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ASSESSMENT OF MARGINAL GAP AND FRACTURE RESISTANCE OF TWO CAD/CAM ANTERIOR ENDOCROWNS (CERASMART VERSUS CEREC TESSERA)

Mostafa Ali Saied*, Jylan Fouad Elguindy** *and* Raiesa Mohamed Hashem***

ABSTRACT

Aim: Evaluation of marginal gaps and fracture strength of two sets of CAD/CAM anterior endocrown ceramic materials (CERASMART & CEREC Tessera)

Materials and Methods: Thirty two anterior endocrowns were constructed. The samples were allocated into two groups based on type of ceramic materials (n=16). Group1 was Tessera ceramic material, while group 2 was CERASMART ceramic material. Each group was split into two sub-groups (n=8) based on the test they were subject to; Sub-group A for marginal gap test and sub-group B for fracture resistance test. Marginal gap was initially measured before cementation and thermocycling using an optical digital stereomicroscope then re-evaluated after cementation and thermocycling. All samples were cemented by self-adhesive resin cement (Biscem). Then samples included a fracture resistance test with a universal testing machine.

Results: There was significant increase in total marginal gaps before and after cementation and thermocycling in both groups: (60.9±9.5 µm - 70.4±8.7 µm) in CERASMART group and (62.3±8.7 µm - 70.1±8.3 µm) in Tessera group. There was insignificant difference in fracture resistance between both groups and the value with greatest mean fracture resistance was observed for CERASMART group (739.2±140.2N) compared to Tessera group (623.6±114.6N). The failure modes of CERASMART showed more damage to the tooth substructure in comparison to CEREC Tessera.

Conclusion: Both CEREC Tessera and CERASMART endocrowns materials exhibited a clinically acceptable range for the marginal gap values. CERASMART endocrowns provided promising fracture resistance values as well as CEREC Tessera endocrowns as a mode of treatment of endodontically treating maxillary anterior teeth.

KEYWORDS: Endocrown, CERASMART, CEREC Tessera, Fracture resistance, Marginal gap

* Msc student of Fixed Prosthodontics, Faculty of Dentistry, Minia University
** Professor of Fixed Prosthodontics, Faculty of Dentistry, Cairo University
*** Associate Professor of Fixed Prosthodontics, Faculty of Dentistry, Minia University

INTRODUCTION

Large coronal destruction in endodontically treated anterior teeth remains a clinical issue, particularly because of the resulting loss of strength characteristics and the anterior teeth's positioning at an angular position to the occlusal surface, resulting in oblique forces that are believed to be the most damaging kind of forces.[1] The conventional technique of treating severely damaged endodontically treated anterior teeth includes applying complete crown coverage with sufficient ferrules and building up the tooth with a post and core. An entirely alternative, more recent method suggests using the so-called endocrown rather than post and core.[2]

There has been a noticeable increase in the variety of materials available for dental application in CAD/CAM technology. Lithium disilicate glass ceramic blocks are among the materials being used for endocrown fabrication using CAD/CAM because of its excellent aesthetics and superior fracture strength. Resin nanoceramic blocks (RNC) or hybrid ceramics are another material that is utilized with CAD/CAM.[3]

CERASMART, GC is a resin nanoceramic CAD/CAM block packed 71 weight percent with a nano composite made of high-density ultrafine glass particles. This material has a respectable degree of marginal adaptability together with a high strength of 230 Mpa and distinctive appearance.[4]

CEREC Tessera, Dentsply Sirona is a novel enhanced lithium disilicate CAD/CAM blocks [5]. This ceramic is specified as it is available to rapidly fired only 4.5 to 12 min at 760C. The manufacturer claims that Tessera strength is 700 MPa.[6]

Microleakage results from the cement dissolving and being exposed to the oral circumstances when the marginal irregularity of an endocrown increases; moreover, insufficient adaptation of the margins results in an increase in the retention of plaque and alterations in the subgingival microflora's composition, both of which point to the start of gingival disease.

One crucial mechanical characteristic that affects how well brittle materials perform is their strength. The final surface finishing, the cementing procedure and the fabrication method are some of the elements that affect fracture resistance.[7]

So, the objective of this in vitro study is to assess the marginal gaps and fracture resistance of both CAD/CAM endocrown materials (CERASMART & Tessera) utilized in restoring endodontically treated anterior teeth.

