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# CLINICAL EVALUATION OF THE BIOMIMETIC ASPECT IN THE RESTORATION OF ENDODONTICALLY TREATED TEETH (RANDOMIZED CLINICAL TRIAL)

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## *ABSTRACT*

**Purpose:** To clinically evaluate the performance of lithium disilicate endocrowns and overlays, restoring root canal treated molars for one year.

**Methods:** A total of 50 restorations, 25 overlays (group O) and 25 endocrowns (group E), were fabricated to restore root canal treated molars. All restorations were fabricated from lithium disilicate (IPS e. max CAD). After tooth preparation, digital impression was done followed by designing, milling and cementation of the restorations. Evaluation was done every 3 month for 12 months by three independent assessors using Modified USPHS criteria. Statistical analysis of collected data was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016.

**Results:** Regarding fracture and marginal adaptation, all restorations in both groups had Alpha score (100%); at base line and during the follow-ups. While for retention, all restorations in both groups had Alpha score (100%); at base line, after 3, 6, and 9 months. However, after 12 months, there was insignificant difference between both groups (P=0.08) as Alpha was (87, 100%) while Charlie was (13, 0%) regarding Group O & E respectively.

**Conclusion:** Within the limitations of this study, e.max overlays showed good performance compared to e.max endocrowns for the restoration of endodontically treated teeth, after one year of clinical evaluation. E.max overlays represent a dependable restorative modality for endodontically **treated molars.**

**KEYWORDS:** overlay, endocrown, lithium disilicate, biomimetics

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## INTRODUCTION

The developed concept of biomimetics seeks to return the missing tooth structure to its original form, function, and physical and mechanical characteristics. Adhesively bonded materials have become widely used by clinicians worldwide to reconstruct teeth while safeguarding the remaining tooth structure, in an attempt to replicate the biomechanical characteristics found in natural teeth.[1]

Utilising dental materials that may mimic the original characteristics of missing enamel and dentin, as well as preserving the remaining tooth structure while adhering to natural anatomy, are the two key components of biomimetic approaches. [(2,3)] Because of the tooth's unusual structure, which combines strong dentin beneath hard, brittle enamel, it is very challenging to mimic. Moreover, natural teeth are resistant to occlusal stresses, temperature fluctuations, and variations in the chemical composition of different food and drinks. [4]

The current materials for biomimetic restorative procedures, such as composites and ceramics, are not perfect and have some drawbacks. They are, nevertheless, the best materials to realise this idea because of their superior mechanical qualities and enhanced adherence to tooth structures. [5] Prior to placing the final restoration, composite resin is utilized to protect the remaining compromised tooth structure, restoring dental stiffness without, needlessly, removing further tooth structure. [6]

On the other hand, the focus should be on restoring non-vital teeth with different materials that closely resemble the mechanical and physical characteristics of vital teeth. This poses a problem since their structure is more weakened than vital teeth, making them more brittle. Thus, creating a restorative framework with characteristics similar to those of a natural tooth, is the primary objective. [1,7]

Traditionally, post, core and full coverage crowns were used to treat root canal treated teeth with significant coronal damage. But in recent years, endocrowns have emerged as a more conservative option, particularly in light of the development of adhesive technologies. It is generally accepted that complete cuspal coverage for posterior teeth that have had endodontic treatment, is necessary to enhance the long-term prognosis under occlusal stresses. [5,6,7,8]

Clinicians favour endocrowns because they provide improved retention and stress distribution by restoring cuspal coverage and extending into the pulp chamber. [9] Numerous in-vitro and in-vivo investigations demonstrated excellent success rate of these conservative restorations. [10]

Since overlays achieve the goal of biomimetics and provide full cuspal coverage while adhering to conservatism, they have been suggested for the restoration of non-vital teeth. The pulp chamber is filled with resin composite, and only the coronal portion of the tooth is restored with an overlay. [9] When utilised with careful case selection and accurate clinical preparation, lithium disilicate overlays are minimally invasive restorations with a long-term survival rate. [11] The physical and mechanical qualities of lithium disilicate ceramics under occlusal loads are widely known as well as their aesthetics. Additionally, they provide a strong adhesive bond to the tooth structure, enhancing the restorations' longevity while they are in use. [12]

The aim of this study was to clinically evaluate the fracture, retention, and marginal adaptation in endodontically treated molars using overlays and endocrowns for 1 year. The null hypothesis was that there will be no significant difference between the indirect adhesive overlays and endocrowns in terms of fracture, retention, and marginal adaptation over a period of 1 year.

