The Saudi Dental Journal (2023) **35**, 699–706

King Saud University

The Saudi Dental Journal

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Clinical outcome of CAD/CAM overlays of MIH affected young permanent molars

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Received 12 February 2023; revised 25 May 2023; accepted 28 May 2023
Available online 3 June 2023

KEYWORDS

Young permanent molars;
Hypomineralization;
MIH;
Overlays

Abstract *Background:* Restoration of first permanent molars with MIH is considered a challenge for dentists because the enamel has less flexibility and hardness with increased porosity and organic content.

Materials and methods: The current study was a randomized control trial in which fifty-two first permanent molars were distributed equally into two groups (Z) teeth that received zirconia overlays and (EC) teeth that received IPS e.max CAD overlays. Clinical assessments were carried out at baseline, 6, and 12 months using modified FDI World Dental Federation criteria.

Results: After the observational period of one year, all restorations were still in function with no significant differences in the esthetic, functional, and biological performance of overlays fabricated with zirconia and IPS e.max CAD except one case have been fractured in the group (EC) and three cases have been de-bonding in the group (Z).

Conclusions: Using monolithic zirconia and IPS e.max CAD overlays could be a viable selection for restoring MIH-affected posterior teeth. In further studies, it is advisable to assess the restoration that combines strength with adhesive properties like zirconia-reinforced lithium silicate glass ceramic restoration.

1. Introduction

MIH is enamel hypomineralization defined as qualitative defects caused by disruptions in either the calcification or maturation phases of amelogenesis affecting one or more first permanent molars (FPMs) and permanent incisors (Dhareula et al., 2019). Moderate MIH is characterized by increased organic content and demarcated opacities on the occlusal/incisal third of teeth. Furthermore, caries are limited to one or

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2023.05.028

two surfaces, increasing the possibility of a bacterial attack on the underlying dentin of hypo-mineralized teeth. Consequently, this leads to dental hypersensitivity (Diago et al., 2021; Hartsock et al., 2020).

Conventional treatment for such defects necessitates additional removal of the complete tooth structure to receive full crowns that cause more biologically harmful consequences like postoperative hypersensitivity and aggressive tooth structure loss (Linner et al., 2020). To fulfill the biological criteria for tooth preparation, conservatism is the major notion and goal that prosthodontists strive to achieve. Nowadays, minimally invasive techniques are frequently employed to support this idea. To meet the growing need for conservative and attractive tooth restorations, overlay ceramic restorations (covering all cusps) are becoming more necessary. These restorations show satisfactory mechanics, restoring function, and esthetic with preserving tooth structure (Mohammed and Majeed, 2020).

Numerous ceramic systems that may diverge in chemical structure and technological processing have been advanced throughout the ages. CAD/CAM technology has recently experienced significant advancements in the materials available for dental use (Abdel Sadek et al., 2021). Zirconia is a polycrystalline ceramic material without a glassy phase characterized by excellent esthetic and biocompatibility (Hassan et al., 2022).

Till now, glass–ceramic-based restorations still offer the best translucency and esthetic qualities. The novel generation of lithium disilicate-based materials as IPS e.max CAD provides standard thickness and quick fabrication. Moreover, the adhesive technique used with this restoration type significantly raises its mechanical properties (Phark and Duarte, 2022).

Since both materials, "zirconia and IPS e.max CAD" have distinct chemical compositions, they have different properties that affect their clinical outcome. Therefore, it is essential to compare them clinically because any restoration's clinical outcome affects its long-term success. According to the null hypothesis, different materials would not significantly affect the clinical result of ceramic overlay restorations.

2. Materials and methods

2.1. Ethical aspects

Children and their parents who agreed to participate in this study knew the objectives of it and its characteristics and signed an informed consent form. One hundred children were diagnosed with MIH, and 52 were allocated to this study. The study depended on children aged 8 to 13 years, selected from those undergoing dental treatments at outpatient clinics of pediatric departments AL-Azhar University, Egypt.