The null hypothesis of current study is that there won't be any differences in marginal gaps or fracture resistance of CEREC-Tessera and CERASMART

MATERIALS AND METHODS

In the present study, the sample size was determined using Nassar's prior research.[8] This study indicated that eight samples per group was the minimum acceptable size in every individual group, the responses were evenly distributed with a standard deviation of 4.15, the type I error probability was 0.05 and the calculated mean difference was 6.28 with 80% power.

Thirty two extracted human upper central incisors teeth were collected and used in current study. The teeth were checked to assure that they were free of caries, depositions, cracks, and fractures. [9] Teeth of identical size and shape were allocated by crown length and dimension. Teeth length was 22 ± 2 mm inciso-apically, 8 ± 1 mm mesio-distally dimension and 8 ± 1 mm labio-lingually. The teeth had a thorough cleaning, scaling, and scrubbing in order to eliminate any remnants of periodontal ligament, blood, plaque, and calculus. The teeth were submerged in sodium hypochlorite solution to disinfect them. for 24 hours and then washed and stored in distilled water until usage.[3]

Teeth were evenly and arbitrarily allocated into two groups based on the kind of ceramic materials used. Group 1 (n=16) CEREC Tessera ceramic material and group 2 (n=16) CERASMART ceramic material. Every group was then sub-divided into 2 sub-groups (n=8) based on the applied test; subgroup (A) marginal gap test and subgroup (B) fracture resistance test.

In order to align each long axis of the tooth should be perpendicular to the horizontal plan; a parallel appliance equipped with self-curing acrylic resin was used to mount it vertically in a specially made mold (2.5 cm internal diameters, 2 cm length). Just as 2 millimeters beyond the CEJ (equivalent to bone level), teeth were implanted in the resin.[10]

Samples preparation

Teeth were endodontically treated as following; a standard process was followed in opening the pulp chamber.. The access cavities of the teeth were performed with a high speed hand piece and cutting burs and tapered stone under copious water coolant. Working length was determined by insertion a size no. 15 K file before the apical foramen by 0.5ml. The root canal was fully prepared to the F3 Protaper rotary file Ni- Ti. A 5% solution of sodium hypochloride (NaOCl) accustomed to irrigate the root canals between each file. Paper points were utilized to dry canals. and f3 cone were checked for tug-back.[11] Then obturation of teeth with single gutta-percha cones taper sized F3 in conjunction with ADSEAL resin based root canal sealant and then the rest gutta percha was removed by a heated condenser. After finishing the endodontic procedure, orifices were closed with non-eugenol temporary restorative materials and all teeth will be stored at 37°C for 48 hours.

For standardization of preparation, CNC (Computer Numerical Control) milling machine was used for endocrown preparation of teeth. The teeth's crown sections were sliced horizontally, 2 mm above the CEJ, with a super coarse diamond disc with copious amount of water to avoid cracking. The margins were designed at the CEJ with 1 mm deep Chamfer finish line with ferrule. The pulp was also prepared by CNC as follow: 2 mm labiolingually width, 2 mm mesiodistally width to form an oval shape uniformed with tooth outlines and the internal taper of the pulp space was 8 degrees divergence of the walls.[12] The internal line angles were finished and smoothed using finishing stone **as shown in figure 1&2**.

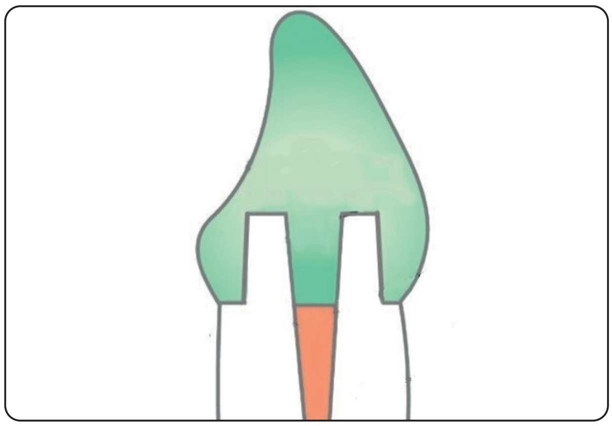

Fig. (1) : Diagram showing preparation design: 2 mm extension from cavosurface margin inside pulp space with ferrule, 1 mm deep chamfer finish line

