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IMPACT OF VARIOUS LINING MATERIALS ON FRACTURE RESISTANCE OF CAD/CAM FABRICATED CERAMIC ONLAYS SUBJECTED TO THERMO-MECHANICAL CYCLIC LOADING

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ABSTRACT

Objectives: This study evaluated the impact of various lining materials on the fracture resistance of CAD/CAM ceramic onlays subjected to thermo-mechanical cyclic loading.

Materials and methods: Forty-eight teeth were assigned at random to four major groups of twelve specimens each according to the lining material used (n=12): group 1, control group with no lining material; group 2, Biodentin; group 3, Cention Forte and group 4, resin-modified glass ionomer (Fuji II LC). Then, each group was separated into two subgroups (n=6), one of which was tested immediately and the other after thermo-mechanical cyclic loading. Standardized IPS e.max ZirCAD ceramic onlays were fabricated with CAD/CAM and bonded on all specimens. Machine. Data were statistically analyzed using the Shapiro-Wilk, one-way ANOVA, student's t-test and post-hoc tukey tests.

Results: One-way ANOVA revealed statistically non-significant differences among experimental groups ($p<0.05$) except for a significant difference between both Biodentin, Fuji II groups and the control group after thermo-mechanical cyclic loading ($p= 0.001$). Moreover, post-hoc tukey test revealed a significant difference between Fuji II group without cyclic loading and Fuji II group after thermo-mechanical cyclic loading ($p < 0.05$).

Conclusions: Within the parameters of this study, the various types of lining materials had significant difference in fracture resistance, as Fuji II showed the most favorable outcome, however, it showed a significant deterioration upon thermo-mechanical cyclic loading.

Clinical relevance: Ceramic onlays with various lining materials may be a viable approach for the restoration of molars.

KEYWORDS: CAD/CAM; lining; Ceramic; Onlays; Cyclic loading

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INTRODUCTION

New materials and technology have long been a source of fascination for dentists. The synergistic effect of digital technology on the one hand and the growth of materials with appropriate mechanical and cosmetic properties on the other resulted in a significant revolution in restorative dentistry. Thereby more and more colleagues are embracing the new Computer-aided design (CAD) and Computer-aided manufacturing (CAM) chairside technology, and manufacturers are expanding their material offering the goal of reducing operating times while maintaining high precision and aesthetics.[1,2]

A wide range of materials is available for digital manufacturing processes, expanding the spectrum of indications in restorative dentistry. All-ceramic onlay restorations have shown to be fatigue resistant enough to satisfy both functional and aesthetic requirements for the oral environment. In vitro, studies have frequently addressed an element that is vulnerable to ageing processes is the adhesive interface between tooth structure, composite cement, and all-ceramic restoration.[3]

Zirconia is a particularly desirable ceramic material because its exceptional mechanical characteristics. Zirconia undergoes a spontaneous phase transformation when external force is applied; this tightens the crack tip, inhibits crack propagation, and increases fracture toughness and flexural strength. The most prevalent complaints about zirconia restorations are chipping and debonding. Debonding can occur due to improper tooth preparation, using the wrong surface treatment, selection of an ineffective bonding agent or cement, or the incorrect application technique.[4]

The integrity of the interface between the restorative material and the prepared tooth is becoming increasingly important to dentists. According to studies, pulp inflammation under restorations is caused mainly by defects in bonding rather than irritation from restorative materials.[5]

The use of resilient/low elastic modulus liners as an intermediate layer (stress breaker) has been advised to regulate the stresses of the adhesive interface. Liners have been used in cavities under the filling material since the 19th century. The liners are supposed to shield the tooth's living pulp from both the filling materials and the possibility of allowing more heat or cold to pass through.[6–8]

Resin-modified glass ionomer (RMGI) liner is a key option for deeper restorations that are near the pulp. These materials have a high degree of structural stability, bond to dentin, and release fluoride. They can help minimize tooth stress and prevent microleakage. The substance forms an actual hybrid layer that serves as a biological and chemical seal.[9]

While the restoration of carious lesions lined with Biodentine offers a very tight seal with minor postoperative sensitivity, also, it has the potential to aid in mineralization and the creation of a thick dentine bridge. Over the several weeks after placement, leakage resistance and mechanical strength will improve.[10]