2.2. Study design

This study is a double-blind, randomized controlled trial (patient and examiner) (Fig. 1). This study was reported according to the CONSORT standards. A sample size (n = 52, divided into 26 in each group) was sufficient to detect a large effect size of 1.42, with an actual power (1-β error) of 0.8 (80%) and a significance level (α error) of 0.05 (5%) for the two-sided hypothesis test. Based on (Souza et al., 2021), restorations exhibited no excess material (90% for IPS e.max CAD and 75% for Lava Ultimate). Using the G*power statistical power analysis program (version 3.1.9.2) for sample size determination (Jaykaran Charan et al., 2013).

The research question in the current study was addressed in terms of the PICO question, which involves 4 elements: problem (P), intervention (I), comparison (C), and outcome (O) as follows:

P: Defected porous, weak enamel with caries extension (problem).
I: Overlays restorations of affected teeth (intervention).
C: Zirconia versus IPS e.max CAD overlays (comparison).
O: Protection of the weak cusps and elimination of carious lesions with an esthetic way out (outcome).

2.3. Study population and allocation of participants

2.3.1. Inclusion specifications

- The study included cooperative children with large carious FPM lesions associated with weak cusps and defected hypo-mineralized enamel.

2.3.2. Exclusion specifications

- The study excluded children with poor oral hygiene, symptoms of pulpitis, parafunctional habits, and any debilitating systemic disorder.

2.3.3. Allocation of participants

Fifty- two patients were divided into two groups (26 patient each) randomly using a pre-randomized code number representing one of the two materials to be used:

Group (Z): Patients received zirconia overlays.
Group (EC): Patients received IPS e.max Cad overlays.

2.4. Clinical procedures

Medical and dental histories were recorded for each patient. Intraoral and extraoral clinical, radiographic inspection and photographs were performed in addition to preparing diagnostic templates for both arches from alginate material prior to initiation of treatment (Fig. 2A).

Before tooth preparation, shade selection was registered, and a silicon index was created with a vertical buccolingual cut to measure the amount of preparation. Using orientation grooves, depth-marker burs (microcopy, USA) of specified lengths (1.5 mm and 2 mm) were used to standardize the preparation quantity and ensure the restorative materials' consistent thickness. The preparations were then checked using the silicon index.

Initially, primary caries or failed restoration were removed for overlay preparation. Cavities were prepared according to the recognized principles for adhesive overlays (Souza et al., 2021); the occlusal box with half of the buccal-lingual distance extended by 2 mm deepness from the cusp tip to the pulpal floor with the divergence of internal cavity wall (6°-12°). Preparation involved the occlusal reduction of the functional

and non-functional cusps by 2 mm and 1.5 mm, respectively, and extended 3 mm in cervical direction at all axial surfaces terminated with a 1 mm circumferential deep chamfer finishing line. Roundation of all internal angles was performed (Diagram 1 and Fig. 2B).

A one-step impression technique was taken with high and low-viscosity addition polyvinylsiloxane materials (Express 2 Penta H and Light Body, 3 M Oral Care). The occlusal bite was recorded with bite recording material (3 M Oral Care) and sent to lap for fabrication of restorations. Bis-acryl interim restorations were fabricated (Protemp, 3 M Oral Care) and cemented with a eugenol-free temporary cement (Cavex, Holland). Restorations were checked on the cast and intra-orally before final cementation with resin cement (Fig. 2C and D).

2.5. Clinical assessment

Restorations were assessed clinically using a dental explorer, mirror, and radiographically according to FDI World Dental Federation criteria over one year at (baseline "1 day", 6 and 12 months) after cementation. There were three assessment categories (esthetics, function, and biological), each with five subcategories. From best to worst, the subcategories were: (1) clinically excellent, (2) clinically good, (3) clinically sufficient, (4) clinically not sufficient but repairable, and (5) clinically unacceptable. Assessment with category (5) was rated as a clinical failure.