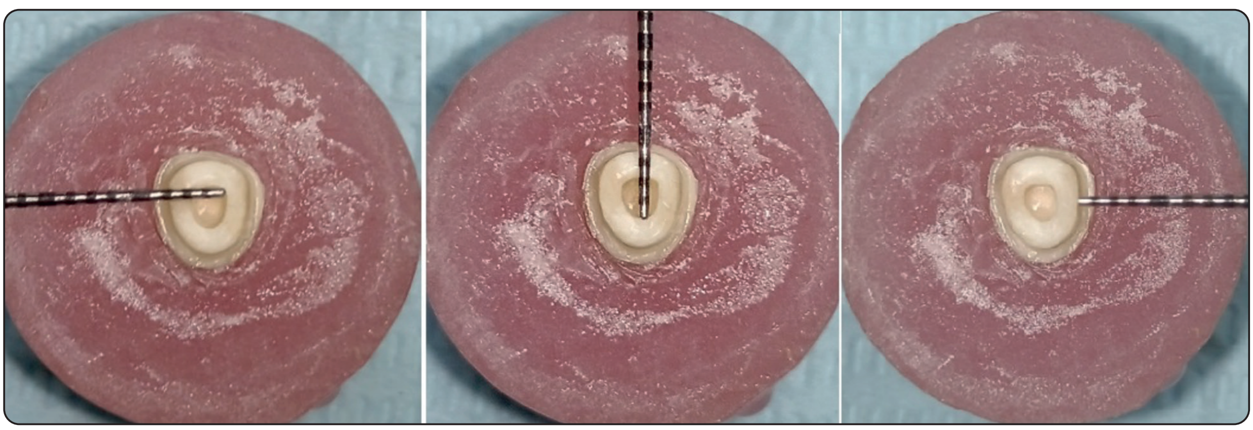

Fig. (2) : Sample preparation

Endocrowns fabrication

Scanning of the samples was made using InEos X5 Sirona extraoral scanner. Special software (inLab SW 4.2) was used in designing of all restorations using a standard protocol and applying design to each digital impression of each sample. The internal gap was set to 50 µm to accommodate the thickness of the cement.[13]

The ceramic block was positioned in milling unit CEREC inLab MC X5. In line with the manufacturer, CEREC Tessera restorations just need a final spray glaze and firing for 4.5 min at 760°C after milling, restorations were put in ceramic furnace CEREC SpeedFire for firing. [5] CERASMART restorations don't require additional glaze firing since they're a hybrid ceramics, GC Ultimate Kit and Diapolisher Paste were used for the final finishing and Polishing of restorations. [1]

Cementation of endocrowns

The internal fitting surfaces of endocrowns were etched according to manufacturer recommendations with 9.5% hydrofluoric acid (Tessera endocrowns for 30 seconds, CERASMART endocrowns for 60 seconds), rinsed for 20 seconds and air dried. Then a BIS-SILANE coupling agent was brushed and left to dry for 2 minutes **as shown in figure 3**. Total-etch protocol was followed; applying 35% phosphoric acid was done for 15 seconds for dentin, 30 seconds for enamel finish line and then rinsed for 20 seconds then air dried.[1] With a microbrush(All-Bond Universal. BISCO Inc) adhesive was applied to coat the prepared teeth. The adhesive was thinned, solvents were evaporated for 5 seconds with air and then light-cured for 20 seconds.[8] Biscem dual-cure adhesive resin cement was applied on the tooth surface, endocrowns were positioned on the teeth and static finger pressure was applied. Initial light cure for 2 seconds then excess cement was removed then a specific loading apparatus was utilized to apply a consistent 5 kg force parallel to each endocrown's long axis, which was maintained for 5 minutes.[8] Restorations were light cured for 20 seconds from each side based on the manufacturer recommendations.