## MATERIALS AND METHODS

This randomized clinical trial was approved by Research Ethics Committee of the Faculty of Dentistry, Cairo University with registration number (#22223). Prior to participation in the study, each participant signed an informed consent form in the patients' native language.

### Study setting and study design

All individuals who met the requirements for inclusion were gathered until the required sample size was attained. Every patient was chosen from the fixed prosthodontics clinic at the Faculty of Dentistry at Newgiza University in Cairo, Egypt. The patients had to be between the ages of 20 and 50 years, have adequate dental hygiene, and have had their molars endodontically treated. In addition to having teeth in a proper alignment with their adjacent teeth and a favourable occlusion. Each patient's treatment strategy was outlined. Before beginning clinical work, they consented to sign the informed consent form and demonstrated that they could and would maintain proper dental hygiene practices. Additionally, every participant consented to return for the follow-up visits. Exclusion from the research occurred for participants with periodontal or pulpal diseases, no opposing dentition, significant medical conditions, pregnancy, noncompliance, and signs of parafunctional habits. Comprehensive dental and medical records were gathered prior to research participation.

### Sample size

Based on previously published research by Osman et al., 2022, which showed that the success rate of lithium disilicate endocrowns was observed in 100% of cases after 12 months. The sample size was determined. Using a two-tailed Z test with an 80% power and a 5% alpha threshold to determine the difference between two independent proportions. For each group, a minimum sample size of 22 will be required to detect a 30% difference. To account for potential dropouts, the sample size was raised by 10% to 25 teeth per group. Sample size calculations were done on Windows using G*Power version 3.1.9.2.

### Randomization

An automatic sequence generator (https://www.randomizer.org/) was used to perform the randomization with allocation ratio 1:1. Based on the restoration design that was employed, group E received e.max endocrowns (IPS e.max CAD; CEREC Ivoclar Vivadent, Liechtenstein), and group O received e.max overlays.

### Allocation concealments and implementation

Each participant of each group had a number written on a white piece of paper using blue ink. The paper was pleated, tightly sealed, and kept in a secure place until the clinical procedure was performed.

### Blinding

Due to the blinding of the participants, outcome assessors, and statistician, this study was conducted with only the operator being in charge of all clinical procedures.

### Restorative procedure

Lithium disilicate overlays and endocrowns (IPS e.max CAD, Ivoclar Vivadent, Liechtenstein) were used in this trial to restore endodontically treated molars. To standardize the restorative procedures, a single operator was chosen to perform all the clinical steps. First, all the participants received scaling and polishing before shade selection using Vitapan's 3D Master shade guide (VITA, Zahnfabrik, Germany). For the endocrown group, preparation of the teeth started with occlusal reduction of 1.5 to 2 mm using wheel diamond stone. Cavity depth should be at least 3 mm with all internal undercuts

removed using tapered diamond stone with round end, preserving a butt margin of at least 2 mm. After finishing the preparation, cavity optimization with immediate dentin seal was performed using a universal bonding agent and flowable resin composite (Te-Econom, Ivoclar Vivadent). **Figure (1)** While for overlay group, the access cavities were filled with fiber reinforced resin composite (Ever X Posterior, GC Dental) over the pulpal floor followed by bulk fill resin composite (DENTOCLIC, ITENA, France). Then occlusal reduction of 2 mm following the occlusal anatomy with slight occlusal bevel which was done using tapered round diamond bur. **Figure (2)** A digital scan, for the preparation, was taken using an intraoral scanner (Medit i500, Medit, Korea), followed by designing the restoration using Exocad software, then milling had been carried out using a 5-axis milling machine (Arum 400 milling machine, Arum Gmbh, Germany).

Prior to bonding, the restorations in both groups were assessed for occlusal contact, marginal adaptation, and interproximal contact. All tooth surfaces were cleaned with a polishing brush and paste, followed by rubber dam isolation. Application of 37% Phosphoric Acid was carried out for 30 seconds on enamel and 15 seconds on dentin. After that, a universal bonding agent was applied, thinned by air, and light-cured for 20 seconds. Conversely, the restorations' intaglio surface was etched for 20 seconds using 9.5% hydrofluoric acid, followed by a thorough water rinsing and air drying. After applying a single coat of silane coupling agent, the air dried after 60 seconds. Dual-cured self-adhesive resin cement (BisCem, Bisco, USA) was used for bonding the restorations to the tooth structure. Three seconds of tack curing were used after the restorations were carefully placed within the cavity using finger pressure. Excess cement was removed, and the curing process took place for additional 40 seconds followed by the removal of all occlusal interferences.