2.6. Statistical analysis

Data management and statistical analysis were performed using the Statistical Package for the Social Sciences (SPSS) version 15. Categorical qualitative data were expressed as numbers and percentages and were compared using the Chi-square test. Kaplan-Meier test was used for survival analysis. All p-values are two-sided. The significance level was set at $P \leq 0.05$.

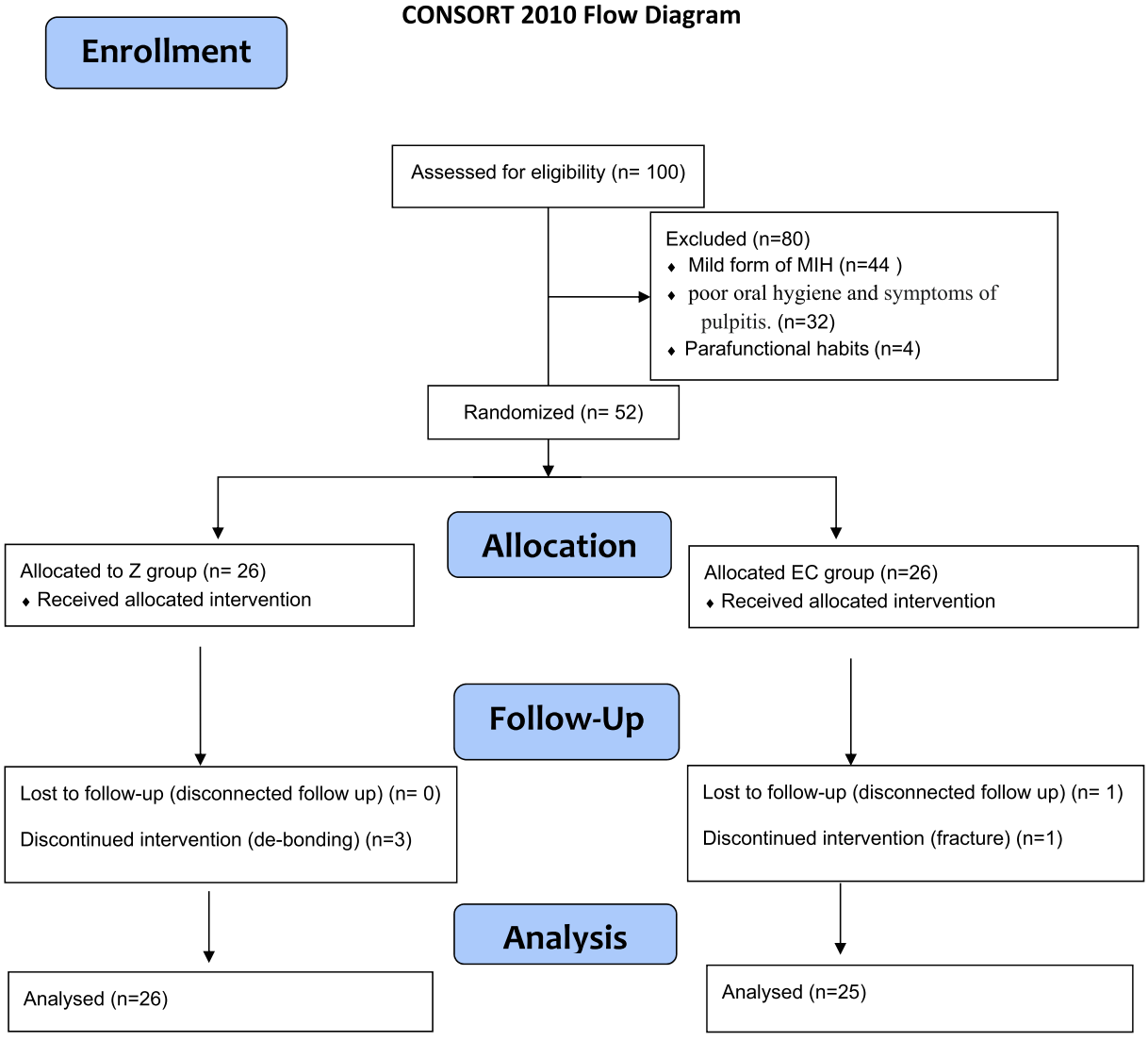

Fig. 1 Study design.