Moreover, a new metal-free aesthetic alkasite material Cention N has been released, claiming to produce considerable levels of fluoride ions comparable to conventional GICs, as well as hydroxyl and calcium ions. During acid assaults, the generation of hydroxide ions by a restorative substance may also aid in neutralizing excess acidity induced by cariogenic bacteria, preventing demineralization. These circumstances may enhance Cention anti-cariogenic N's potential.[11,12]

Teeth are frequently stressed during mastication and parafunctional behaviors in the oral environment. These forces will cause some microfractures, which will compromise the long-term survival rate and the eventual mechanical degeneration of tooth tissue and the restorative interface. Thermo-mechanical cycling loading is used to imitate the stress that restorative materials and teeth are subjected to when drinking and eating. Dental research can take years to produce any beneficial results, as well as being time-intensive and costly due to patient dropout. All-ceramic crown fracture toughness is another crucial attribute directly related to clinical effectiveness and is thus a hotly debated topic. [13]

While Pucci CR et al., demonstrated that regardless of the ceramic thickness, choosing a more flexible base material decreases the fracture load and increases the stress magnitude of adhesively cemented lithium disilicate restorations. Therefore, it is advised to utilize more study substrates to eliminate mechanical repair failures. Souza AC et al. that independent of the foundation or repair material. It can be concluded that the inlay materials combined with a base had a similar stance.[14,15] Hence this study intended to evaluate and compare the effect of various lining materials on the fracture resistance of CAD/CAM fabricated ceramic onlays. So, our query is which appraisable lining material may be employed during the final restoration fabrication?

MATERIALS AND METHODS

Materials utilized in the current study

1. RMGI (Fuji II LC, GC; Tokyo, Japan).
2. Biodentine (Septodont, Saint Maur des Faussés, France).
3. Cention Forte (Cention, Ivoclar Vivadent, Schaan, Liechtenstein, Germany).
4. G-Cem Capsule (Hasunuma-cho, Itabashi-ku, Tokyo, Japan).
5. IPS e.max ZirCAD blocks (Ivoclar Vivadent, Amherst, NY, USA).

Table 1 contains a listing of the restorative and lining materials, including the brand names, specifications, manufacturers, compositions, and application processes for each one. **Table 2** describes the luting resins cement system used in this investigation and its application procedures.

Study Design

This laboratory study evaluated the fracture resistance of CAD/CAM fabricated ceramic onlays using one independent variable, which is the lining material used under onlays (RMGI, Biodentin, and Cention Forte).

Specimen Preparation

In this in vitro study, forty-eight extracted human permanent non-carious molars were used. The molars were extracted due to periodontal diseases and were collected from the Oro-Maxillofacial Surgery Department clinic at Mansoura University’s Faculty of Dentistry. The collected teeth were subjected to infection control standards approved by the Faculty of Dentistry Ethical Committee.

Following the elimination of any residual soft tissue and calculus with a hand scaler (Zeffiro, Lascod, Florence, Italy), the teeth were kept at room temperature in a 1% chloramine-thymol solution (ChloramineT) for 72 hours. The teeth were cleaned using a rubber cup filled with a fine slurry of pumice and water. The teeth were examined under a stereomicroscope (Olympus model SZ-PT, Tokyo, Japan); Only intact, unrestored, non-carious teeth were used in this study.

The roots of the teeth were embedded up to 2 mm below the cementoenamel junction in a cylindrical polymerization of vinyl chloride PVC ring (1.4 x 2 cm) using an auto-polymerizing acrylic resin (Acrostone, Cairo, Egypt).

The specimens were randomly divided into four main groups of twelve specimens each (n=12): group 1, control group with no lining material; group 2, Biodentin; group 3, Cention Forte and group 4, RMGI (Fuji II LC). Then, half of the specimens of each group were tested immediately and the other half was tested after thermo-mechanical cyclic loading.

