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CLINICAL RESEARCH

# Clinical behavior of posterior fixed partial dentures with a biologically oriented preparation technique: A 5-year randomized controlled clinical trial

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## ABSTRACT

**Statement of problem.** Evidence of the behavior of the periodontal tissues around anterior teeth restored with the biologically oriented preparation technique (BOPT) is available. However, outcomes of this technique in posterior teeth restored with fixed partial dentures (FPDs) are lacking.

**Purpose.** The purpose of this randomized controlled clinical trial was to evaluate the clinical, mechanical, and biological behavior of posterior 3-unit FPDs placed on teeth prepared with BOPT.

**Material and methods.** Forty participants received a 3-unit zirconia FPD in the posterior region of the mandible or maxilla. Twenty FPDs were placed on teeth prepared with BOPT (study group) and 20 on teeth with a horizontal chamfer finishing line (control group). Follow-up examinations were performed 1, 3, and 5 years after treatment to evaluate periodontal responses around the prepared teeth by means of the following parameters: plaque index, gingival index, probing depth, and marginal stability (MS). Mechanical behavior was also assessed, as were any complications.

**Results.** After the 5-year follow-up, 57.9% of the control group and 35% of the BOPT group presented a plaque index of 1. The gingival index was 1 in 68.4% of the control group and 30% of the BOPT group after the follow-up period. In the analysis of probing depth, 26.3% of teeth in the control group had pockets of more than 3 mm in depth, whereas the BOPT group had only 10%. Marginal stability appeared in 100% of the BOPT group, whereas only 10.5% of the control group exhibited gingival stability. Complications during the follow-up period were similar, 20% in the control group and 15% in the BOPT group.

**Conclusions.** Posterior FPDs prepared by using BOPT had a good clinical response over a 5-year follow-up, with a low gingival index, a small increase in pocket depth, and a 100% marginal stability of the surrounding tissues. High survival rates after 5 years indicated that the technique produced predictable outcomes. (J Prosthet Dent 2020;■:■-■)

The biologically oriented preparation technique (BOPT) is a prosthodontic protocol that consists of preparing teeth to receive fixed prostheses without a finish line.[1] The dental preparation gives the tooth a convergent shape, and the restoration slides telescopically onto the cervical surface before being cemented in place.[2] The marginal gap between the restoration and the prepared horizontal plane produced with a conventional preparation is therefore eliminated.[2-4]

Unlike other preparation techniques, the BOPT creates an axial vertical plane between the dental root and crown areas, eliminating the emergence of the anatomic crown above the cementoenamel junction (Fig. 1).[1,2] Therefore, the complete coverage restoration accommodates periodontal tissue easily, helping it to become established around the cervical portion.[3,5] With this clinical protocol, tooth preparation is not as important as the fabrication of the prosthetic crown, as this must replicate the shape of the anatomic crown, its

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## Clinical Implications

The biologically oriented preparation technique technique is a good treatment option in posterior fixed partial dentures, with good periodontal outcomes and marginal stability.

cementoenamel junction, and its cervical emergence profile.[1-5]

In the BOPT, unlike other dental preparation techniques, well-managed cervical contouring in a horizontal direction should benefit the health of the adjacent periodontal tissue and help stabilize the gingival margin. In this type of restoration, the finish line is located on the crown in relation to the gingival architecture at between 0.5 and 1 mm inside the gingival sulcus, similar to the anatomic crown of a healthy natural tooth.[1-5]

Case series and prospective studies have evaluated the behavior of periodontal tissues around teeth restored with the BOPT, reporting that the periodontal soft tissues are stable around restorations of anterior teeth.[3,5,6] However, evidence of this technique for the treatment of posterior teeth is sparse, and evidence for treatment with posterior fixed partial dentures (FPDs) is lacking. However, posterior FPDs with finish line preparations have been widely evaluated, with long-term research on their biological and mechanical behavior.[7-17]

The purpose of this prospective clinical study was to assess the clinical, mechanical, and biological behavior of posterior 3-unit FPDs placed on teeth prepared with the BOPT. The null hypothesis was that prostheses on teeth prepared with BOPT would have similar periodontal outcomes, clinical survival, and mechanical behavior to restorations on teeth prepared with traditional finish lines.