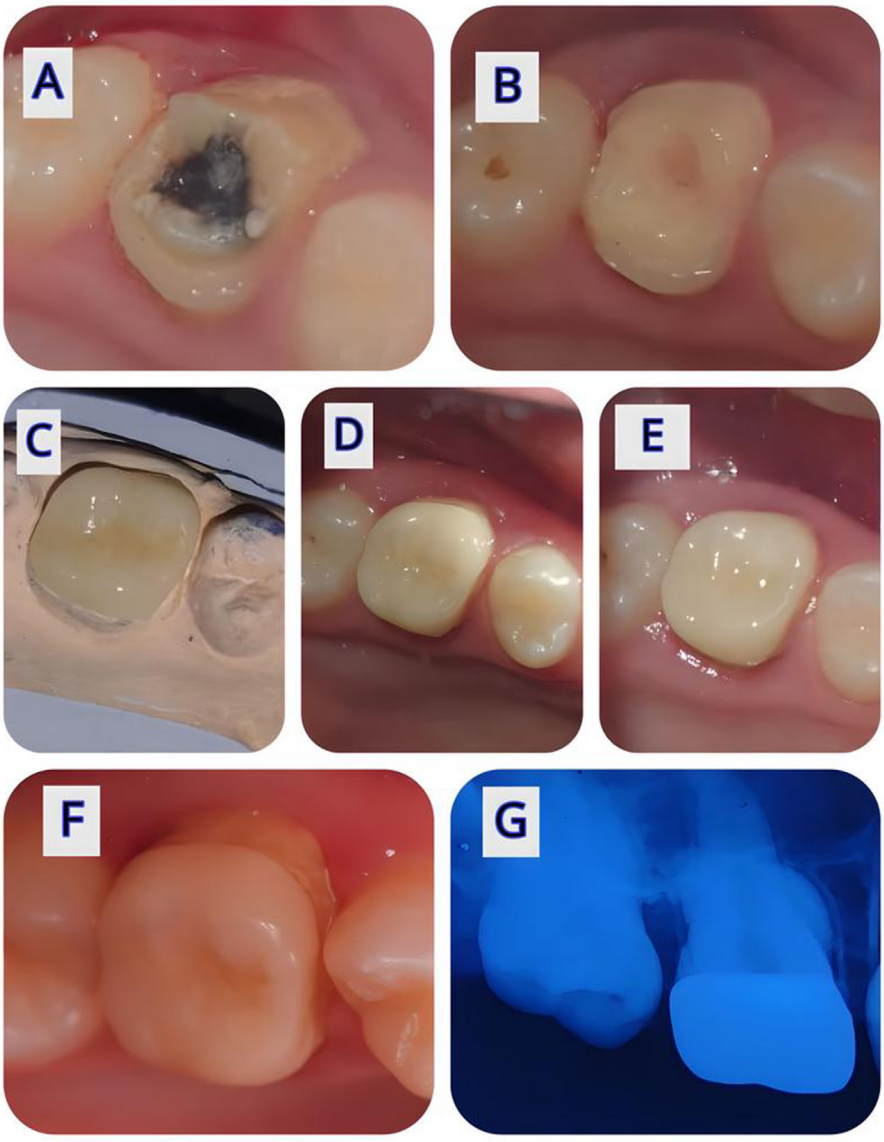

Fig. 2 Rehabilitation of maxillary left first permanent molar using overlay restoration; (A) Pre-operative clinical photograph, (B) Preparation of the abutment, (C) Overlay on cast before cementation. (D) Overlay at baseline, (E) Follow up after 6 months, (F) Follow up after one year, and (G) Radiographic image of zirconia overlay after one year.

