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# BIOLOGICAL RESPONSE OF MONOLITHIC ZIRCONIA CROWNS WITH BOPT AND CHAMFER FINISHING LINE DESIGNS: A 1-YEAR PROSPECTIVE CLINICAL TRIAL

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## *ABSTRACT*

**Objective:** The goal of this prospective 1-year clinical trial was to determine how two types of finishing line (FL) designs—biologically oriented preparation technique (BOPT) and chamfer—affect the biological behavior of monolithic zirconia (M-$ZrO_2$) crowns for anterior teeth, including their pocket depth (PD), clinical attachment level (CAL), plaque index (PI), and gingival index (GI). **Subjects and Methods:** Eight healthy adults over the age of 18 who had good oral hygiene, a normal occlusion, healthy periodontium, and normal gingival biotypes were enrolled in this clinical trial from patients who were seeking treatment for endodontically treated anterior teeth with monolithic zirconia crowns. A split-mouth design was intended for this clinical trial. The BOPT or chamfer FL designs were used to prepare a total of 16 maxillary incisor teeth that had undergone endodontic treatment—eight in each group. At three distinct follow-up intervals (baseline, 6 months, and 12 months), the PD, CAL, PI, and GI were clinically assessed using Williams' periodontal probes in accordance with explicitly developed criteria. **Results:** Regarding the biological outcomes, there were no statistically significant differences detected between the finish line configurations. Over the course of the follow-up period of one year, PD, CAL, PI, and GI measurements from BOPT and chamfer FLs were normal. **Conclusions:** Zirconia crowns produced a positive biological response, regardless of the type of finish line.

**KEYWORDS:** Biological response, BOPT, Chamfer, Finishing line, Monolithic zirconia crowns

## INTRODUCTION

Clinicians greatly value $ZrO_2$ restorations for their superior chemical stability, high fracture toughness, and flexural strength in addition to their biocompatibility and physical characteristics, which give them a more natural appearance[1]. Furthermore, even at a thin layer, production milling of ZrO2 had no structural impact before or after the eating simulation [2].

Normally, while creating dental abutments for fixed partial dentures (FPD), physicians indicate the tooth on which the prosthetic restoration rests with a finish line[3,4]. These finish lines can be classified into two main categories: horizontal lines, which include chamfer, deep chamfer, and shoulder with bevel, or vertical lines, which include feather or knife-edge margins. Some authors suggest adopting the BOPT as a substitute for the method of dental preparation without a completion line[5,6].

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The difference between horizontal and vertical preparation is that with the former, the dentist applies the margin to the tooth, leaving a distinct line that is reproduced in the imprint and working model[7,8]. For this reason, prosthodontists likely prefer horizontal preparation[6].

However, there are a number of advantages to vertical preparation without a specific end in mind. Clinicians can reposition the cementoenamel junction (CEJ) on teeth that have been prepped or teeth that have not, with the latter removing the pre-existing finish line [9]. In cases where aesthetics has been compromised, the prosthesis is positioned to leave the gingival margin in the ideal position while simultaneously establishing a new prosthetic CEJ[3,6]. Based on the information about the gingival tissue, the technicians place the vertical preparation margin. Because it determines the new emergence that will support the gingival margin and guide healing, reinsertion, and thickening of the gingival tissue, the creation of the interim prosthesis, which will be replicated when the final prosthesis is inserted, is essential to the success of BOPT preparation design[10,11].

According to Bennani (2017)[12], the architecture of the visible soft tissues has a significant role in producing an aesthetically pleasing smile. It's also crucial to understand how the gingiva and the healing margin interact for the outcome to hold up over time. Gingival architecture and health are essential for ensuring excellent aesthetics after prosthodontic work. The likelihood of a satisfactory outcome will be considerably increased by paying close attention to the soft and hard tissues surrounding the teeth before, during, and after restorative procedures [13].

Daniel (2020)[5] added that the unfavorable cosmetic result caused by the gingival margin's apical migration is a significant problem with tooth-supported FDPs. The gingival margin's propensity to shift apically over time is influenced by a variety of factors, including gingival biotype, prosthetic preparation, invasion of biological width, and iatrogenic. One of these, the manner of preparation and the geometry of the finishing line, is particularly significant. The location and design of the finishing line for dental preparation have long been a topic of discussion in the literature [5, 14, 15].