Marginal gap measurements

Marginal gap was initially measured before cementation and thermocycling using an optical digital stereomicroscope then re-evaluated after cementation and thermocycling to determine their impact on the gap distance. Scanning with a fixed 35X magnification utilizing a USB digital stereomicroscope with an integrated camera attached to an IBM associated PC.[14] Marginal gap was measured at 8 predeterminated points; mesiobuccal, midbuccal, distobuccal, midlingual,

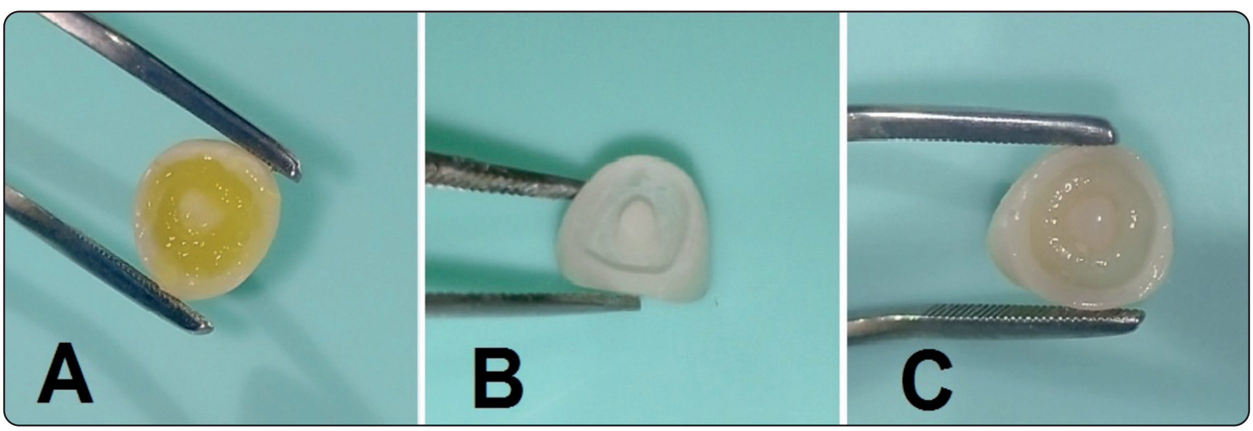

Fig. (3) A) 9.5% hydrofluoric acid application on fitting surface of endocrown, B) washing & drying of the endocrown, C) silane coupling agent application mesiolingual, distolingual, middistal, midmesial. Then all samples were subjected to artificial thermocycling. Thermocycling was performed for 5000 cycles (Cold water bath immersion for 30 seconds at 5c degree & Hot water bath immersion for 30 seconds at 55c) and Dwell time 10 seconds. The entire records were gathered, tabulated and then statistical analysis was performed.[15]

Fracture resistance test

The fracture resistance test was performed using a custom-designed attachment that was made to mount teeth at a 135-degree inclined. Utilizing a 4 mm diameter round-tipped metallic rod,[12] the load was applied palataly placing one sheet of tin foil between for achieving homogenous load distribution and reductions of the transfer of local force.[9] The highest load measured in Newtons (N). An audible crack sound indicated failure, and an abrupt fall on the load deflection curve confirmed what was noted by BlueHill computer software. All data was collected, tabulated and statistically analyzed.

RESULTS

Statistical technique analysis of the data was accomplished using the IBM SPSS version 25 statistical package software. The Shapiro-Wilk test was utilized to verify the data's normalcy. Data were stated as mean (SD) and the range are lowest and highest. Analyses were carried out between both groups for quantitative data using Independent Samples T-test and among the same group between every two times using Paired Samples T-test. P-value less than 0.05 were taken into consideration statistically significant.

Marginal gap test results:

TABLE (1) Comparison of total margin gap between the two groups before cementation and thermocycling

Before thermocycling		Tessera N=8	Cerasmart N=8	P value
Total margin gap	Range	(50.8-74.4)	(52.5-72.6)	0.798
	Mean ± SD	62.3±8.7	60.9±9.5	

Independent samples T test for quantitative data between both groups

Significant level at P value < 0.05

There was insignificant difference in total marginal gaps between both groups before cementation and thermocycling as shown in table1. Results revealed that better marginal gap value in CERASMART group (60.9±9.5 µm) when compared to Tessera group (62.3±8.7 µm) before cementation and thermocycling **as shown in figure 4**