3. Results

3.1. Comparison between groups

3.1.1. Clinical assessment after 6 months

51 patients were examined for follow-up assessment after 6 months (one patient in the group (EC) with one overlay did not show up at 6 months' recall times, his data was excluded from statistical assessment) for the primary outcomes assessment (Fig. 2E).

- ***Esthetic criteria:*** Regarding surface gloss, group (Z) recorded 92.3% (score 1) and 7.7% (score 2), in comparison to 96% and 4% in group (EC), respectively, with no significant difference between groups ($p = 0.515$). Regarding marginal staining, all cases in both groups recorded a score 1. Regarding anatomic form, group (Z) recorded 88.5% (score 1) and 11.5% (score 2), in comparison to 100% (score 1) in group (EC), with no significant difference between groups ($p = 0.125$).
- ***Functional criteria:*** One overlay in group (EC) was rated as a clinical failure as a result of fracture (score 5); however, with no significant difference between groups ($p = 0.47$). Regarding retention, two overlays in group (Z) had been de-bonding, which have been reinserted again (score 4); still, with no significant difference between groups ($p = 0490$). One overlay in group (EC) was rated as a clinical failure as a result of loss of marginal adaptation (score 5) due to its fracture; however, with no significant difference between groups ($p = 0490$). Regarding patient view, two patients in group (Z) recorded 7.7% (score 2), while one patient only in group (EC) was rated as a clinical

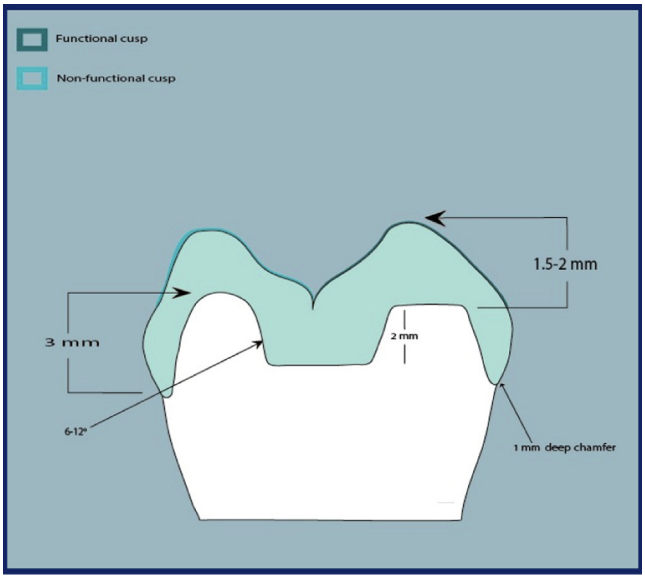

Diagram 1 Schematic diagram showing overlay preparation dimension.

failure (score 5); but with no significant difference between groups ($p = 0490$).
- ***Biological criteria:*** All cases in both groups recorded a score 1.

3.1.2. Clinical assessment after 12 months

51 patients were examined for follow-up assessment after 12 months (one patient in group (EC) with one overlay did not show up at 12 months recall times, its data was excluded from statistical assessment) for the secondary outcomes assessment. The esthetic, functional, and biological criteria are listed and illustrated in Table 1, Diagram 2, and Fig. 2F.

