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ORIGINAL ARTICLE

Clinical evaluation of cemented and adhesively resin-bonded monolithic and partially layered zirconia and lithium disilicate crowns

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KEYWORDS

Zirconia crowns;
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Survival rate variables

Abstract *Purpose:* Zirconia and lithium disilicate crowns are very popular dental restorations. The cement type and layering technique used can profoundly affect the clinical performance of these crowns.

This retrospective study is designed to investigate the success rate of cemented and adhesively bonded monolithic and partially layered zirconia and lithium disilicate crowns placed in faculty practice settings.

Materials and Methods: Patients who had received zirconia or lithium disilicate crowns at the faculty practice were invited for clinical examination. The examiner used the modified United States Public Health Service (MUSPHS) evaluation criteria to evaluate the crowns. The crowns were either glass ionomer cemented zirconia (GIC-Zr), resin-bonded zirconia (Adh-Zr), or resin-bonded lithium disilicate (Adh-LD). The crowns were also divided into monolithic and layered groups. Inferential analysis was used to examine the differences through bivariate analysis using *t*-testing and one-way ANOVA.

Results: Thirty-five patients, with a combined total of 218 single crowns, agreed to participate in the study. No statistically significant differences in the quality outcome variables considered were found between the groups, except for marginal adaptation, where Adh-Zr achieved significantly higher scores compared to GIC-Zr and Adh-LD. Layered zirconia and lithium disilicate crowns have significantly higher quality outcomes in terms of anatomic form, marginal adaptation, and color match compared to monolithic zirconia and lithium disilicate crowns.

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Conclusions: Conventionally cemented zirconia and adhesively bonded zirconia and lithium disilicate crowns are reliable treatment options with high short-term success rates. Clinical studies with longer follow-up times are needed to investigate their long-term success rates.

1. Introduction

Ceramic fixed dental prostheses fabricated from lithium disilicate (LD) or zirconia (Zr) are very popular dental restorations. Zirconia has better physical properties than LD, but LD has superior optical properties (Manso et al., 2011). Both materials have high survival rates when used to fabricate single crowns (Pjetursson et al., 2015; Sailer et al., 2015), and both can be used in layered or monolithic forms (Larsson and Wennerberg, 2014; Maroulakos et al., 2019; Pieger et al., 2014; Takeichi et al., 2013). One of the main technical complications in layered restorations is chipping of the veneering porcelain (Pjetursson et al., 2018). One study reported that LD crowns had a cumulative ceramic-chipping-related failure rate of 3.3% (Yang et al., 2016). Monolithic restoration reduces the incidence of chipping, but long-term studies are required (Sadowsky, 2020). The esthetic outcomes of anterior monolithic restorations are sub-optimal. To overcome this issue, the cutback technique can be applied to the facial surface only, without including the load-bearing areas in the incisal or lingual surfaces (Abd Alraheam et al., 2019; Moscovitch, 2015). This technique has been mentioned in the literature, but there are no clinical studies investigating the success rate of monolithic vs. partially layered restorations.

Zirconia can be cemented using conventional cement when the preparation is retentive; otherwise, adhesive cementation is indicated. By contrast, resin bonding is necessary for LD, especially if the preparation is non-retentive or minimally invasive (Blatz et al., 2018; Christensen, 2014; Mizrahi, 2008). The bonding of full-coverage restorations fabricated from Zr and LD is a subject of ongoing debate (Maroulakos et al., 2019). Most in vitro studies have shown that adhesive cementation increases the fracture load of zirconia crowns compared to non-adhesive cementation (Campos et al., 2017; Indergård et al., 2021) and increases the retention and fracture resistance of LD crowns (Johnson et al., 2018; de Kok et al., 2017). Other studies have shown that there is no difference in the fracture resistance or retention of Zr and LD restorations after adhesive bonding vs. conventional cementation (Ernst et al., 2009; Gehrt et al., 2013; Heintze et al., 2008; Nakamura et al., 2016; Torres et al., 2021). Maroulakos et al. (2019) found that the survival rate for adhesively cemented LD crowns ranged from 83.5% to 100%, whereas the survival rate reported for conventionally cemented LD crowns was 98.5%. For Zr crowns, the survival rate was 83.3% to 100% for the adhesively cemented crowns, whereas the values reported for conventionally cemented Zr crowns range from 82.0% to 100% (Maroulakos et al., 2019).