TABLE (1) Current research restoration materials

Brand	Specifications	Composition	Manufacturer	Batch Number	Steps of Application
IPS e.max ZirCAD	Yttrium-stabilized zirconium oxide	ZrO_2, Y_2O_3, HfO_2, Al_2O_3	Ivoclar Vivadent, Amherst, NY, USA	X08278	1. The internal surfaces of all onlays were blasted with Al2O3, 25 –70 µm, 1 bar 2. Treated with Monobond N for 60s. 3. Bonded by G-Cem Capsule.
Fuji II LC	Light-cured, resin-modified glass ionomer	Polyacrylic acid 20-30%, 2HEMA 30-35%, Distilled water 20-30%, Initiator	GC; Tokyo, Japan	1009041	1. The capsule was Activated. 2. Then mixed with an amalgamator for 10s. 3. After that injected directly by capsule applier. 4. Then light cured for 20s.
Biodentine	Calcium-silicate based material	Solid: Ca3SiO5 (> 80%), CaCO3, ZrO2 Liquid: Water, CaCl2, partially modified polycarboxylate	Septodont, Saint Maur des Faussés, France	635780	1. The capsule was loaded with the liquid component. 2. The capsule was then activated for thirty seconds. 3. The product, a pliable paste, was applied to the tooth using the little disposable spatula included in the kit. 4. Then left to set for 12 mins.
Cention Forte	Self-curing "bioactive" Alkasite	Ca-fluorosilicate glass, Ba-Al silicate glass, copolymer, Ca-Ba-Al fluorosilicate glass, UDMA, ytterbium trifluoride, aromatic aliphatic UDMA, DCP and PEG-400-DMA.	Ivoclar Vivadent, Schaan, Liechtenstein	740870	1. Actively scrub and agitate the primer for 10s. 2. Dry with compressed air until a glossy thin immobile layer remains. 3. Activate the capsule. 4. Then extrude it directly by capsule applier. 5. Finally light cured for 15s to speed up the process.

TABLE (2) System of luting resin composite used in this investigation

Material	Description	Constructor	Batch Number	Steps of Application
Try-In Paste	Glycerin, mineral fillers and dyes	Schaan, Liechtenstein, Ivoclar Vivadent	7405413	1. First the paste was spread on the fitting surface of ceramic restoration. 2. Then, the ceramic was positioned in the correct position.
Liquid Strip	Glycerin gel		740436	1. Spread the coating throughout the whole margin prior to light polymerization. 2. Apply a light cure for 10 seconds on each part. 3. Then rinse and dry
Monobond N	Ethanol, 3-trimethoxysilyl propyl, methacrylate silane, methacrylated phosphoric acid ester, sulphide methacrylate		Z02CPK	1. With a brush and a gentle scrubbing motion, apply one layer of the bond. 2. Let 5 seconds for a gentle air drying. 3. Light curing for 10 seconds
G-Cem Capsule	Powder and liquid: initiator, pigment, silica powder, dimethacrylate, phosphoric acid ester, fluoroalumino-silicate glass, initiator, trimellitic acid, monomer, water, urethane dimethacrylate, stabilizer 65-70%wt, 4-methacryloxyethyl	Hasunuma-cho Itabashi-ku Tokyo, Japan	141928	1. First the capsule was activated. 2. Then mix for 10s using an amalgamator. 3. Spread cement within the ceramic. 4. Secure the ceramic. 5. Brush excess cement. 6. Light cure each surface for 40s.

Cavities were prepared with a high-speed handpiece (Sirona T3, Bensheim, Germany) using coarse diamond and finishing diamond burs (Onlay Prep-Set, Intensiv, Viaganello-Lugano, Switzerland). An independent operator performed all of the preparation work. To ensure cutting efficiency each bur was replaced after five preparations to guarantee cutting efficiency.

For the standardization of cavity preparation measurements, the cavity floor depth was standardized at 2.5 (±0.1) mm from the occlusal surface, for the control group and 3.5 (±0.1) mm for the other groups. The occlusal isthmus, as well as the bucco-lingual boxes in the mesial and distal areas, were 2.5 (± 0.1) mm wide, and the palatal cusp was dropped by 1(± 0.1) mm.