## MATERIAL AND METHODS

This prospective observational study investigated the behavior of posterior 3-unit zirconia FPDs on teeth prepared with finish line and with the BOPT. The study was carried out at the Faculty of Medicine and Dentistry, University of Valencia, Spain, and the study design was approved by the University of Valencia Ethics Committee for Research Involving Human Subjects (Reg. No: H1525954738096).

Participants were enrolled from patients seeking treatment for a missing posterior tooth with a 3-unit FPD at the University Department of Stomatology by applying the following inclusion criteria: older than 18 years, in good general health, nonsmokers or smoking <10 cigarettes per day, vital abutment teeth or teeth treated endodontically, good oral hygiene as determined by clinicians, periodontally healthy teeth (without signs of periapical disease and probing depth between 0 and 3 mm), and a stable occlusion with a natural dentition in the opposing arch. Exclusion criteria were requiring an FPD of more than 3 units, poor oral hygiene, high caries activity, active periodontal disease around the relevant teeth, bruxism, unmanaged diabetes or any other systemic disease that could compromise prosthetic treatment, and those receiving bisphosphonates.

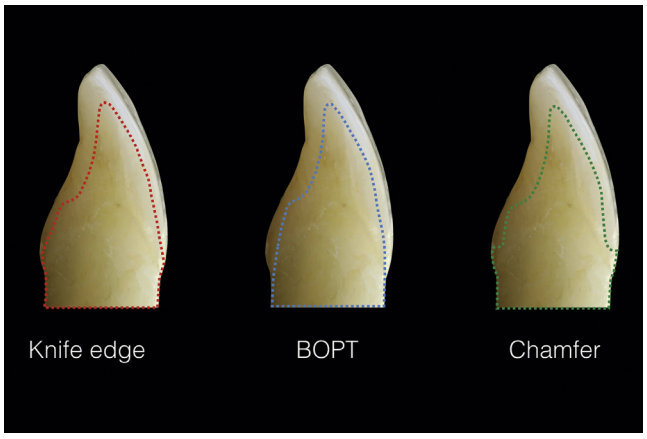


**Figure 1.** Different preparation techniques. BOPT eliminates complete emergence of teeth (cementoenamel junction). BOPT, biologically oriented preparation technique.

Following the Declaration of Helsinki guidelines for experiments involving human subjects, the participants received a full description of the treatment, an explanation of the procedure, and the need to attend follow-up appointments. All participants signed an informed consent form before treatment.

The objective of the study was to assess the clinical, mechanical, and biological behavior of posterior 3-unit FPDs placed on teeth prepared with the BOPT (study group), comparing them with posterior 3-unit FPDs placed on teeth prepared with a horizontal finish line (control group). Participants were allotted to the 2 groups randomly by using the online randomization software program available at www.alazar.info. A numbered list of 40 participants was created, and the software program indicated which numbers would be treated with finish line and which with the BOPT (Tables 1 and 2).

Two experienced prosthodontists (R.A.-P., J.P.) treated the participants, who received professional tooth cleaning and instructions in oral hygiene before treatment. Participants in periodontal maintenance received individual treatment as necessary. Professional tooth cleaning was maintained during the study as was periodic periodontal maintenance.

Tooth preparation was carried out following standard procedures, which only varied in accordance with the presence or absence of a cervical finish line. The control group teeth were prepared with a 1-mm-wide circumferential chamfer at the gingival margin (Fig. 2A). The BOPT group was prepared without a cervical finish line, creating a vertical axial plane between the anatomic crown and the root

**Table 1.** Distribution of prepared teeth and FPDs with finish line

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | O | X | O | | | | | | | | | | | |
| 3 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 4 | – | – | – | – | – | – | – | – | – | O | X | O | – | – |
| 5 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 6 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 8 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 10 | – | O | X | O | – | – | – | – | – | – | – | – | – | – |
| 11 | – | – | – | – | – | – | – | – | – | O | X | O | – | – |
| 14 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 16 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 18 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| Mx | R. second molar | R. first molar | R. second premolar | R. first premolar | R. canine | R. lateral incisor | R.central incisor | L. central incisor | L. lateral incisor | R. canine | R. first premolar | R. second premolar | R. first molar | R. second molar |
| Md | R. second molar | R. first molar | R. second premolar | R. first premolar | R. canine | R. lateral incisor | R.central incisor | L. central incisor | L. lateral incisor | R. canine | R. first premolar | R. second premolar | R. first molar | R. second molar |
| 2 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 7 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 9 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 12 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 13 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 15 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 17 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 19 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 20 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |

FPD, fixed partial dentures; L, left; Mx, maxilla; Md, mandible; R, right. Numbers in left column indicate number of participants in sample.