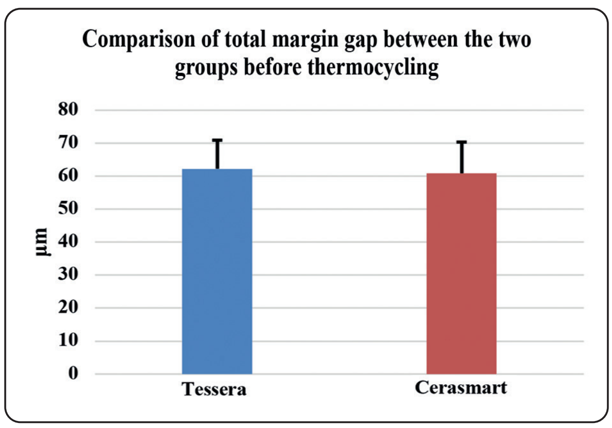

Fig. (4) Bar graph showing comparison of total margin gap between the two groups before cementation and thermocycling

TABLE (2) Comparison of total margin gap between the two groups after cementation and thermocycling

After thermocycling		Tessera N=8	Cerasmart N=8	P value
Total margin gap	Range	(59.9-82.8)	(61.4-81.8)	0.958
	Mean ± SD	70.1±8.3	70.4±8.7	

Independent samples T test for quantitative data between both groups

Significant level at P value < 0.05

There was insignificant difference in total margin gap between both groups after cementation and thermocycling as shown in table 2. Results revealed that better marginal gap value in Tessera group (70.1±8.3 µm) when compared to CERASMART group (70.4±8.7µm) after cementation and thermocycling **as shown in figure 5**

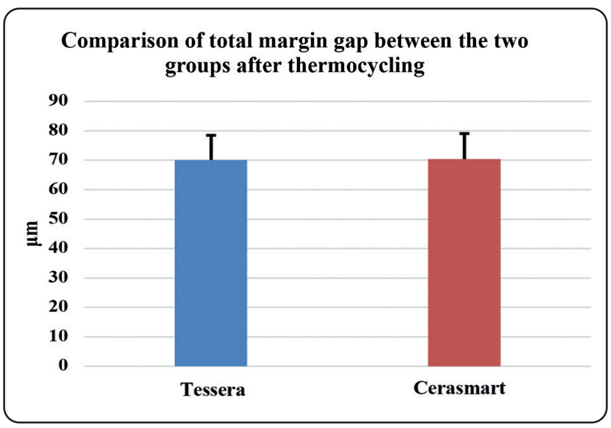

Fig. (5) Bar graph showing comparison of total margin gap between the two groups after cementation and thermocycling

Fracture resistance test results:

TABLE (3) Comparison of fracture resistant between the two groups

		Tessera N=8	Cerasmart N=8	P value
Fracture (N)	Range	(500.6-837.9)	(610.6-985.8)	0.149
	Mean ± SD	623.6±114.6	739.2±140.2	

Independent samples T test for quantitative data between both groups

Significant level at P value < 0.05

There was insignificant difference in fracture resistance between both groups as shown in table3. The highest fracture resistance mean value was noted for CERASMART group (739.2±140.2N) compared to Tessera group (623.6±114.6N) **as shown in figure 6**

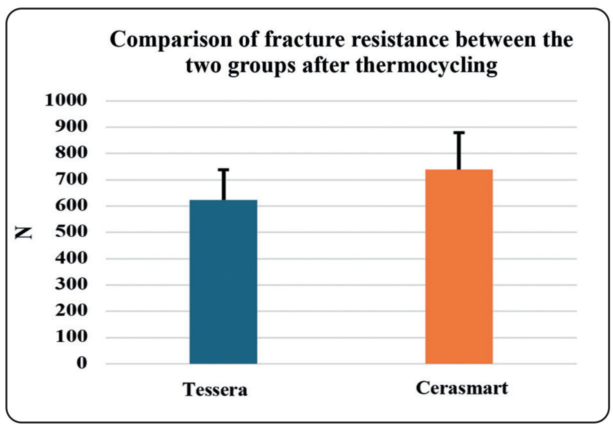

Fig. (6) Bar graph showing comparison of fracture resistance between both groups after cementation and thermocycling

Failure modes:

The samples were examined to verify different failure modes **as shown in figure 7** either:

- **Mode A** stands for a fracture in the restoration's coronal part (repairable)
- **Mode B** stands for favorable fracture in the cervical part of the restoration (repairable)
- **Mode C** stands for unfavorable fracture at CEJ of the teeth above the height of the bone (repairable)
- **Mode D** stands for fracture in the midroot or apical part of the root beyond the bone height (irrepairable).