Restoration procedure

Three types of lining materials were employed in this study. They were used in accordance with their manufacturer's instructions. Any polymerization in this study was done using the Bluephase N light-curing (Ivoclar Vivadent, AG, Shaan, Liechtenstein). A radiometer (Bluephase Meter II, Ivoclar Vivadent AG, Shaan, Liechtenstein) was used with the Bluephase N to ensure that the light output was always 1000 mW/cm2. Specimens in the Biodentin, Cention Forte, and RMGI groups lining materials were placed 1mm as a dentin replacement.

Regarding Group 2 (Biodentin group), the lining material was placed in a single 1 mm increment. The liquid component is added to the capsule. The capsule is then triturated for 30 seconds. The material, a malleable paste, was applied to the tooth with the supplied small disposable spatula, then allowed to be set for 12 mins.

Regarding Group 3 (Cention Forte group), the material was placed in a single 1 mm increment, however, Cention primer was applied on the pulpal floor for conditioning. Following capsule trituration for 10 sec, the material was injected into the floor with as little manipulation as possible to avoid air bubble formation and left to self-cure.

Regarding Group 4 (RMGI group), the material was placed in a single 1 mm increment; after the capsule had been triturated, the material was injected into the floor, and the tip end of the capsule must be buried into the material surface to avoid the formation of air bubbles, which will then be light polymerized.

Digital impression

An intraoral scanner (Cerec Omnicam, Dentsply Sirona, Charlotte, NC, USA) was used to scan the teeth before and after the preparation. Furthermore, forty-eight yttrium stabilized zirconium oxide onlays were designed and machined utilizing the CEREC system using IPS e.max ZirCAD blocks.

Fabrication of onlay restorations

Each restoration was completed by a technician using a systematic technique in accordance with the manufacturer's specifications. A CAD/CAM technology was used to generate all indirect restorations. The application made advantage of the Cerec software's biogeneric copy function to create indirect restorations that preserved the original shape of the created samples. The IPS e.max ZirCAD indirect restorations were created using a milling machine (InLab MC XL, Dentsply Sirona, Bensheim, Germany). The indirect restorations were glazed and then burnt at 710°C after sintering at 1500°C (Programat EP 5000, Ivoclar Vivadent, Schaan, Lichtenstein).

Adhesive bonding of onlay restorations

All processes were carried out in accordance with the manufacturer's instructions. The restorations were tried using try-in paste to ensure a good marginal fit. Following that, any residual was removed from the cavity and the restoration. After that process, the internal surface of each onlay was treated using sandblasting with Al2O3, 25 –70 µm, 1 bar.

Self-adhesive cement was used to cement the onlay to the teeth (G-Cem Capsule). To avoid the formation of an oxygen-inhibited layer, a liquid strip was applied to all edges before the light polymerization process. Finally, smooth out the cement lines using finishing and polishing strips (OptraPol, Ivoclar Vivadent, Amherst, NY, USA).

Thermo-mechanical cyclic loading

Following a 48-hour storage period in water, the cemented samples were exposed to thermo-mechanical cycling. To apply mechanical cycles of axial compressive stresses through a customized cone-shaped stainless-steel bar with a rounded tip, a masticatory simulator (CS-4.4 SD Mechatronik GmbH, Feldkirchen-Westerham, Germany) was used. This bar described a vertical movement of 2.5 mm at a speed of 60 mm/s. The simulator provided a fifty-newton (N) stress to each onlay's central fossa.

The Thermo-cycling (TC-3; SD Mechatronik GmbH) was adapted to the chewing simulator in order to perform thermal cycles. The thermocycling was conducted for thirty seconds in distilled water at temperatures ranging from 5 to 55 degrees Celsius.

Each restoration was subjected to 5000 thermal and 120,000 mechanical cycles. These simulations approximated a period of six months of oral service. Each piece was then examined under a stereomicroscope with a 40x magnification (Nikon SMZ-10; Nikon Corporation, Tokyo, Japan) to ensure that the onlay had not been cracked

Fracture resistance

In a universal testing machine (Instron 3345, Canton, Massachusetts), each specimen was subjected to axial compressive stress with an 8 mm metal sphere applied vertically at a crosshead speed of 0.5 mm/min in contact with the cusp slopes. In Newtons, the breaking force was calculated (N).