**Clinical evaluation**

Three unbiased assessors evaluated the restorations for primary and secondary outcomes at baseline, 3, 6, 9 and 12 months. Fracture and marginal adaptation were checked visually under magnification using a probe, following the modified USPHS criteria at 3, 6, 9, 12 months of clinical service. **Figures (3,4)**

Fig. (1) Endocrown preparation in maxillary molar

Fig. (2) Overlay preparation in mandibular molar

Fig. (3) Follow-up after 12 months for maxillary endocrown

Fig. (4) Follow-up after 12 months for mandibular overlay

## Statistical analysis

Microsoft Excel 2016, Graph Pad Prism, and SPSS 20® were used for statistical analysis. Every data point was expressed as a frequency and a percentage, and the Chi square test was used for every comparison.

## RESULTS

During the follow-up periods, all participants attended at the 1st follow-up at 3 months. However, starting at 6 months, 2 patients of the group O and 3 patients of the group E, didn't show up as well as for the remaining follow-up periods.

### Fracture and marginal adaptation

All restorations in both groups had Alpha score (100%); at base line, after 3, 6, 9 and 12 months, as demonstrated in table (1,3) and figures (5,7).

### Retention

All restorations in both groups had Alpha score (100%); at base line, after 3, 6, and 9 months. Regarding follow-up after 12 months, 3 cases were debonded in group O and recemented in place without further modifications. Thus, there was insignificant difference between groups (P=0.08) as Alpha was (87, 100%) while Charlie was (13, 0%) regarding Group O & E respectively, as demonstrated in table (2) and figure (6).

TABLE (1) Frequency and percentages of all scores regarding fracture in group I and II at baseline, after 3, 6, 9, and 12 months

| Fracture | | Group O | | Group E | | Chi square test | |
|---|---|---|---|---|---|---|---|
| | | N | % | N | % | X2 | P value |
| **Baseline** | Alpha | 25 | 100.0% | 25 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **3 months** | Alpha | 25 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **6 months** | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **9 months** | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **12 months** | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |

***N: count*** ***%: percentage*** *P: probability level which is significant at P ≤ 0.05*

TABLE (2) Frequency and percentages of all scores regarding retention in group O and E at baseline, after 3, 6, 9, and 12 months

| Retention | | Group O | | Group E | | Chi square test | |
|---|---|---|---|---|---|---|---|
| | | N | % | N | % | X2 | P value |
| Baseline | Alpha | 25 | 100.0% | 25 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| 3 months | Alpha | 25 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| 6 months | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| 9 months | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| 12 months | Alpha | 20 | 87.0% | 22 | 100.0% | 3.1 | 0.08 |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 3 | 13.0% | 0 | 0.0% | | |

***N: count*** ***%: percentage*** *P: probability level which is significant at P ≤ 0.05*

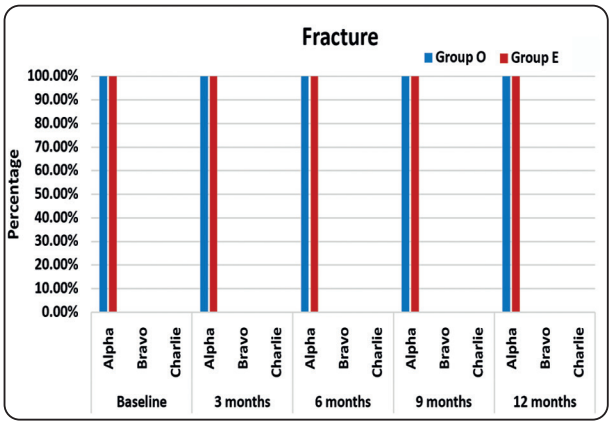


Fig. (5): bar chart showing percentages of all scores regarding fracture in group O and E at baseline, after 3, 6, 9, and 12 months.

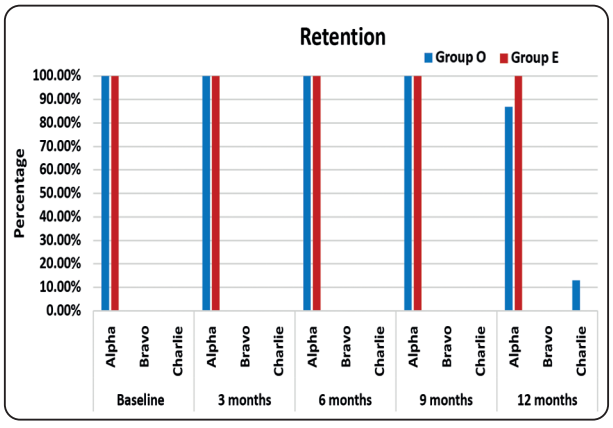


Fig. (6): bar chart showing percentages of all scores regarding retention in group O and E at baseline, after 3, 6 , 9 , and 12 months.