TABLE (4) Results for failure modes for both groups

	Repairable			Irrepairable
	Mode A	Mode B	Mode C	Mode D
Group 1 Cerec Tessera	0/8 (0%)	4/8 (50%)	3/8 (37.5%)	1/8 (12.5%)
Group 2 Cerasmart	0/8 (0%)	2/8 (25%)	5/8 (62.5%)	1/8 (12.5%)

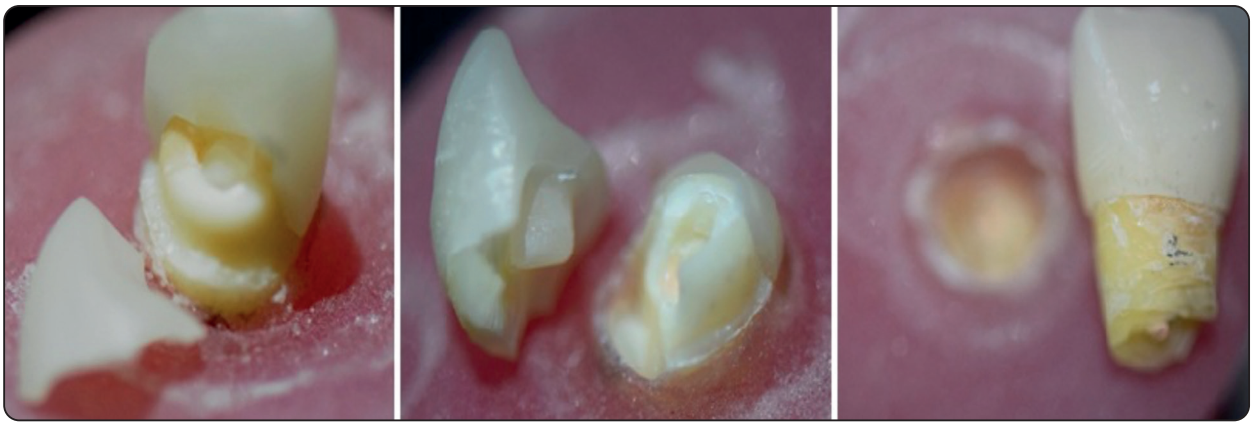

Fig. (7) Different failure modes

DISCUSSION

Anterior teeth that have undergone endodontic treatment generally display significant tooth structural loss, necessitating partial or full coverage restorations. In order to preserve a core for the final restoration, posts are frequently employed to restore teeth with minimal coronal tooth structure. The endocrown design was selected because it forms a single piece that fits the pulp chamber and the root canal more accurately compared to glass fiber posts that are manufactured, whose shapes are fixed and may not be appropriate for teeth with extensive damage and large root canals.[16] Endocrowns are monoblock restorations that provide both macro- and micromechanical retention because they assemble the crown, core, and intraradicular post as a single piece.[12]

Zirconia reinforced lithium silicate ceramic as CEREC Tessera is the enhancement of glass ceramic material with zirconia (about 10 % by weight) which helped in increase the strength of the material. [6] This ceramic's ability to fire very quickly is one of its characteristics only 4.5 to 12min at 760C. According to the manufacturer Tessera is over 700MPa strength. [5]

Flexible nano-hybrid ceramics CERASMART was chosen in the present study, because it has improved stress-absorbing properties than ordinary ceramics and have a lower brittleness and more flexible. The authentic structure of CERASMART provides these materials with a modulus of elasticity similarly to dentin (18 ± 2 GPa) with 220–240 MPa strength that positions it slight above feldspathic ceramics.[3]

The capacity of CAD/CAM technology to regulate restorative anatomy and thickness during manufacturing led to its selection.[17] Standardizing the mechanical qualities of restorative materials and the internal adaptation of the restoration were created as well. Scanning samples with CEREC InEos X5 Sirona extraoral digital scanner with high-precision axis control was the most accurate scanning procedure rather than using traditional silicon impression techniques.[13]

Because the majority of studies indicated that the resin cement would offer both chemical and micromechanical adhesion to the structure of the teeth and low solubility, cemented the endocrowns with BisCem (Bisco Inc., Schaumburg, IL, USA) dual-cure adhesive resin cement.[8] Deep cavities can benefit from dual-cured properties because they can be self-cured and light-cured. It's available as clicker dispenser delivery system of two pastes (base and catalyst) for flexible dosing. A previous research by Mahrous et al (2020)[18] revealed that utilizing calcium-fluoride-releasing self-adhesive resin cement contain MDP (Biscem) improved bond strength for enamel, dentin and ceramic.