Statical analysis

In terms of the material's fracture resistance, the data underwent statistical analysis with the Shapiro-Wilk, post hoc-tukey, student t-test and one-way ANOVA tests. The Shapiro-Wilk test was carried out in order to ascertain whether or not the force distribution was uniform under the most extreme conditions of compression. The value of $p<0.05$ was chosen to denote a statistically significant correlation.

RESULTS

Fracture strength values were subjected to the Shapiro-Wilk confidence test, which proved that data of all groups were normally distributed ($p > 0.05$). One way ANOVA (Analysis of variance) followed by post-hoc tukey test was used for comparing more than two different groups of parametric data while student's t-test was used for comparing two different groups of parametric data. Thereby, P value less than 0.05 was considered statistically significant.

Additionally, one-way ANOVA revealed statistically non-significant differences among experimental groups ($p> 0.05$) within force at maximum compressive stress (Newton) except for significant difference between both Biodentin, Fuji II groups and control group after thermocycling ($p= 0.001$). Moreover, post-hoc tukey test revealed significant difference between Fuji II group without thermocycling and Fuji II group after thermocycling ($p < 0.05$) as shown in **Tables 3, 4.**

TABLE (3) Comparison of force at maximum compressive stress (N) between all groups

		Control	Cention Forte	Fuji II	Biodentin	P^a
No Thermocycling	Fracture Resistance	3199±605	2234±438	2848±758	2201±831	0.058
	Post-hoc		P1=0.09	P1=0.8 P2=0.4	P1=0.08 P2=0.99 P3=0.36	
Thermocycling	Fracture Resistance	3085±580	2164±762	1336±212	1525±754	**<0.001***
	Post-hoc		P1=0.08	**P1=<0.001*** P2=0.12	**P1=0.0016*** P2=0.3 P3=0.95	
P^b		0.74	0.84	<0.001*	0.17	

Data expressed as mean ± SD ***SD: standard deviation*** ***P: Probability *: significance <0.05***

Test used: One way ANOVA followed by post-hoc tukey

P1: significance vs Group control group, P2: significance vs Cention Forte group, P3: significance vs Fuji II group C

TABLE (4) Post-hoc tukey test for comparison of force at maximum compressive stress (N) between all groups

		Control	**Cention Forte**	**Fuji II**	**Biodentin**
No Thermocycling	Fracture Resistance	3199±605^a	2234±438^a	2848±758^a	2201±831^a
Thermocycling	Fracture Resistance	3085±580^a	2164±762^{ab}	**1336±212$^{b\#}$**	1525±754^b

Data expressed as mean ± SD; SD: standard deviation; test used: One way ANOVA followed by post-hoc tukey for comparison between groups & student's t-test for comparison between No Thermocycling & Thermocycling within each group; different alphabetical letters indicate difference in significance between groups; #: indicate significance between Thermocycling vs No Thermocycling

DISCUSSION

Patients' preferences and developments in computer science have significantly altered dental treatment in today's culture. Demand from the public has compelled modern dentistry to become more aesthetic and immediate. Moreover, advances in computer-aided design/computer-aided manufacturing (CAD/CAM) have enabled clinicians to construct definitive indirect ceramic restorations in a single visit, thereby satisfying the patient's desire. Moreover, CAD/CAM eliminates the need for conventional impressions, stone casts, and, occasionally, temporary restorations.[16]

Restorations fabricated using CAD/CAM have proven to be reliable for up to 18 years with marginal integrity comparable to crowns fabricated using conventional laboratory techniques.[17, 18] In addition, machinable ceramics are guaranteed to have consistent mechanical and physiochemical properties since the material is free of voids and condensation flaws. As crack initiation caused by Small structural imperfections that act as stress concentrators and lower restoration strength, such as voids, pores, and cracks, could be minimised.[19, 20] Also, using machinable ceramic helped to keep standardized uniform restorations in the study.

Typically, when caries is removed, undercuts are left behind that are incompatible with cavity preparation principles designed for inlays/onlays. Therefore, lining materials (bases) are utilized beneath ceramic inlays for the different reasons, as eliminating undercuts to preserve as much enamel/dentin as possible, and provide the appropriate internal tapered cavity design for ceramic inlay/onlay restorations.[21]The use of lining/base materials creates a structure consisting of multiple layers, with one side bonding to the overlaid material and the other adhering to the tooth structure. The physio-mechanical properties of the base material must be able to resist the applied forces.