**Table 2.** Distribution of prepared teeth and FPDs with BOPT

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | | O | X | O | | | | | | | | | | |
| 13 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 15 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 16 | – | O | X | O | – | – | – | – | – | – | – | – | – | – |
| 17 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 18 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| Mx | R. second molar | R. first molar | R. second premolar | R. first premolar | R. canine | R. lateral incisor | R.central incisor | L. central incisor | L. lateral incisor | R. canine | R. first premolar | R. second premolar | R. first molar | R. second molar |
| Md | R. second molar | R. first molar | R. second premolar | R. first premolar | R. canine | R. lateral incisor | R.central incisor | L. central incisor | L. lateral incisor | R. canine | R. first premolar | R. second premolar | R. first molar | R. second molar |
| 1 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 2 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 3 | – | O | X | O | – | – | – | – | – | – | – | – | – | – |
| 4 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 5 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 6 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 7 | O | X | O | – | – | – | – | – | – | – | – | – | – | – |
| 8 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 9 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 10 | – | – | – | – | – | – | – | – | – | – | – | O | X | O |
| 11 | – | O | X | O | – | – | – | – | – | – | – | – | – | – |
| 14 | – | O | X | O | – | – | – | – | – | – | – | – | – | – |
| 19 | – | – | – | – | – | – | – | – | – | – | O | X | O | – |
| 20 | – | O | X | O | – | – | – | – | – | – | – | – | – | – |

BOPT, biologically oriented preparation technique; FPD, fixed partial denture; L, left; Mx, maxilla; Md, mandible; R, right. Numbers in left column indicate number of participants in sample.

area (Fig. 2B) as per the protocol described by Loi and Di Felice[1] and Serra-Pastor et al.[5] In both preparation procedures, the axial walls were reduced by 1 mm with convergence of approximately 10 to 12 degrees. Occlusal reduction was of 1.5 mm on nonfunctional cusps and 2 mm on functional cusps.