Therefore, the goal of this clinical trial was to determine how the two types of FL preparation (BOPT and chamfer designs) of monolithic zirconia crowns affected the PD, CAL, PI, and GI in maxillary incisor teeth. According to the study's null hypothesis, there will be no discernible difference in the biological response between the various preparation methods used.

## SUBJECTS AND METHODS

The Faculty's Ethics Committee for Research Involving Human Subjects (Eth. Ref. No. 173/264), Faculty of Dental Medicine, Al-Azhar University, Cairo, Egypt, approved the design of this trial as a split-mouth prospective observational clinical trial. According to a prior study by Agustin-Panadero et al. (2018)[4], the sample size calculation indicated that a total sample size of 16 (8 in each group) will be sufficient to detect an effect size of 0.94 at a power (1-error) of 0.8 and using a two-sided hypothesis test and a significance level (error) of 0.05 for data.

This clinical trial involved 8 adult Egyptian non-smokers who were over 18 years old, had good oral hygiene and attended the outpatient clinics of the Crown and Bridge Department at the Faculty of Dental Medicine (Assuit-branch), Al-Azhar University. Before the trial began, all of the selected subjects were made aware of all the methods used in this clinical investigation. Before beginning any procedure, each participant completed an informed consent form that contained information about the full therapeutic therapy. A total of 16 maxillary incisors with endodontic treatments on both sides, normal occlusion, healthy periodontium, and normal gingival biotypes were used in this investigation [4].

**Tooth preparation and temporization**

The procedures used to prepare the maxillary incisor teeth were identical, and they only varied based on the presence or absence of a cervical finish line. The axial walls were reduced by 1 millimeter with a convergence of approximately 10 to 12 degrees in both preparation methods, whereas the occlusal reduction was 1.5 millimeters. In order to prepare the tooth dies for the chamfer design, a high-speed handpiece and burs (taper modified shoulder with round end) (Komet, Germany, 8847KR, S 6856, Okodent GmbH & Co. KG- Germany) were used [4,16]. The tooth preparation for the BOPT design was created without a cervical finish line, creating a vertical axial plane between the anatomic crown and the root area [4]. This was done in accordance with the procedure described by Loi and Di Felice (2013) [3] and Serra-Pastor et al. (2019) [10]. **(Fig.1)**

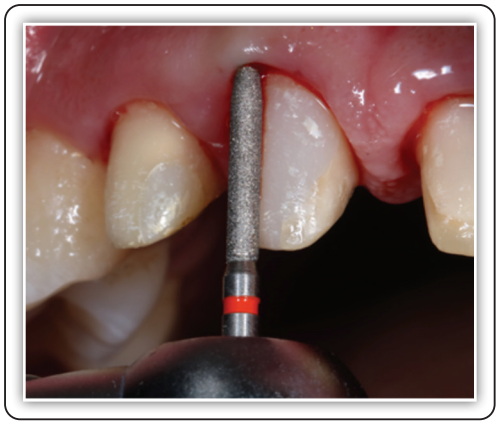

FIG (1) Flame shaped bur with avertical axial plane between the anatomic crown and root area.

To stabilize and heal the soft tissue surrounding the tooth, the BOPT approach specifies an 8-week intermediate restoration phase[4]. **(Fig.2)** Even though this is not necessary for the customary preparation with the finish line, imprints were obtained after 8 weeks to standardize the two groups. Provisional restorations were made using auto-polymerizing resin from (VOCO GmbH in Cuxhaven, Germany, and were bonded in place using zinc oxide cement free of eugenol from Promedica Dental Materials GmbH in Domgkstrasse, Germany), before the completion of the final restorations [4].

