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One-year clinical evaluation of monolithic zirconia crowns restoring endodontically treated molars with two finish line designs

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***Abstract*---**The study's objective was to assess the clinical behavior of monolithic zirconia crowns with two different margin designs in terms of fracture during a one-year period. Forty-four posterior endodontically treated molars received full coverage monolithic crowns. The teeth were separated into two groups depending on the margin design: the control group (RS) had a rounded shoulder finish-line while the intervention group (F) had a feather-edge finish-line. An intra-oral scan was used for the full coverage restorations, which were designed using open source software and machined on a 5 axis machine. The crowns were sandblasted and cemented with conventional glass ionomer cement. The modified United States Public Health Service (USPHS) criteria were used to assess clinical behavior in terms of fracture following cementation. The grades were immediately taken after cementation and at three consecutive three-month follow-up assessments over the course of a year. In terms of restoration fractures, all three follow-up examinations yielded a perfect Alpha score of 100 percent for each group. (P<0.05) There was no statistically significant difference between the control (RS) and

intervention (F) groups. In this one-year randomized clinical investigation, all of the crowns assessed were clinically successful, with no signs of fractures.

***Keywords*---**Zirconia crowns, feather edge finishline, rounded shoulder finishline, USPHS criteria, endotreated posterior teeth.

Introduction

Endodontically treated molars are more prone to fracture than the vital ones. The loss of tooth structure, following the pathological process and endodontic treatment of the tooth, is one of the chief reasons for their increased weakness. (1) The goals of the restoration are to reestablish form, function, and aesthetics while also preventing bacterial micro-leakage into the root canal system and preserving the remaining coronal structure.(1-2). Monolithic zirconia has grown in popularity as a result of the development of CAD/CAM technology and fast improvements in the mechanical properties of ceramic materials. (2-3) The mechanical properties of translucent zirconia are comparable to those of traditional zirconia in terms of fracture strength, which allows its use as a material of choice for conservative and ultra-conservative preparations. (3-6)

The feather edge finish line configuration conserves the tooth structure at the marginal area.(7) This conservative configuration, minimized technical errors caused by the definitive line configurations, as the presence of a finish line necessitates excellent definition in the preparation process before sending it to the laboratory. Most studies related the marginal misfit of a restoration to the design of the finish line and revealed minor to untraceable differences. (7-8) The rounded internal geometry was introduced in order to avoid tensile stress and minimize fractures of the brittle ceramic material. Habib et al (9) found no differences between zirconia CAD/CAM restorations with marginal gap of shoulder and chamfer horizontal finish-line configurations. Recently, Kasem et al (10) recommended that vertical preparations be used as a conservative alternative to horizontal preparations.(7,10) Although it is well established that tooth preparation affects the success of any restoration, the influence of the occlusal preparation scheme has received less attention.(11) The modification of the occlusal scheme might alter the stress distribution in ceramic restorations as well as the tooth's capacity to withstand fracture better, especially in the case of brittle teeth such as endodontically treated teeth. (12) Regardless of the cementation procedure, preparing a flat occlusal surface leads in equal stress distribution during crown seating and function, as well as greater fracture strength. (12) When employing brittle ceramics, the choice of resin cement is more important in the occlusal preparation design than when using zirconia ceramics. The fracture resistance values of endodontically treated molars with flat and two-plane occlusal preparation designs, on the other hand, exceeded the average and maximum biting forces measured in the mouth. (12)

Thus, the current in vivo investigation was carried out to assess the clinical behavior of monolithic translucent zirconia crown fractures with two different finish lines, feather edge and rounded shoulder marginal designs, over a one-year

period using the USPHS criteria. The null hypothesis was set that there would be no difference in fracture restorations between zirconia crowns made with a feather edge and those made with a rounded shoulder finish line configuration.