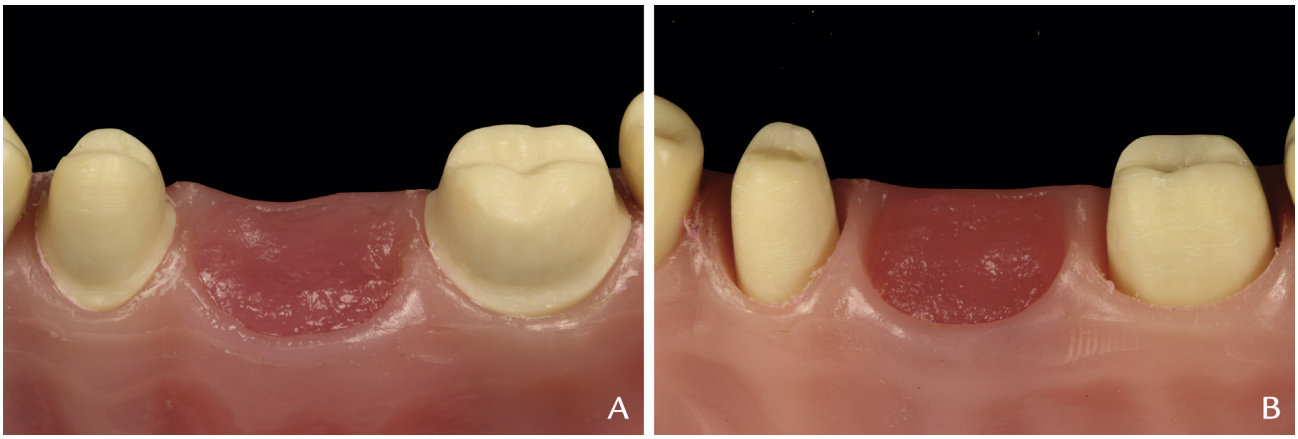


**Figure 2.** Tooth preparations. A, Conventional with finish line. B, Biologically oriented preparation technique.

Interim restorations were fabricated in autopolymerizing resin (Sintodent Resin C&B; Sintodent) and were cemented in place using zinc oxide cement without eugenol (Integrity TempGrip; Dentsply Sirona). The BOPT protocol requires an 8-week interim restoration phase for soft tissue stabilization and healing around the tooth. Although this is not necessary in the traditional preparation with finish line, impressions were made after 8 weeks to standardize the 2 groups. Impressions of the complete arch were made by using polyvinyl siloxane with the putty-wash technique (Express Penta Putty and Express Penta Ultra-Light Body; 3M ESPE), poured in type IV gypsum (GC Fujirock EP; GC), and mounted in a semiadjustable articulator (ARL2; Dentatus AB).

The zirconia restorations were fabricated by using a computer-aided design and computer-aided manufacturing system (Lava; 3M ESPE) equipped with a scanner (Lava; 3M ESPE) to digitalize the prepared teeth and the edentulous space. The FPD frameworks were designed by using a software program (Lava CAD; 3M ESPE) and with an anatomical shape and a coping thickness of at least 0.5 mm and connector dimensions of 3×3 mm. They were milled from a block of presintered zirconia and sintered in a furnace (Lava Therm; 3M ESPE) at 1500 °C. A feldspathic ceramic veneer (Lava Ceram; 3M ESPE) of uniform thickness was applied over the entire framework. All FPDs were fabricated by an experienced technician.

The FPDs were evaluated independently using the California Dental Association Quality Evaluation System[18] by 2 researchers (R.A.-P., J.P.) who had not participated in the study treatment phase. The lower assessment was recorded if a discrepancy occurred. Each criterion was evaluated on a scale of 1 to 4, whereby 4 is excellent, 3 is good, 2 is acceptable, and 1 is unacceptable. Only FPDs evaluated as 3 or 4 were cemented; others were refabricated. The FPDs were cemented with a resin-based cement (Rely X Unicem; 3M ESPE). The occlusion was adjusted, and adjusted surfaces were polished after cementation.

The same 2 researchers (R.A.-P., J.P.) performed follow-up examinations after 1, 3, and 5 years recording periodontal status with plaque index (PI), gingival index (GI), probing depth (PD), and gingival marginal stability (MS) or recession. Biological and mechanical complications during the follow-up period, such as framework fracture or veneer chipping and secondary caries, pulpitis, periapical lesions, or abutment tooth fracture were recorded.

The data were analyzed with a statistical software program (SAS 9.1; SAS Institute). Descriptive statistics were calculated for all variables to determine clinical survival. All parameters related to periodontal status were represented by scores of 0 to 3 (PI and GI) or 1 to 4 (MI and PD) ($\alpha$=.05). The Mann-Whitney test was used to determine whether clinical parameter values differed at each follow-up time as per the type of dental preparation performed. The Wilcoxon test was used to determine whether differences in the distribution of clinical parameter values over time could be found within each group. The Friedman test was used to determine the differences between groups over time for clinical values. ANOVA-type statistical (ATS) analysis was performed (Brunner-Langer nonparametric model for longitudinal data)[19] to determine the principle effects as per the group over time. The Fisher exact test was applied to compare complications between groups. The statistical power was achieved by considering the effect size to detect a large magnitude (d=0.8) was 91.1%.

## RESULTS

The proportion of participants with PI of 1 (slight) in the control group (with finish line) was 60% after the first year (T1) and 57.9% after 3 and 5 years (T3, T5). For participants with FPDs on teeth prepared with BOPT, 35% had a slight or moderate PI (15% slight, 20% moderate) at T1, 25% at T3 (15% slight, 10% moderate), and 35% at T5 had slight PI (Fig. 3). However, differences between groups were not statistically significant at any follow-up time

