its working principle as sonic energy is applied, the incorporated modifier causes the viscosity to drop up to 87% during composite insertion thus increasing its flowability ,while when the sonic activation stopped, the composite returns to a more viscous, non-slumping state that is suitable for carving and contouring. [40] The bulk-fill flowable material SDR has previously demonstrated lower polymerization stress, cuspal deflection and flexural modulus. [41] Material with low modulus of elasticity allows higher deformation under stresses thus dissipating the stress and improving the fracture strength.

It is important to point out that the present study do not accurately reflect the dynamic intraoral conditions. The application of combined thermal, chemical, and physical stresses may further clarify the results obtained. In addition, the destructive fracture testing methods used is not typical of the type of loading that occurs clinically. Accordingly, long term clinical studies are recommended to verify in vitro results.

CONCLUSIONS

Based on this in vitro study, it can be concluded that the use of resin composite base has improved the fracture strength of endodontically treated premolars with endocrown restorations.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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