Conventional cementation appeals to clinicians due to its simplicity and lower cost compared to adhesive resin cementation (Kern et al., 2012; Kern, 2017; Mizrahi, 2008; Wolfart et al., 2009).

This retrospective study was designed to investigate the success rate of cemented and adhesively resin-bonded monolithic and partially layered Zr and LD crowns placed in a faculty practice setting.

The null hypotheses of the study are as follows:

- There are no statistically significant differences in the quality outcomes or success of conventionally cemented glass ionomer zirconia crowns (GIC-Zr), adhesively bonded zirconia crowns (Adh-Zr), and adhesively bonded LD (Adh-LD) crowns.
- There are no statistically significant differences in the quality outcomes or success of monolithic and partially layered Zr and LD crowns.

2. Materials and methods

The study was approved by the deanship of scientific research at the University of Jordan (Ref #2457–2022). This clinical phase was conducted at the Restorative Department at the University Hospital. Patients' records were searched to find those who had received all-ceramic crowns made of Zr or LD by one restorative consultant.

The inclusion criteria were as follows: the patient had received LD or Zr crowns from the consultant, and the patient record had a phone number and/or email address via which communication was possible. The following data were extracted from the dental records: patient age, phone number or email address, type of material used, type of cement, and any documented complications or repair attempts. The sample size was estimated using G*power 3.03 with a high effect size of 0.2, a power of 0.95, and a one-tailed significance level of 0.05, using Pearson correlation as the test statistic for one sample. This estimation showed that the sample size needed for the study was 210 crowns.

Patients were reached via phone or email to arrange a clinical evaluation/exam. The exam was performed by a single calibrated consultant. Calibration was performed using the MUSPHS criteria (Table 1) (Bayne and Schmalz, 2005). The Kappa value for the examined parameters was 0.91 (>0.8).

During the clinical examination, the examiner evaluated the crowns according to the MUSPHS criteria. The examination was performed using a dental mirror, sharp explorer, and UNC periodontal probe. Radiographs were only taken when needed.

The primary aim was to determine the quality outcomes and success of LD and Zr crowns. Failure was defined as a crown that had been removed or required removal at a follow-up visit. A complication was defined as an event that affected function or esthetics.

The clinical procedures required for the fabrication of the crowns were performed according to the general guidelines

Table 1 Modified USPHS criteria used for evaluation of lithium disilicate and zirconia crowns.

Domain	Rating	Restoration condition
Anatomic form	Alpha	The restoration is continuous with the anatomy of the teeth
	Bravo	Slightly over- or undercontoured restoration; slightly undercontoured; contact slightly open (maybe
	Charlie	self-correcting); locally reduced occlusal height
	Delta	* Restoration is grossly over- or undercontoured, with an exposed base or dentin; faulty contact, i.e., not self-correcting; reduced occlusal height; occlusion affected
		* Marginal overhang present; traumatic occlusion; damaged tooth, supporting bone or soft tissues
Marginal adaptation	Alpha	The restoration is continuous with current anatomic form, and the sharp explorer will not catch
	Bravo	The sharp explorer does catch, but there are no observable crevices that the explorer will penetrate
	Charlie	There is a crevice at the margin, and there is an exposed enamel margin
	Delta	* The crevice at the margin is very apparent, and there is exposed dentine or lute
Integrity of restoration	Alpha	Intact
	Bravo	* Crack apparent on transillumination
	Charlie	* Fracture observable
	Delta	* Crown lost (state at which interface debond occurred)
Color match	Alpha	Excellent color match and shade between restoration and adjacent tooth, restoration almost invisible
	Bravo	Slightly mismatching between the restoration and the adjacent tooth, which is in the normal range of tooth
	Charlie	color, translucence, and/or shade
	Delta	* Obvious mismatch, beyond the normal range
		* Gross mismatch/aesthetically displeasing colour, shade, and/or translucence
Secondary caries	Alpha	No apparent caries contiguous with the restoration margin
	Bravo	* Caries are observable contiguous with the restoration margin
Postoperative sensitivity	Alpha	No sensitivity
	Bravo	* Sensitivity
Retention	Alpha	Complete retention of the restoration
	Bravo	* Mobility present