3.2. Comparison within the same group regarding the effect of time

- In group (Z), marginal staining, fracture, marginal adaptation, and caries remained constant throughout the study. Besides, surface gloss, anatomic form, retention, patient view, and post hypersensitivity recorded slightly higher scores throughout the study; however, with no significant difference by time ($p = 0.855$, $p = 1.0$, $p = 0.360$, $p = 538$, $p = 0.325$, respectively).
- In group (EC), marginal staining, anatomic form, post hypersensitivity, and caries remained constant throughout the study (from baseline till 12 months follow up). However, one case recorded fracture, loss of retention, and loss of marginal adaptation. Nevertheless, one patient was unsatisfied (from 6 months to 12 months follow-up). At the same time, surface gloss recorded slightly higher scores throughout the study with no significant difference by time ($p = 0.040$).

3.3. Comparison between esthetic, functional, and biological symptoms regardless of time interval within the same group

- There are statistically significant differences between all criteria in both groups.

3.4. Survival and success analysis

- According to Kaplan–Meier analysis, the survival rate was 100% in group (Z) compared to 96% in group (EC), with no significant difference between groups ($p = 0.0490$) (Table 2).
- The success rate was 98.8% in group (Z) compared to 98.7% in group (EC), with no significant difference between groups ($P = 0.947$) (Table 2).

4. Discussion

Pediatric dentist frequently finds it difficult to manage young FPM with moderate MIH due to its fragile teeth and caries on one or two surfaces with high sensitivity (Linner et al., 2020). Conventionally, stainless steel crowns were used for molars. However, due to the need for esthetics and the young age of patients, it was necessary to look for a cosmetic and conservative restoration alternative (De Leon Flores et al., 2022). Overlay restorations were recommended as a substitute for crowns to maintain teeth healthy without fracture. It is considered a minimally invasive approach (Schiffenhaus, 2021).

Currently, indirect esthetic restorations are better fabricated using CAD/CAM technology because they are less technique-sensitive and take less time (Mainjot et al., 2016), with more homogeneity and minimum flaws (Morton et al., 2021, Gowida et al., 2016). Monolithic zirconia restorations provide acceptable esthetics with superior mechanical properties and biocompatibility and exhibit promising clinical performance (Kauling et al., 2020). Nevertheless, due to zirconia's challenge in bonding, IPS e.max CAD has become widespread due to its better bonding ability with better esthetics and high strength (Elsherbini et al., 2022).

Both materials comprise the biomimetic principles of minimal invasive with strength properties. So, it is significant to trial fabricating posterior overlay restorations using these materials. Consequently, this study's principal significance was focused on assessing the clinical outcome of zirconia versus IPS e.max CAD overlay restorations.

The modified FDI was used to evaluate the clinical outcome of the materials. To remove prejudice, the assessment was performed with two clinicians who did not have initial data about the type of investigated restorations.

The results of this investigation approved that there are no significant differences in the esthetic, functional, and biological performance of overlays fabricated with zirconia and IPS e.max CAD after 1 year; thus, the null hypothesis was accepted. Concerning esthetic criteria after 6 months, there was no change in parameters from baseline to 6 months follow-up in surface gloss or anatomic form in both groups. Furthermore, after 12 months, only one patient showed surface gloss loss in (Z) group, which is considered clinically good (Table 1 and Diagram 2). This may be because overlay restorations can provide clinically acceptable esthetics when polished and optimum natural tooth surface gloss when stained and glazed. The degree of surface gloss loss increased over time, partially related to changes in the color and translucence of the natural teeth (Zou et al., 2018).

Table 1 Comparison between groups regarding esthetic, functional, and biological criteria at 12 months.