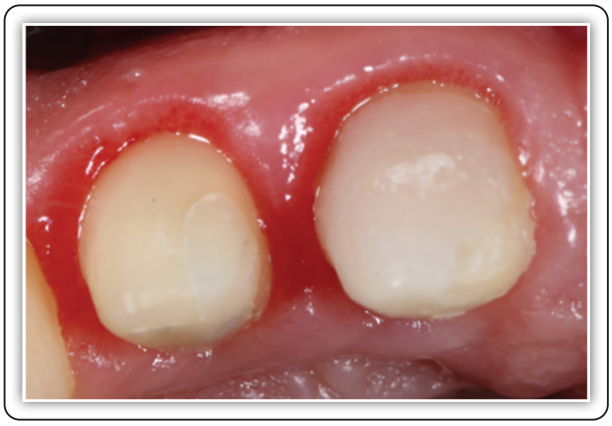

FIG (2) Occlusal view showing initial healing of soft tissue and widening of gingival sulcus after 2 weeks

**Fabrication of monolithic Zirconia crowns:**

Each subject's impression was digitalized and used to construct the monolithic zirconia restorations utilizing a CAD/CAM system with a lab scanner[4]. The monolithic ceramic crowns were created using CEREC 3D Software (AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria), and then CAD/CAM milled in an oversize dimension with the green stage zirconia blanks in order to compensate for the dimensional shrinkage of 25–30%[17]. This was done for the fabrication of super-high translucent zirconia crowns. The manufacturer's recommended firing parameters were then followed, and ultra-high translucent zirconia crowns were sintered in a furnace (Ceramill Therm, AMANNGIRRBACH, Herrschaftswiesen1, Koblach, Austria) at a temperature of 1450°C for a 120-minute holding period, concluding with a sintering process that took a total of 7.5 hours for each zirconia crown [17].

**Cementation of monolithic Zirconia crowns:**

After fabrication, all the monolithic zirconia crown restorations were tried on their corresponding teeth and checked for complete seating then were cemented with conventional glass ionomer cement

(CGIC) (Medicem application capsules, ProMedica Dental Materials Germany), the cementation protocol was done without any surface treatment for both restorations and teeth.

**Clinical evaluation and follow-up:**

At 3 distinct follow-up intervals (baseline, 6 months, and 12 months), all patients had clinical assessments for PD, CAL, PI, and GI. One periodontist took all of the readings using a dental mirror, a dental explorer, and William's graduated periodontal probe. On the central incisors and surrounding gingiva, the PD was assessed. The following findings were evaluated to the nearest 0.5mm: Doctor's cap dimensions pillar size, pillar height, and crown height[18,19]. The CAL was calculated from measures of gingival recession and pocket depth collected at the lingual and mesial-distal sides of the afflicted teeth. A CAL of less than one millimeter (normal group), one to three millimeters (mild group), three to five millimeters (moderate group), and more than five millimeters (severe group) was used to calculate the mean value of clinical attachment loss [20, 21].

By using a periodontal probe to examine the mesial, distal, buccal, and palatal surfaces of each tooth, the PI was calculated. The dental plaque thickness of the patients was evaluated in order to determine their PI. The PI of a person was determined by averaging the results for each tooth and putting them together. The PI was determined using the references from Silness & Löe listed below: PI 0 signifies the absence of any plaque near the gingiva, PI 1 shows a thin film-like plaque at the gingival margin, PI 2 shows apparent plaque at the gingival pocket and gingival border, and PI 3 shows thick plaque at the gingival pocket and gingival border [22].

The patient's GI was calculated using the amount of bleeding that occurred when a Williams periodontal probe was inserted into the pocket on the mesial, distal, buccal, and palatal sides of all teeth. The GI of a person was determined by averaging the values discovered for each tooth and putting them together. The GI was calculated using the references below from Löe & Silness: GI 0: Healthy gingiva; GI 1: Oedematous gingiva and little discoloration. The gingiva is red, edematous, and glossy; nothing bled when you probed it, GI 2. GI 3 is bleeding on prodding, and the gingiva is red, oedematous, and ulcerated. Spontaneous bleeding happens [23].

**Statistical analysis**

The numerical values for the PD, CAL, PI, and GI data were gathered for statistical analysis. The Shapiro-Wilk test was performed to assess normality. Unpaired t-tests were used to compare two groups, and one-way ANOVA tests were used to compare different time periods. The threshold for significance was fixed at p 0.05.

**RESULTS**

The normality assumption was checked based on the Shapiro-Wilk Test, it is assumed that the data is normally distributed. Regarding the biological parameters, the unpaired t-test results at the baseline, 6 months, and 1 year of clinical follow-up of PD, CAL, PI, and GI revealed that the difference between the sample average of the BOPT FL group and the chamfer FL group is not big enough to be statistically significant (**Table 1**).