USPHS: United States Public Health Service. * Unsatisfactory.

for Zr and LD ceramics. For Zr crown preparation, a uniform 0.8 mm shoulder finish line with a 1 mm axial reduction and a 1.5–2 mm occlusal reduction was performed. For LD crown preparation, a uniform 1 mm shoulder finish line with a 1.2–l.5 mm axial reduction and a 1.5–2 mm occlusal reduction was performed. The restoration margins were placed at equigingival or 0.5 mm subgingival locations, except when deep caries were present. All molar crowns were monolithic. By contrast, all anterior crowns and some of the premolar crowns were made using the cutback technique at the facial surface and layered with feldspathic porcelain. The Zr crowns were made of Ceramill Zi (Amann Girrbach, Koblach, Austria), and Cerabien ZR layering porcelain powder was used for the layered crowns (Kuraray Noritake Dental Inc, Tokyo, Japan). The LD crowns were made of IPS e.max material (Ivoclar Vivadent, Liechtenstein, Germany). The veneering porcelain was also made from e.max (Ivoclar Vivadent, Liechtenstein, Germany). All restorations were polished and glazed before final cementation.

The cements used were glass ionomer (Cavex Holland BV, Haarlem, Netherlands), for conventional cementation, and dual-cure resin cement (Duo-Link Universal, Bisco Dental Products, Schaumburg, Illinois, USA). The adhesive protocol for LD crowns was as follows: the intaglio surface of the restoration was etched for 20 s using hydrofluoric acid etch (Porcelain Etchant 4% HF, Bisco Dental Products, Schaumburg, Illinois, USA), followed by the application of a silane coupling agent (Bis-Silane, Bisco Dental Products, Schaumburg, Illinois, USA); the tooth was etched using phosphoric acid (PA) etch for 15 s (Uni-Etch 32%, Bisco Dental Products, Schaumburg, Illinois, USA), followed by the application of a bonding agent (All Bond Universal, Bisco Dental Products, Schaumburg, Illinois, USA), and was finally cemented using resin cement (Duo-Link Universal, Bisco Dental Products, Schaumburg, Illinois, USA). For Zr crowns, the adhesive protocol was air abrasion of the intaglio surface using aluminum oxide powder, followed by the application of zirconia primer (Z-Prime, Bisco Dental Products, Schaumburg, Illinois, USA); the tooth was etched with PA and coated with a bonding agent, and, finally, the crown was cemented using dual cure resin cement (Duo-Link Universal, Bisco Dental Products, Schaumburg, Illinois, USA).

Statistical analyses were carried out using the Statistical Package for Social Sciences (SPSS) platform. A detailed description of participants' characteristics was obtained using descriptive analysis (central tendency and dispersion). Quantitative data were presented as mean ± standard deviation (SD), and range. Data were checked for the presence of outliers, normality, linearity, and homoscedasticity; in addition, inferential analysis was used to examine the differences through bivariate analysis using *t*-testing and one-way ANOVA. Internal consistency was checked using Cronbach's alpha coefficient, and statistical analysis was conducted to estimate effect sizes and confidence intervals; statistical significance was set at $p < 0.05$.

3. Results

Fifty-five patients with a combined total of 263 single crowns met the inclusion criteria. They were aged between 21 and 75 years old (mean age = 41.4 years, SD = 12.9 years); 47% were male and 53% were female. The follow-up time

ranged from 6 to 45 months (mean = 22.2 years, SD = 8.2 y ears). Forty patients answered their phones, and 35 patients, with a total of 218 crowns, agreed to participate in the clinical phase of the study and were scheduled for an exam. The other five patients were either out of town or could not participate in the clinical exam. However, all of the patients who did not attend a clinical exam reported being very satisfied with their crowns and reported no complications.

The results of this study showed no statistically significant differences between GIC-Zr and Adh-Zr for the success rate variables considered, except for marginal adaptation, where the quality outcome was significantly higher for Adh-Zr. The data also showed no statistically significant differences between GIC-Zr and Adh-LD for all the variables considered. In addition, no statistically significant differences were found between Adh-Zr and Adh-LD for these variables, except for marginal adaptation, where the quality outcome was significantly higher for Adh-Zr (Table 2).