Materials and Methods

All teeth enrolled in this in vivo investigation were endodontically treated molars with excellent root canal treatment and moderate coronal loss, such that no posts were required to retain the core and avoid further weakening of the brittle tooth. Uncooperative patients and those with parafunction habits, minimally destructed molars such that can be restored with direct composite fillings, or periodontal and apical infections, on the other hand, were eliminated from this investigation. The forty-four molars were evaluated in terms of root canal therapy, remaining tooth structure, and restorability. The sample size calculation with a power test of 0.8 recommended twenty-two molars in each group in terms of dropout incidences. An intra-oral polyvinyl silicone index was taken after composite core buildup and prior to reduction procedures. (11) The flat occlusal reduction was done in both groups with flat-surfaced wheel stone (909 040 C FG, ökoDENT GmbH & Co. KG).

To achieve standardization, the occlusal surface was flattened to 1 mm below the central fossa. (12) A 1 mm thick finish line for the control group with rounded shoulder was achieved by the multi-radius stone (Winter Shoulder Diamond Burs, Brasseler). While the intervention group with the feather-edge finish line, a torpedo-like stone (863 014 C FG, ökoDENT GmbH & Co. KG) was used to form the bevel, or the vertical finish line area. (13) (Figure 1) (Figure 2) An intra-oral scan was done by the Medit i500 (MEDIT corp., Korea) intra-oral scanner after retraction cord placement for soft tissue management. The total occlusal convergence was then assessed to be clinically acceptable at 12–20 degrees, and the axial wall thicknesses were 1 mm. (14) Prior to designing the final restoration, Exocad software was utilised to ensure that the preparation fulfilled the criteria of this study. Following the final restoration design, a temporary polymethyl methacrylate was milled by a 5-axis milling machine (inLab MC X5, Dentsply Sirona) and used as a try in restoration to evaluate marginal adaptation, occlusal and proximal contacts, as well as temporary restoration for emergence profile formation, particularly with the intervention (F) group.

The zirconia (KATANA Zirconia STML, Kuraray Noritake Dental Inc.) crowns were then milled following the approved design and sintered following the manufacturer's recommendations. The intaglio surface of the attained zirconia crowns was sandblasted with alumina particles (50 um at 2.8 bar) for surface treatment and then cemented with conventional powder and liquid glass ionomer cement (Ketac™ Cem Radiopaque, 3M ESPE) (15). Immediately after cementation, the crowns were assessed with a sharp explorer and, under 4,5X magnification, taken as a baseline record. The modified USPHS criteria, (Alpha: Smooth surface of the restoration, no signs of fracture, Bravo: chipping of porcelain that does not impair function (Minor fracture), Charlie: Chipping of veneering material impairing esthetics and function (Moderate fracture), Delta: Major fracture) were also used in the consecutive follow-up visits over a one year period. (16) The Chi square test was also used to perform all of the comparisons between groups and follow-up records as $P < 0.05$.

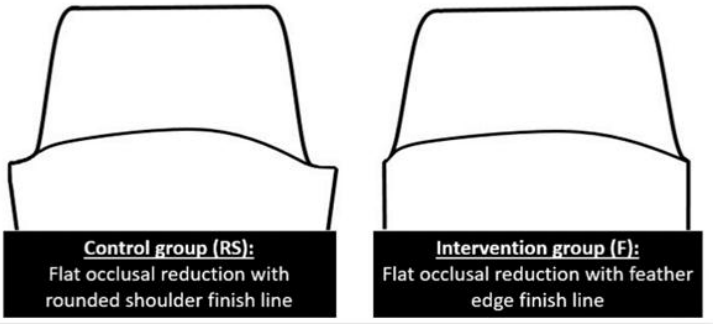

Figure 1. Schematic illustration of the preparation designs included in this study

Figure 2. Intervention (F): Flat occlusal surface design and feather-edge finish line preparation

Results and Discussion

There were no fractures or evidence of fractures in any of the groups during any of the four follow-up visits; they were all flawless. Each group received a perfect Alpha score of 100 percent on all four follow-up visits. The comparison between control group (RS) and (F) regarding fracture of restoration was performed by using the Chi-square test, which revealed an absolute insignificant difference in alpha (A) as $P > 0.05$ at baseline (Immediately post-cementation), 1st follow-up (after 3 months), 2nd follow-up (after 6 months), and 3rd follow-up (after 12 months), as presented in Table (1) The null hypothesis was accepted and the factors that might have influenced the results are:

Zirconia ceramic and restoration thickness

With the introduction of highly translucent monolithic ZrO2, the concern of chipping with porcelain fused to ZrO2 has been greatly alleviated and allowed the use of 1 mm thick restorations. Guilardi et al. (17) recommended the use of ZrO2 with ultra-high translucency be limited to monolithic, single-unit anterior or posterior prostheses. The material for this study was super translucent multilayered zirconia, which has a bending strength of 748 MPa and a fracture

toughness of 2-4 MPa m1/2, which is more convenient for posterior use than the UTML (Ultra Translucent Multi layered zirconia KATANA, Kurarary Nortake Dental INC.), which has better color parameters but a lower bending strength of 557 MPa. Despite the fact that the strength of high cubic-containing zirconia (5 Y-TZP) is lower than that of traditional tetragonal zirconia (3 Y-TZP), translucent cubic zirconia may not deteriorate further due to low temperature deterioration (LTD). In accordance with Kwon et al. (18) and Kolakarnprasert et al. (19), UTML and STML (Super Translucent Multi-layered Zirconia KATANA, Kurarary Nortake Dental INC.) have a larger cubic and lower tetragonal composition, thus, they are not affected by low temperature deterioration when compared to 3-TZP. In the study by Konstantinidis et al. (20), which revealed a high clinical success rate for monolithic zirconia full-coverage restoration of single posterior teeth in 65 patients at one year of follow-up. This is consistent with the recommendations of Leitão et al.'s systematic review and meta-analysis in 2021, which advocated the use of monolithic zirconia in the posterior area as a single complete coverage restoration. (21)

Preparation design

The minimal thickness of the restorative material that provides sufficient strength, as well as the minimal space required to develop a physiologic emergence, determine the width and design of the finish line. This study utilized two finish line designs, rounded shoulder and feather edge finish lines. According to Ferrari et al.'s (13) study, high-precision, full-coverage zirconia restorations with a feather-edge finish line can be used, and there are no differences in survival and success rates between zirconia crowns with feather-edge or chamfer margins after 4 years of clinical service. According to Jubhari et al. (22) systematic review, it was revealed that both rounded shoulder and shoulder-less/knife-edge restorations were equally used in research studies using zirconia full coverage restorations, which validates their use in the preparation designs of this current research. In addition, the occlusal preparation design has a significant impact on stress distribution and restorative survival. When force is exerted beyond the physiological limit, flat occlusal preparation, according to Oyar et al. (23) and Nabil et al. (12), allows for improved stress distribution and more favorable fractures than planar reduction. The aforementioned factors support the use of zirconia crowns with a feather edge finish line that perform similarly clinically to those with a rounded shoulder finish line.

Table 1
Frequency and percentages of Alpha and Bravo restoration fractures in control, intervention groups, with comparisons

Fracture of restoration	N	Alpha		Bravo, Charlie, Delta	
		N	%	N	%
Baseline Immediately post cementation	Control (RS)	22	100.00%	0	0.00%
	Intervention (F)	22	100.00%	0	0.00%
	P value	Absolute insignificant		----------	
First follow-up After 3 months	Control(RS)	22	100.00%	0	0.00%
	Intervention(F)	22	100.00%	0	0.00%

	P value	Absolute insignificant		----------	
Second follow-up after 6 months	Control (RS)	22	100.00%	0	0.00%
	Intervention (F)	22	100.00%	0	0.00%
	P value	Absolute insignificant		----------	
Third follow-up after 12 months	Control (RS)	22	100.00%	0	0.00%
	Intervention (F)	22	100.00%	0	0.00%
	P value	Absolute insignificant		----------	

Conclusions

- Endodontically treated molars with rounded shoulders and feather edge finish line designs restored with monolithic translucent zirconia, exhibited the same clinical durability with no evidence of fractures in a one-year clinical assessment.
- When using monolithic translucent zirconia, the feather-edge finish line design can be employed as a safe and conservative treatment option for endodontically treated molars. Long-term randomized clinical studies are suggested to back up the findings of this study.

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Funding & conflict of interest

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Legal remark

This study was carried out in accordance with all of the laws of the country's human subjects' investigative committee standards and policies of the ethics committee of scientific research- Faculty of Dentistry- Cairo University- Egypt.

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