Moreover, regarding the follow-up periods, the One-way ANOVA results of PD, CAL, PI, and GI in the BOPT and Chamfer finishing line groups revealed that the difference between the sample average of some groups is not big enough to be statistically significant. For the intergroup comparison, the Tukey HSD revealed that the means of all pairs are not significantly different ($p>0.05$) for all measured biological variables (**Table 2**).

**Table (1)** Comparison of the clinical results at the baseline:

| | Variables | BOPT | Chamfer | t-value | p-value |
|---|---|---|---|---|---|
| Baseline | PD | 2.09±0.60 | 2.04±0.62 | 0.16 | 0.872 ns |
| | CAL | 1.2±0.27 | 1.1±0.15 | 0.92 | 0.372 ns |
| | PI | 0.87±0.25 | 0.75±0.31 | 0.89 | 0.386 ns |
| | GI | 0.24±0.18 | 0.14±0.14 | 1.22 | 0.243 ns |
| 6 months | PD | 1.84±0.65 | 1.87±0.72 | 0.108 | 0.914 ns |
| | CAL | 1.05±0.38 | 1±0.24 | 0.31 | 0.761 ns |
| | PI | 0.68±0.37 | 0.60±0.19 | 0.59 | 0.564 ns |
| | GI | 0.2±0.19 | 0.08±0.11 | 1.42 | 0.175 ns |
| 1 year | PD | 1.68±0.63 | 1.77±0.76 | 0.251 | 0.805 ns |
| | CAL | 0.95±0.35 | 0.96±0.19 | 0.08 | 0.931 ns |
| | PI | 0.48±0.31 | 0.6±0.19 | 0.86 | 0.402 ns |
| | GI | 0.24±0.19 | 0.09±0.11 | 1.85 | 0.085 ns |

**; Significant (p<0.05), ns; nonsignificant.*

**Table (2)** Comparison of clinical results of the BOPT group at the different follow-up periods:

| BOPT | Bassline | 6 Months | 12 Months | p-value |
|---|---|---|---|---|
| PD | 2.09±0.60 | 1.84±0.65 | 1.68±0.63 | 0.452 ns |
| Sig. between groups | p1=0.711 ns, p2=0.427 ns, p3=0.883 ns | | | |
| CAL | 1.2±0.27 | 1.05±0.38 | 0.95±0.35 | 0.351 ns |
| Sig. between groups | p1=0.656 ns, p2= 0.323 ns, p3=0.827 ns | | | |
| PI | 0.87±0.25 | 0.68±0.37 | 0.48±0.31 | 0.070 ns |
| Sig. between groups | p1=0.473 ns, p2=0.057 ns, p3=0.428 ns | | | |
| GI | 0.24±0.18 | 0.2±0.19 | 0.24±0.19 | 0.904 |
| Sig. between groups | p1=0.92 ns, p2=1 ns, p3=0.92 ns | | | |
| Chamfer | Bassline | 6 Months | 12 Months | p-value |
| PD | 2.04±0.62 | 1.87±0.72 | 1.77±0.76 | 0.754 ns |
| Sig. between groups | p1=0.889 ns, p2=0.738 ns, p3=0.956 ns | | | |
| CAL | 1.1±0.15 | 1±0.24 | 0.96±0.19 | 0.380 ns |
| Sig. between groups | p1=0.584 ns, p2=0.371 ns, p3=0.925 ns | | | |
| PI | 0.75±0.31 | 0.60±0.19 | 0.6±0.19 | 0.361 ns |
| Sig. between groups | p1=0.429 ns, p2=0.429 ns, p3=1 ns | | | |
| GI | 0.14±0.14 | 0.08±0.11 | 0.09±0.11 | 0.648 ns |
| Sig. between groups | p1=0.698 ns, p2=0.698ns, p3=1 ns | | | |

**; Significant (p<0.05), ns; nonsignificant. P1; between baseline and 6 months.*
*P2; between baseline and 12 months. P3; between 6 months and 12 months.*

## DISCUSSION

The shape of the finish line (horizontal versus vertical) has frequently been cited as the cause of inaccuracy and subsequent gingival tissue instability due to trauma[24,25]. Moreover, conservative dentistry has been shown to have trouble delivering acceptable aesthetic outcomes while simultaneously paying close attention to the biological structures involved, therefore, it was imperative to assess the biological reaction of different tooth preparation designs [26].