The results also showed that, compared to their monolithic counterparts, layered Zr and LD crowns achieved significantly higher scores in three out of the seven success rate variables considered. These variables are anatomical form, marginal adaptation, and color match (Table 3).

For all groups, no significant differences were found between the anterior and posterior crowns for the seven success rate variables considered (Table 4).

Statistically significant differences were found for the marginal adaptation variable. First, differences were found in favor of maxillary crowns over mandibular crowns in the conventionally cemented Zr crowns group, but in favor of mandibular crowns over maxillary crowns in the adhesively bonded LD crowns group. However, this variable does not show a statistically significant difference between the upper and lower crowns in the adhesively bonded Zr crowns group (Table 5). Second, differences were found in favor of crowns opposed by natural teeth over those opposed by ceramic crowns in the conventionally cemented Zr crowns group, but in favor of crowns opposed by ceramic crowns over those opposed by natural teeth in the adhesively bonded LD crowns group (Table 6).

No failures were reported in any group except for one case of a single tooth fracture in the Adh- Zr crowns group. The crown came off with the fractured part of the tooth, leaving the root, which was non-restorable. The tooth was extracted, and implant placement was planned.

Table 3 Comparison of the success rate of layered vs. monolithic zirconia and lithium disilicate crowns.

	Zr&LD-L n = 169 (m ± SD)	Zr&LD-M n = 46 (m ± SD)	P
AF	3.98 ± 0.15	3.91 ± 0.29	**0.026***
MA	3.34 ± 0.48	3.09 ± 0.29	**0.001***
CM	3.99 ± 0.08	3.52 ± 0.51	**< 0.001***
IoR	4.00 ± 0.00	4.00 ± 0.00	–
SC	4.00 ± 0.00	4.00 ± 0.00	–
POS	3.99 ± 0.11	4.00 ± 0.00	0.5314
R	4.00 ± 0.00	4.00 ± 0.00	–

* Statistically significant at the 0.05 level (two-sided), Zr&LD-L = layered zirconia and lithium disilicate crowns, Zr&LD-M = monolithic zirconia and lithium disilicate crowns, n = number of crowns, m = mean, SD = standard deviation, AF = anatomical form, MA = marginal adaptation, CM = color match, IoR = integrity of restoration, SC = secondary caries, POS = postoperative sensitivity, R = retention.

4. Discussion

This retrospective clinical study was designed to evaluate the quality outcomes and success of tooth-supported conventionally cemented and adhesively bonded Zr crowns and adhesively bonded LD crowns after a mean follow-up time of 22.2 months. The study also investigated the performance of monolithic and partially layered crowns.

The null hypotheses were accepted since the success rate of GIC-Zr was similar to that of the Adh-Zr and Adh-LD crowns. The success rate of monolithic crowns was also similar to that of partially layered crowns.

The retention of all crowns was rated as alpha (Table 1). No difference was noted between the two cementation methods. These results agree with those of other recent clinical

Table 2 Comparison of the success rate of conventionally cemented zirconia crowns, adhesively resin-bonded zirconia crowns, and adhesively resin-bonded lithium disilicate crowns.

	Zr-GIC-L n = 57 (m ± SD)	Zr-Adh-L n = 39 (m ± SD)	P	Zr-GIC-L n = 57 (m ± SD)	LD-Adh-L n = 73 (m ± SD)	P	Zr-Adh-L n = 39 (m ± SD)	LD-Adh-L n = 73 (m ± SD)	P
AF	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	3.95 ± 0.23	0.102	4.00 ± 0.00	3.95 ± 0.23	0.177
MA	3.25 ± 0.43	3.56 ± 0.50	**0.002***	3.25 ± 0.43	3.30 ± 0.46	0.531	3.56 ± 0.50	3.30 ± 0.46	**0.007***
CM	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	3.99 ± 0.12	0.521	4.00 ± 0.00	3.99 ± 0.12	0.596
IoR	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–
SC	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–
POS	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	3.97 ± 0.16	0.171	4.00 ± 0.00	3.97 ± 0.16	0.257
R	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–

* Statistically significant at the 0.05 level (two-sided), Zr-GIC-L = glass ionomer cemented and layered zirconia crowns, Zr-Adh-L = adhesively resin-bonded and layered zirconia crowns, LD-Adh-L = adhesively resin-bonded and layered lithium disilicate crowns, n = number of crowns, m = mean, SD = standard deviation, AF = anatomical form, MA = marginal adaptation, CM = color match, IoR = integrity of restoration, SC = secondary caries, POS = postoperative sensitivity, R = retention.