TABLE (3) Frequency and percentages of all scores regarding marginal adaptation in group O and E at baseline, after 3, 6, 9, and 12 months

| Marginal adaptation | | Group O | | Group E | | Chi square test | |
|---|---|---|---|---|---|---|---|
| | | N | % | N | % | X2 | P value |
| **Baseline** | Alpha | 25 | 100.0% | 25 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **3 months** | Alpha | 25 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **6 months** | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **9 months** | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |
| **12 months** | Alpha | 23 | 100.0% | 22 | 100.0% | ….. | ….. |
| | Bravo | 0 | 0.0% | 0 | 0.0% | | |
| | Charlie | 0 | 0.0% | 0 | 0.0% | | |

***N: count*** ***%: percentage*** *P: probability level which is significant at P ≤ 0.05*

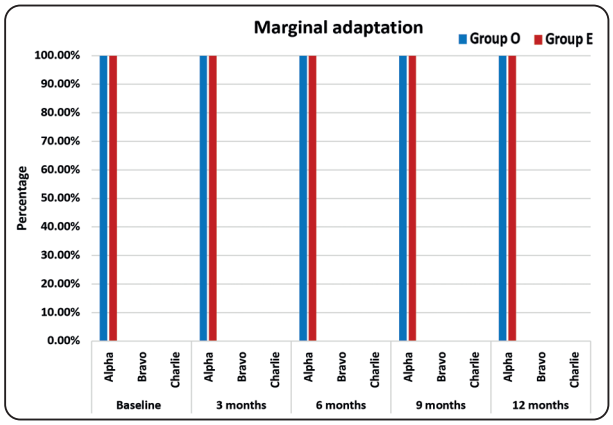


Fig. (7): bar chart showing percentages of all scores regarding adaptation in group O and E at baseline, after 3, 6, 9, and 12 months.

## DISCUSSION

With the advancement of adhesive dentistry and ceramic materials, partial coverage restorations are thought to be a conservative treatment modality requiring limited dental preparation, making them the widely emerging treatment of choice nowadays. [14] Since the overall survival rates of endodontically treated teeth without crown coverage and restored with bonded partial indirect restorations were 96% and 88%, respectively, at 1, and 2 years, it was strongly advised that an indirect restoration be placed on posterior endodontically treated teeth. [15]

Ever X resin composite was utilized for overlays group because it was claimed to replace dentin and absorb stresses, reducing the chance of tooth fracture

by focusing stresses on the material rather than transferring them to the underlying tooth structure. [16] In this research, a lithium disilicate monolithic restoration was chosen because of its good aesthetic outcomes and ability to improve fracture resistance while preserving the remaining tooth structure. [14, 17]

Partial adhesive restorations are a minimally invasive treatment modality, that cover and protect cusps without removing a significant amount of tooth structure. This approach falls within the minimal intervention dentistry concept, which emphasizes on the importance of considering the type of failures evaluated during clinical studies rather than the failure rate itself. The tooth survival rate, nowadays, plays a far more crucial role than restoration failure because it is crucial to distinguish between irreversible failures, which may need tooth extraction, and reversible ones, which the clinician could treat or even replace. Therefore, it is possible to consider that most partial adhesive restoration complications, including our research's debonding cases, were restorable or replaceable without having an impact on the longevity of the tooth.[18]

The outcomes evaluation was performed following the modified USPHS criteria, every 3 months for 12 months. The drop-out of patients, who did not complete the follow-up visits, was within the 10% increased range considered in the sample size calculation.

In the current study, our hypothesis was accepted as there were no statistically significant difference between endocrowns and overlays for all evaluated outcomes.