Because ceramics have a far lower tensile strength than their compressive strength, tensile stresses are the main reason ceramic restorations fail.[22] Therefore, the occlusal force causes the restoration to flex, leading to internal tensile stresses that eventually lead to fracture. Rigid support (dentin or the base material) reduces the flexing of the restoration and consequently the plastic deformation. Also, one of the probable causes that may fracture the restoration includes the elastic modulus of the base material.[23-25]

The internal surface of ceramic inlays can be protected against tensile stress by using a lining material with a high enough elastic modulus. However, if you use a base material with a low elastic modulus, the restorations will be able to deflect above them, thereby generating a significant number of tensile stresses in the restoration, which results in restoration fracture. Scherrer et al,[26] investigated the effect of the supporting structure's elastic modulus on the fracture load of all-ceramic crowns. The study demonstrated a positive correlation between the fracture load and the elastic modulus of either the supporting structure or the core material. Little information is available investigating the fracture resistance with this type of zirconia-based ceramics when a base is added.

This brief discussion will go through three lining or base materials used in the current study to assess the fracture resistance of CAD/CAM zirconia-based ceramics onlays: RMGI, Biodentine, and Cention forte. Glass ionomer cement (GIC) has a long history of use in dentistry due to its ability to chemically bind to tooth structure and the cariostatic effect caused by fluoride release.[27-29] Despite their benefits, some drawbacks have been reported, including lower mechanical properties and more complicated handling than resin composites.[30-32] RMGIs exhibit improved mechanical properties, while keeping the desirable characteristics of the conventional GICs.[33]

These formulations of GICs capable of forming a covalent connection with the self-adhesive resin cement used to bind ceramic onlay.[34] Both GICs and RMGIs are polymer-based composites, hence their elastic behavior could be described as viscoelastic. Nevertheless, the viscoelastic properties differed greatly among the available brands of RMGI.[35] Fuji II LC had been reported to have high flexural strength and fracture toughness when compared to other resin modified glass ionomer.[36] On the other hand, RMGI When compared to resin composite liners, had no effect on the fracture resistance of the underlying indirect ceramic restorations.[37]

Tricalcium silicate- based endodontic materials such as Biodentine can be used as a lining or as a base material under a final restoration.[38] This material serves as a satisfactory substitute for dentine and provides protection for the pulp.[39] It is considered one of bioactive lining materials that have been developed to overcome MTA's major drawbacks.[40] These drawbacks include the long setting time, difficult handling characteristics, high price, poor mechanical properties, the presence of some toxic elements (e.g., arsenic), difficulty of removal after setting, and the potential for discoloration.[39-41]

Biodentine offers several benefits, including a decreased (initial) setting time of 12 minutes, enhanced mechanical characteristics, user-friendly characteristics, and convenient handling, as reported in previous studies.[39, 42] The quick setting time of the material allows the clinician to immediately place restorations, enabling the procedure to be completed in a single appointment.

Cention Forte is a novel dental material that has been developed for use as a long-term restorative material.[43] It is the successor of Cention N that was available on the market in hand-mixing formula. Cention forte are supplied in a capsulated form. According to the manufacturer, the application mode of Cention forte require a special adhesive system.

In this invitro study, the used blocks for CAD/CAM were monolithic Zirconia-based ceramics. Conventional zirconia-based ceramics contain a crystalline tetragonal matrix that is stabilized at room temperature by the addition of yttrium oxide (Y2O3) and is called yttria-stabilized tetragonal zirconia polycrystals (Y-TZP).[44] Using tetragonal phase properties and the associated tetragonal-to-monoclinic transformation toughening mechanism has been the rationale for zirconia use as a dental restorative material.[45]

The quantity of yttria in the material influences the strength value of the zirconia. In general, zirconia with a higher yttria content will have lower strength but higher translucency. This is due to the high tetragonal phase composition (85%–90%), which results in outstanding mechanical characteristics. However, it is necessary to apply veneering high aesthetic ceramic in order to mask their opacity (low translucency). Subsequently, the problem of chipping the veneering layer might emerge as a significant concern.[46]

So, a transition has been made towards the use of translucent zirconia ceramics, specifically 4Y-SZP and 5Y-SZP, that have brand name IPS e.max® ZirCAD to mitigate this problem. That form enabled the utilization of the material in a monolithic manner, thereby achieving homogeneity without the need for a veneering layer.[47] So, the blocks were used as introduced by the manufacturer.