Table 4 Comparison of the success rate of anterior vs. posterior conventionally cemented zirconia crowns, adhesively resin-bonded zirconia crowns, and adhesively resin-bonded lithium disilicate crowns.

	Zr-GIC-L-A n = 32 (m ± SD)	Zr-GIC-L-P n = 25 (m ± SD)	P	Zr-Adh-L-A n = 25 (m ± SD)	Zr-Adh-L-P n = 14 (m ± SD)	P	LD-Adh-L-A n = 46 (m ± SD)	LD-Adh-L-P n = 27 (m ± SD)	P
AF	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.91 ± 0.29	4.00 ± 0.00	0.106
MA	3.34 ± 0.48	3.12 ± 0.33	0.057	3.60 ± 0.50	3.50 ± 0.52	0.558	3.37 ± 0.49	3.19 ± 0.40	0.108
CM	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.98 ± 0.15	4.00 ± 0.00	0.483
IoR	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–
SC	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–
POS	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.98 ± 0.15	3.96 ± 0.19	0.619
R	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–

* Statistically significant at the 0.05 level (two-sided), Zr-GIC-L-A = glass ionomer cemented and layered zirconia anterior crowns, Zr-GIC-L-P = glass ionomer cemented and layered zirconia posterior crowns, Zr-Adh-L-A = adhesively resin-bonded and layered zirconia anterior crowns, Zr-Adh-L-P = adhesively resin-bonded and layered zirconia posterior crowns, LD-Adh-L-A = adhesively resin-bonded and layered lithium disilicate anterior crowns, LD-Adh-L-P = adhesively resin-bonded and layered lithium disilicate posterior crowns, n = number of crowns, m = mean, SD = standard deviation, AF = anatomical form, MA = marginal adaptation, CM = color match, IoR = integrity of restoration, SC = secondary caries, POS = postoperative sensitivity, R = retention.

Table 5 Comparison of the success rate of maxillary vs. mandibular conventionally cemented zirconia crowns, adhesively resin-bonded zirconia crowns, and adhesively resin-bonded lithium disilicate crowns.

	Zr-GIC-L-Mx n = 37 (m ± SD)	Zr-GIC-L-Mn n = 20 (m ± SD)	P	Zr-Adh-L-Mx n = 29 (m ± SD)	Zr-Adh-L-Mn n = 10 (m ± SD)	P	LD-Adh-L-Mx n = 63 (m ± SD)	LD-Adh-L-Mn n = 10 (m ± SD)	P
AF	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.94 ± 0.25	4.00 ± 0.00	0.446
MA	3.38 ± 0.49	3.00 ± 0.00	**0.001***	3.52 ± 0.51	3.70 ± 0.48	0.335	3.22 ± 0.42	3.80 ± 0.42	< **0.001***
CM	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.98 ± 0.13	4.00 ± 0.00	0.619
IoR	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–
SC	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–
POS	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.97 ± 0.18	4.00 ± 0.00	0.596
R	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–

* Statistically significant at the 0.05 level (two-sided), Zr-GIC-L-Mx = glass ionomer cemented and layered zirconia maxillary crowns, Zr-GIC-L-Mn = glass ionomer cemented and layered zirconia mandibular crowns, Zr-Adh-L-Mx = adhesively resin-bonded and layered zirconia maxillary crowns, Zr-Adh-L-Mn = adhesively resin-bonded and layered zirconia mandibular crowns, LD-Adh-L-Mx = adhesively resin-bonded and layered lithium disilicate maxillary crowns, LD-Adh-L-Mn = adhesively resin-bonded and layered lithium disilicate mandibular crowns, n = number of crowns, m = mean, SD = standard deviation, AF = anatomical form, MA = marginal adaptation, CM = color match, IoR = integrity of restoration, SC = secondary caries, POS = postoperative sensitivity, R = retention.