Therefore, the purpose of this prospective 1-year clinical trial was to compare the biological effects of teeth prepared with BOPT to those prepared with chamfer finish lines and restored with zirconia crowns. The null hypothesis was accepted because the data showed no statistically significant difference between the various modes of preparation utilized for the PD, CAL, PI, and GI. Clinical factors such as PD, CAL, PI, GI, and gingival stability were used to assess periodontal health in this clinical trial because they are regularly used clinical variables that may predict the prognosis and survival rate of teeth [27].

The ultimate goal of prosthetic dentistry is to achieve exceptional cosmetic results while maintaining biological traits[28]. It was shown that the periodontally troubled abutments for fixed prostheses were often advised for vertical (BOPT) preparation because, depending on the clinical situation, it may be more conservative (minimally invasive) than horizontal preparation [3]. Due to its most acute marginal restoration and the fact that its vertical preparation can preserve the healthiest tooth structure, BOPT was chosen as the tested group in this trial [28]. Although the shoulder is frequently used in practice as the horizontal finish line for the preparation due to their alleged benefits in preventing overhangs and over-contouring of the restorations, as well as this has improved workflow and lab-clinician communication, the chamfer finishing line was selected in this trial as a control group since it demonstrates the best marginal fit as well as produce the most conservative tooth preparation [29].

When using natural teeth, the researcher can apply a variety of bonding techniques, which drastically change how the materials under investigation behave [30]. As the primary objective of this research was to examine the impact of the two tested finishing lines on marginal fit and biological behavior, we chose a single material (monolithic zirconia) and GIC for both preparation designs in this clinical trial in order to avoid skewed results from other factors[31].

The results of the present clinical trial revealed that the PD, and CAL, as well as plaque and gingival indices, were insignificantly lower for BOPT preparation after 12 months of follow-up when compared with the chamfer finishing lines. This could be attributed to the fact that vertical geometry, as opposed to horizontal geometry, has a smaller impact on gingival sulcus irritation and a smaller marginal gap in the restoration [32-34].

Moreover, the results of this current investigation revealed that the CAL of the BOPT preparation was higher than the chamfer finishing line, however, it was insignificant at the baseline and after 6 months. This could be attributed to a smaller gap that resulted in less cement being forced out into the delicate gingival sulcus environment [14].In this clinical experiment, vertical preparation was chosen to see if zirconia monolithic ceramics could replace horizontal preparation as a viable aesthetic option. However, the amount of exposed cement was very small due to the total $10^{o}$ -$12^{o}$ occlusal convergence of the axial walls and the thin geometry of the zirconia vertical margins, and as a result, the possibility of plaque accumulation was very small[28,35].

Moreover, the results of this present clinical trial revealed that the PD insignificantly decreased with time for both finishing line designs. These could result from improvements in CAL and gingival stability along with good oral hygiene. As Chen

et al. (2020) [27] stated effective oral hygiene can decrease tissue inflammation and pocket depth as well as increase the CAL, which leads to a reduction in PD after mechanical instrumentation. Moreover, the insignificant difference in the reduction of PD and CAL gain could be attributed to the lower initial measurement and severity of the gingival case, as it was stated that the degree of PD reduction and attachment level gain corresponds with initial assessment and severity [27]. Our results are consistent with other research, which suggests that patients with deeper baseline PD have a more pronounced PD decrease.

The existence of a sufficient band of keratinized gingiva, measuring around 2 mm after 12 months of follow-up for BOPT preparation, was unquestionably a plus and likely contributed to the gingival tissue stability of the outcome of this clinical trial. This could be related to right crown margin positioning, respect for the biological width, and achievement of a good soft tissue response were made possible by the adoption of a standardized clinical process and special instruments [14].

## CONCLUSIONS

The results of this clinical trial show that independent of the type of finish line, monolithic zirconia crowns with various finishing line designs produced a positive biological reaction. Furthermore, no statistically significant differences between the finish-line designs were discovered in terms of biological effects. Instead of the traditional chamfer finishing line design, the BOPT finishing line design can be employed as a minimally invasive preparation without causing any negative biological impacts.

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