All samples have been placed in epoxy resin to mimic the root position, two millimeters below the cemento-enamel junction. Epoxy resin has been employed as the elasticity modulus (12GPa) near the human bone (18GPa). Marginal gap values ranging up to120 µm have been shown in earlier research to be clinically appropriate for cemented restorations. For others, the optimal clinical condition was a marginal gap of ≤75 µm.

In order to replicate the contact angle that occurs in class I occlusions between maxillary and mandibular anterior teeth, the force was delivered to the tooth's long axis at a level of 45 degrees by utilizing a universal testing machine with a 4 mm diameter metallic rod with round tip with a piece of tin foil placed between to ensure uniform stress distribution and reduce the transmission of local force peaks till failure.

Since artificial aging has been shown to impact the marginal gap values that enable restoration assessment under clinically simulated conditions, it is an essential component of all in-vitro studies involving ceramic materials. All specimens were subjected to 5000 cycles, at 5° and 55°C water which are similar to 6 months of clinical service.

In this study the variable was the different ceramic materials of the endocrown. However, concerning the outcome where the marginal gap was measured, the results were recorded before and after cementation of the endocrown.

The study's findings indicate that there was a significantly higher value in marginal gap values in both groups before and after cementation and thermocycling. Before thermocycling was 60.9±9.5 µm and after thermocycling was 70.4±8.7 µm in CERASMART group, before thermocycling was 62.3±8.7 µm and after thermocycling was 70.1±8.3 µm in Tessera group. That's because thermocycling accelerated the cement degradation at endocrown margins. Which were agreeing with the outcomes attained by Taha et al[11], Hanaa S. Nassar[8] both reported that thermocycling elevates the tested groups' marginal discrepancies while keeping them within a clinically reasonable range. These findings disagreed with Kassem et al[7] who found that following the cementation and thermocycling, marginal gap values decreased.

Results of fracture resistance test showed that CERASMART endocrowns group insignificantly had higher mean fracture loads (739.2±140.2) compared to the CEREC Tessera group (623.6±114.6). This result might be explained by the low elasticity modulus, similar to that of dentine, of CERASMART endocrowns and they were more resistant to the propagation of cracks and avoid fractures because of their increased resilience and greater capacity for load absorption during loading compared with CEREC Tessera ceramic. This was in agreement with Rizk et al[19] who found that reinforced composite ceramics had better tolerance to fracture resistance. This study disagrees with the research conducted by Bankoglu Gungor et al[13] where they revealed no variation in the two materials' fracture strengths.

Every group's fracture pattern was evaluated by analyzing the failure mode; restorations that avoid causing damage to the tooth's structure have more endurance and better prognosis, 50% of CEREC Tessera group fracture mode was favorable repairable failure in the cervical portion of the restoration, while 37.5% was unfavorable repairable fracture at the CEJ of the tooth. 62.5% of CERASMART group was unfavorable repairable fracture mode at the CEJ of the tooth. Therefore, CERASMART endocrowns under fracture load test showed more damage to the tooth substructure in comparison to CEREC Tessera, because a greater fracture load was required to failure in CERASMART group because of the material's closeness to the dentin's modulus of elasticity and its increased resilience with greater load absorption under loading. This was agreed with Alghalayini et al[3] who found that nano hybrid ceramics needed a higher load for fracture to fail.

The null hypothesis of current study was rejected, since there was significant increase for both materials in marginal gap before and after cementation and thermocycling, and insignificant difference in fracture resistance between the two materials (CEREC-Tessera and CERASMART).

CONCLUSIONS

The following conclusions can be drawn within certain limits of the current study:

1. Both CEREC Tessera and CERASMART endocrowns materials exhibited a range of the marginal gap that is clinically accepted values.
2. Thermocycling had a drastic influence on marginal gap of cemented endocrowns.
3. CERASMART endocrowns provided promising fracture resistance values as well as CEREC Tessera endocrowns as a method of therapy for endodontic maxillary anterior teeth.

RECOMMENDATIONS

More research involving various variables is needed to provide standards guidelines for anterior endocrowns.

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