Table 6 Comparison of the success rate of conventionally cemented zirconia crowns, adhesively resin-bonded zirconia crowns, and adhesively resin-bonded lithium disilicate crowns regarding the opposing teeth (natural teeth vs. ceramic crowns).

	Zr-GIC-L-NT n = 26 (m ± SD)	Zr-GIC-L-CC n = 31 (m ± SD)	P	Zr-Adh-L-NT n = 29 (m ± SD)	Zr-Adh-L-CC n = 10 (m ± SD)	P	LD-Adh-L-NT n = 53 (m ± SD)	LD-Adh-L-CC n = 20 (m ± SD)	P
AF	4.00 ± 0.00	4.00 ± 0.00	–	4.00 ± 0.00	4.00 ± 0.00	–	3.92 ± 0.27	4.00 ± 0.00	0.186
MA	3.42 ± 0.50	3.10 ± 0.30	**0.005***	3.52 ± 0.51	3.70 ± 0.48	0.335	3.13 ± 0.34	3.75 ± 0.44	< **0.001***

studies, which found that glass ionomer cement exhibited similar retention to self-adhesive resin cement (Torres et al., 2021).

The integrity of all of the crowns under study was rated as alpha since no fractures or chippings were noticed in the monolithic or layered crowns. In multiple previous studies, chipping of the veneering porcelain has been reported as the main issue with layered single crowns and fixed partial dentures (Tanner et al., 2018), with a reported chipping rate of 11.7–12.4% in single crowns (Miura et al., 2018; Rinke et al., 2015). In those studies, chipping was mainly observed in posterior crowns.

Anatomic form was rated as either alpha or bravo for all of the restorations since no crowns with incorrect forms were delivered. The layered crowns showed better outcomes in

multiple variables compared to the monolithic crowns; this result was expected, as the layering technique was introduced to improve esthetic outcomes.

The marginal adaptation of all crowns was rated as either alpha or bravo. The Adh-Zr crowns achieved a higher score for marginal adaptation than the GIC-Zr and Adh-Zr crowns.

Color was rated as alpha or bravo for all restorations. In this study, all crowns were delivered after obtaining the correct shade. Multiple in vitro studies have shown that Zr and LD optical properties are stable after fatiguing and aging (Abd Alraheam et al., 2019; Sorrentino et al., 2021). One important factor for color stability is that the color is achieved via the shade of the porcelain, not through the use of superficial stains (Dal Piva et al., 2020; Kanat-Ertürk, 2020). In this study, layering was performed to obtain the correct shade.

The sensitivity category was rated as alpha for all restorations except one LD crown, which was sensitive after cementation and the pain became worse with time. The patient exhibited signs and symptoms of irreversible pulpitis. Root canal treatment was performed through the crown, and the access cavity was closed with composite. The cumulative damage sustained by the dental pulp during tooth preparation and impression-making has been documented in the literature (Habsha, 1998; Kim et al., 1992).

The secondary caries category was rated as alpha for all of the crowns. Patients' high compliance in this study played a significant role in the prevention of caries. Additionally, the follow-up time in this study is quite short; this is one of its limitations. Secondary caries might be more of a concern with a longer follow-up time.

It is worth noting that some of the differences found between the variables considered did not reach the level of statistical significance. This is likely due to the relatively small sample size. Larger samples should be examined in future studies to verify whether or not such differences are significant.

As mentioned above, one of the main limitations of this study is the short follow-up time. However, to our knowledge, the dental literature contains no studies with long follow-up times that examine the survival of monolithic and partially layered crowns. Another limitation is the retrospective nature of this study, which restricts our ability to control for multiple variables in the study design.

In the future, a longer follow-up for this cohort of patients could be performed to investigate the success of these crowns over the long term.

5. Conclusions

Zirconia and LD crowns are reliable treatment options with high short-term success rates. Zirconia can be cemented or bonded to the underlying structure. Selective cutting back and layering can improve the esthetic outcomes of the crowns without jeopardizing their integrity or increasing the risk of chipping of the veneering porcelain. Clinical studies with longer follow-up times and larger sample sizes are needed to investigate their long-term success rate.

Ethical statement

The study was approved by the deanship of scientific research in the university of Jordan, Amman, Jordan (Ref #2457-2022).

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.

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