Soliman M et al. (2021) reported that e.max restorations, restoring teeth with sufficient tooth structure with three or four walls, are the most preferred treatment option for endodontically treated teeth. This treatment approach offers the patient the best chance of preserving as much of their natural tooth as possible.[19] However, some research showed contradicting results with this study. They suggested that the performance of full coverage restorations is better, with higher success rate and longevity, when compared to partial coverage restorations.[20,21] Partial coverage restorations show a favorable medium-term survival rate like that of conventional full coverage crowns with the main mode of failure is ceramic fracture, followed by adhesion failure. [22]

In terms of fracture evaluation, there was no statistically significant difference between both evaluated groups as all restorations were classified as Alpha. Additionally, our results supported the findings of El Ghoul WA et al. (2019), who claimed that the high flexural strength and modulus of elasticity of glass-ceramic materials like e.max, resist chipping and fracture propagation of the restorations. As a result, follow-up for a year revealed no chipping. [23]

This was consistent with the findings of Mohamed MS (2020), who found that the use of e.max CAD, has strong mechanical characteristics along its microstructure containing needle-like particles with various orientations. Additionally, its elongate grain structure and densely packed crystals with a 70% crystalline content provide it with excellent toughness by preventing fracture propagation and increasing mechanical strength. Even if cracks did develop, they would be contained inside the crystals and might not be able to spread further. [24] Furthermore, bonded restorations with complete occlusal coverage positively impact the fracture strength of root canal treated teeth as they exhibit a more uniform distribution of biting pressures during function.[25] It was assumed that the design of overlay restorations decreases the stress created in the ceramic and underlying tooth during functional loading. This is since they are purely adhesive restorations with simple, flat preparations, that allow better absorption of forces and reduction of stresses, offering greater resistance to fracture than full-coverage crowns.[26]

Our findings also concurred with those of Belle-

flamme MM et al. (2017), who said that endocrowns were seen to be a reliable approach for restoring posterior teeth, even in situations where there was significant coronal tissue loss.[27] Additionally, it was consistent with Dioguardi M et al. (2022) study, which declared that indirect partial adhesive restorations on teeth that had undergone endodontic treatment, demonstrated ideal clinical performance in a brief to medium follow-up time, with the possibility of reversible favourable failure. [28]

Regarding retention, no significant difference was detected among the evaluated groups. This may be justified as both restorations preserve sound tooth structure more than conventional full coverage restorations which require more removal of tooth structure during preparation.[15] Our findings also agreed with those of Eisa NS et al. (2020), who reported that excellent micromechanical retention between the ceramic surface of IPS e.max CAD and dental cement following treatment with hydrofluoric acid etching and silane coupling agent contributed to the material's good bonding between tooth structure and e.max restorations. [29]

The outcomes, likewise, matched those of Bhalla VK et al. (2020), who found that non-vital teeth could be restored with excellent bonding and long-term lifespan using both endocrown and overlay restorations. Proper material selection combined with tooth preparation and adhesive technique will result in restorations that fail as little as possible, even if, they can still be repaired. [30]

Debonding was carried out in 3 overlays in this study, after a year, because dentin preparation was included in this study and adhesive bonding of restorations to dentin has been shown to be weak and technique sensitive.[14,15] Also Thomas RM et al. (2020) explained that debonding in endocrown restorations or any adhesive restoration is a multifactorial process and may be due to the type of cement used. Light cured resin cements are not preferable as the light penetration may be insufficient that may lead to adhesive failure.[31] Regarding this trial, dual cured resin cement was used to overcome this problem. Nevertheless, debonding may be due to increased thickness of restoration or a lower intensity curing light (750 mW/cm2). However, the debonding of restorations are not considered catastrophic failures as re-cementation was performed.

In this study, all restorations showed Alpha score for marginal adaptation, so, no statistically significant difference between both groups was found. This may be explained by the standardization of teeth selected (molars), restorative material (e.max CAD), and meticulous bonding protocols. Results of this research are in harmony with the findings of Hassouneh et al. (2023) that concluded that marginal adaptation and internal fit of lithium disilicate endocrowns showed smooth homogenous margin compared to other materials, which was within clinically accepted range with good performance.[32] Also, overlay preparations have a simple geometry with uniform occlusal reduction which improved stress distribution and convert them into compressive stresses. This is achieved by having smooth preparation margins that end in enamel to achieve a more stable bond and grant an adequate marginal integrity. [22]

Following the biomimetic approach allows working in harmony with natural remaining tooth structure to improve the longevity and prognosis of both the tooth and the restoration. Finally, limited follow-up period and clinical assessment of alternative restorative materials were the limitations of this study.

## CONCLUSION

Within the limitations of this study, the following conclusions could be withdrawn:

1. After one year of clinical evaluation, e.max overlays showed good performance compared to e.max endocrowns for restoration of endodontically treated molars.
2. E.max overlays represent a dependable restorative modality for endodontically treated molars.

## Clinical recommendation

To assess the clinical efficacy of overlay restorations, more randomised clinical studies with a bigger sample size and longer observational periods are suggested.

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