	Criteria	Scores	Z group (n = 26)	EC group (n = 25)	Total (n = 51)	X^2	P Value	Sig.
Esthetic criteria	*Surface gloss*	*Clinically excellent (score 1)*	23 (88.5%)	24 (96.0%)	47 (92.2%)	1.002	0.320	NS
		Clinically good (score 2)	3 (11.5%)	1(4.0%)	4(7.8%)			
	Marginal staining	*Clinically excellent (score 1)*	26 (100%)	25 (100%)	51 (100%)	a	–	–
	Anatomic form	*Clinically excellent (score 1)*	23 (88.5%)	25 (100%)	48 (94.1%)	3.06	0.125	NS
		Clinically good (score 2)	3 (11.5%)	0	3(5.9%)			
Functional criteria	*Fracture*	*Clinically excellent (score 1)*	26 (100%)	24(96%)	50(98%)	1.06	0.490	NS
		Clinically failure (score 5)	0	1(4%)	1(2%)			
	Retention	*Clinically excellent (score 1)*	23 (88.5%)	24 (96.0%)	47 (92.2%)	4.003	0.235	NS
		Clinically not sufficient but can be repairable (score 4)	3 (11.5%)	0	3(5.9%)			
		Clinically failure (score 5)	0	1(4.0%)	1(2.0%)			
	Marginal adaptation	*Clinically excellent (score 1)*	26 (100%)	24(96%)	50(98%)	1.06	0.490	NS
		Clinically failure (score 5)	0	1(4%)	1(2%)			
	Patient view	*Clinically excellent (score 1)*	24 (92.3%)	24(96%)	48 (94.1%)	2.98	0.490	NS
		Clinically good (score 2)	2(7.7%)	0	2(3.9%)			
		Clinically failure (score 5)	0	1(4%)	1(2%)			
Biological criteria	*Postoperative hypersensitivity*	*Clinically excellent (score 1)*	24 (92.3%)	25 (100%)	49 (96.1%)	2.002	0.255	NS
		Clinically good (score 2)	2(7.7%)	0	2(3.9%)			
	Caries	*Clinically excellent (score 1)*	26 (100%)	25 (100%)	51 (100%)	a	–	–

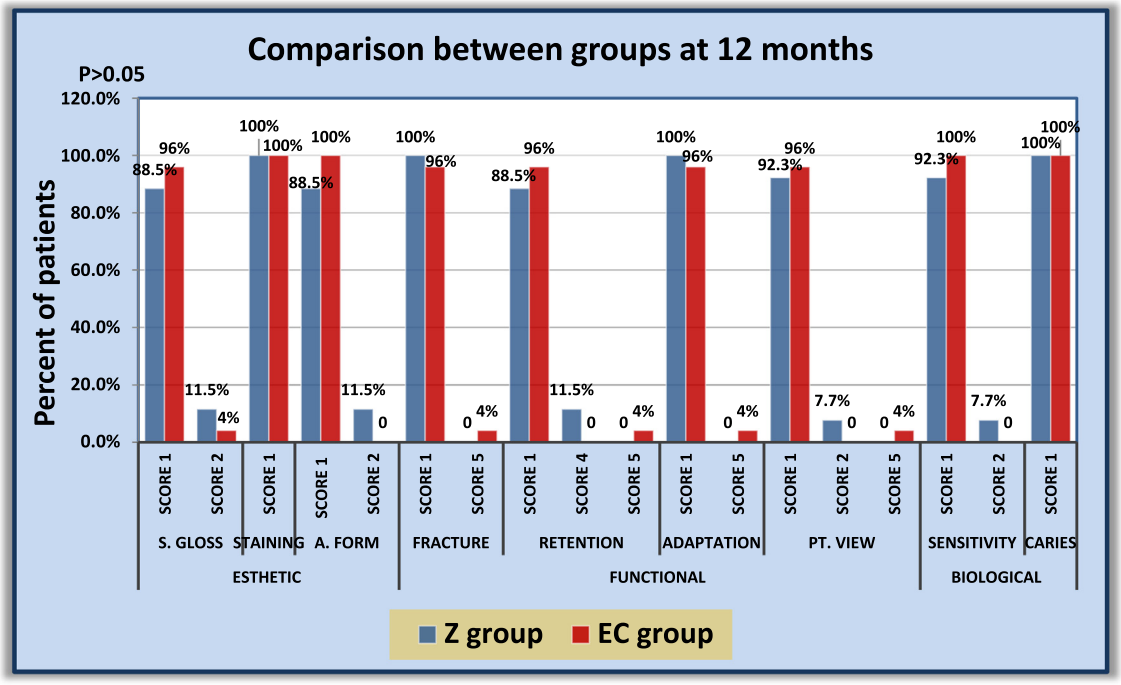

Diagram 2 Bar chart representing a comparison between groups at 12 months.