Then, Self-adhesive resin cements (G-cem) was used for final cementation. This luting agent was claimed to provide good bond strengths to tooth structures and restorative materials without any pre-treatment or bonding agents. Therefore, their application is very simple and can be accomplished in a single clinical step. Market acceptance and widespread popularity of this cement was due to their physical and functional properties, the simplification of clinical stages, the low frequency of postoperative sensitivity, and the early clinical success.[48] GC contains 4-META as well as a UDMA methacrylate structure, which has a low molecular weight and less viscosity compared to Bis-GMA. These chemical properties may illustrate a favorable bonding capability and mechanical properties. [49,50]

Furthermore, the luting agent's elastic modulus may influence the fracture strength values of teeth restored with ceramic inlays and onlays.[51] The fracture stress of ceramics was somewhat influenced by the cement film's thickness. Scherrer and others[52] concluded that when cement film thickness exceeded 300 μm, the strength of all-ceramic restorations decreased markedly. Below 300 μm, however, the thickness of the cement layer had no influence on their fracture resistance. Fortunately, the film thickness reported about G-cem was less than this value (100 μm).

A valid laboratory fracture test should be developed by carrying out meticulously prepared experiments that as nearly as possible reflect clinical settings. The specimens' size and form should be equivalent to those utilized in clinical scenarios.[53] To simulate clinical conditions, Human molars that had been extracted had inlays made and cemented to them. Additionally, the cavity dimensions were controlled for each experimental group by a paralleling device. This approach has the potential to eliminate operator mistakes while also regulating cavity occlusal divergence.

Also, the periodontal ligament simulation replicates tooth accommodation in the alveolus, preventing stress concentration in the tooth's cervical region.[54] Chewing simulator with a sliding component corresponded as closely as possible to the physiological intraoral condition and was used in the present study for the artificial thermo-mechanical ageing of the tested restorations.

This study's findings found no statistically significant differences between the no-liner control group and the base/liner restorations when thermo-mechanical ageing was not applied. As for RMGIC, this agrees with a previous study in which the liners were used to elevate margins.[37] The finding was attributed to the different stress patterns induced by the long proximal wing extension. While in our study the lining materials was used as a dentine replacement material hence, different stress distribution.

Another study reported that the elastic modulus of the used bases has a significant effect on the fracture resistance of machinable zirconia ceramics.[23] In spite of this, when thermomechanical ageing was not performed, this study revealed no significant differences. This does not imply that the elastic modulus of the liners used has no impact on the fracture resistance of zirconia ceramics. As, when onlays were subjected to thermomechanical ageing, those supported by RMGI and Biodentin fractured at a statistically lower load than those supported by Cention forte or dentin (p.05). The hygroscopic expansion of RMGI in the presence of water may account for this observation.[55, 56]

Thus, the null hypothesis stating that there has been no significant difference in fracture resistance between lining materials used as liners under CAD/CAM fabricated ceramic onlays after thermo-mechanical cyclic loading was partially rejected.

Moreover, it needs to be assured that, because only one of the variables leading to onlay fracture was assessed. Due to scarcity of data available in the effect of using the suitable dentin replacement materials material under machinable zirconia ceramics. Further clinical and laboratory data are required regarding this concern. Also, the elastic modulus of different available liners used under machinable zirconia ceramics onlays needs further investigations in future studies.

CONCLUSIONS

Within the parameters of this study, the various types of lining materials had significant difference in fracture resistance, as Fuji II showed the most favorable outcome, however, it showed a significant deterioration upon thermo-mechanical cyclic loading. In the future, clinical relevance studies of CAD/CAM ceramic indirect restorations with a variety of lining materials will be required.

Conflict of Interest

The authors of this article confirm that they have no ownership, financial, or other personal interest in the products, services, and/or companies featured in this article.

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