Table 2 Comparison between groups regarding success and survival rate till 12 months follow up.

Rate							
Success rate	**Group**	**N**	**Mean%**	**SD**	**Median**	**P Value**	**Sig.**
Esthetic	***Z***	**26**	**99.7**	**1.3**	**100**	**0.332**	**NS**
(12mnths)	***EC***	**25**	**100**	**0.0**	**100**		
Functional	***Z***	**26**	**97.3**	**7.6**	**100**	**0.757**	**NS**
(12mnths)	***EC***	**25**	**96.0**	**20.0**	**100**		
Biological	***Z***	**26**	**99.2**	**2.7**	**100**	**0.163**	**NS**
(12mnths)	***EC***	**25**	**100**	**0.0**	**100**		
Total success rate	***Z***	**26**	**98.8**	**2.6**	**100**	**0.947**	**NS**
	EC	**25**	**98.7**	**6.7**	**100**		
Survival rate	***Z***	**26**	**100**	**0**	**100**	**0.0490**	**NS**
(12 months)	***EC***	**24**	**96**	**20.0**	**100**		

Concerning functional criteria after 12 months, one case in (EC) group had been fractured and was not repaired, so it rated as clinical failure (Table 1 and Diagram 2). This may be attributed to factors including the formation of cracks resulting from polymerization shrinkage of cement, which creates stress concentrations at the adhesive interface and the ceramic subsurface and the difference in production processes (Jaykaran Charan et al., 2013). This outcome is incompatible with an earlier examination in which total fractures were reported (Souza et al., 2021). On the other hand, three cases in (Z) group had been de-bonding, which have been reinserted again (Table 1 and Diagram 2). De-bonding may be related to the imperfect elimination of clinically hypo-mineralized enamel or decontaminated zirconia restoration before preparing with a priming agent (Soleimani et al., 2020). This is similar to a previous investigation (Aikaterini et al., 2021).

Concerning biological criteria after 12 months, two patients in **(Z)** group reported slightly post hypersensitivity (Table 1 and Diagram 2), which may be related to the use of a higher amount of pretreatment ceramic primer to ensure bond strength which got in contact with the patient's gingiva during the second cementation than during the first cementation (Yamashiro et al., 2021).

Survival and success rate was measured using the Kaplan-Meier test (Table 2). The survival rate was 100% in (Z) group compared to 96 % in group (EC) group, which agrees with the prior studies (Souza et al., 2021, Tsanova et al., 2018). At the same time, the success rate was 98.8% in (Z) group compared to 98.7% in (EC) group, which agrees with prior researchs (Leitão et al., 2022, Husain et al., 2020).

This research's main limitations are the lack of overlays inspected and the short follow-up period.

5. Conclusions

The current findings suggest that using both types of overlays could be a viable selection for restoring single posterior teeth. It is advisable to use restoration that combines strength with adhesive properties, like zirconia-reinforced lithium silicate glass ceramic restoration.

Author contributions

Alaa M. Eldehna: Conceptualization, Investigation, Methodology, Funding acquisition. **Ayat G. Montaser:** Data curation, Formal analysis, Funding acquisition. **Shaimaa A. ALrafee:** Resources, Software, Supervision, Validation, Visualization, Funding acquisition. **Asmaa Abdelgawad:** Project administration, Writing – original draft, Writing – review & editing, Funding acquisition.

Funding

None.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors thank Dr. Asmaa Eltobgy for helping us in this investigation.

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