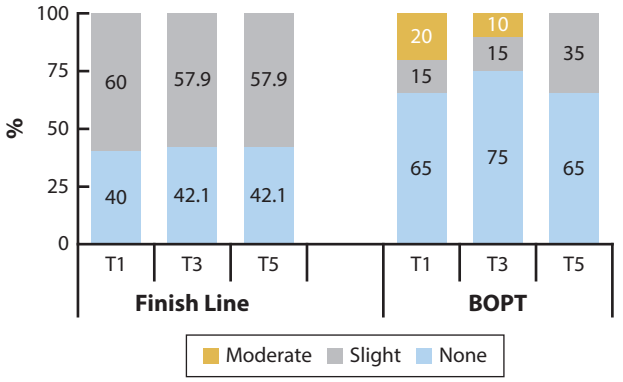


**Figure 3.** Change in plaque index with time. BOPT, biologically oriented preparation technique.

(Mann-Whitney test; T1, *P*=.495; T3, *P*=.149; T5, *P*=.224). No significant differences were found when this parameter was analyzed in each group over time (Friedman *P*=.510 for the whole sample; *P*=1.000 in the control group with finish line; *P*=.331 in the study group with BOPT). The Brunner-Langer model ATS test corroborated that there were no significant differences between groups (*P*=.102) or between follow-up times (*P*=.567); stability was similar for both groups (*P*=.706).

An analysis of GI results found that 40% of participants in the control group (with finish line) had a GI value of 1 (slight inflammation) at T1, reaching 68.4% at T3 and T5, whereas the study group (BOPT) only presented a GI of 1 in 25% of participants at T1 and T3, reaching 30% at T5. A higher percentage of participants had a GI of 1 at T1 in the control group, which then tended to increase over time with statistically significant differences between the groups (Friedman test: control group *P*=.028; study group *P*=.882; entire sample *P*=.127). At T3 and T5, the mean GI in the study group (BOPT) was significantly lower than in the control group (with finish line) (Mann-Whitney: T1, *P*=.429; T3, *P*=.019; T5 *P*=.041). This was confirmed in the Brunner-Langer model ATS test (*P*=.007 by group; *P*=.093 over time), this variable being similar at all follow-up times (*P*=.168) (Fig. 4).

Evaluating PD, 20% of the control group (with finish line) had pockets between 4 and 6 mm at T1 compared with 0% in the study group (BOPT). At T3 and T5, PD increased to 21% (pockets of 4-6 mm) and 5.3% (pockets of 7-9 mm) of control group participants compared with 5% at T3 and 10% at T5 of study group participants presenting pocket depths of 4-6 mm (Fig. 5).The Brunner-Langer model ATS test showed a tendency toward greater PD among control group participants (*P*=.062), but this was not statistically significant.

In relation to MS, clinical response was significantly different between the 2 dental preparation techniques. In the study group, gingival margins remained stable in all participants, whereas in the control group, recession was notable (Fig. 6). Marginal recession was significantly

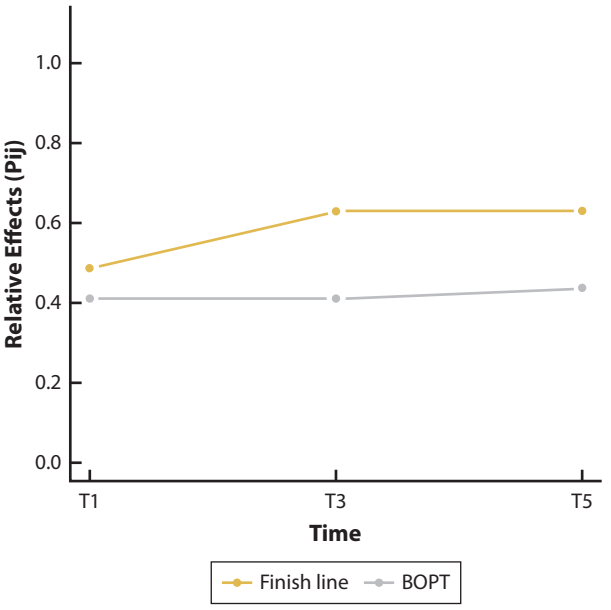


**Figure 4.** Probability that gingival index in biologically oriented preparation technique (BOPT) group is lower than in finish line group at each time period.

greater in the control group than the study group at all follow-up times (Mann-Whitney: T1, *P*=.002; T3, *P*=.001; T5 *P*=.001). Changes to the gingival margin over time were only significant in the control group (Friedman: control group *P*=.001; study group *P*=1; entire sample *P*=.001). Differences between the groups were evident and did not remain the same over time (interaction *P*=.001) but intensified as per the ATS test (*P*=.001 for time; *P*=.001 for groups). At T5, only 10.5% of the control group maintained gingival margin as at the start of treatment (Fig. 7).

The rate of mechanical and biological complications was 20% for FPDs in the control group (with finish line) and 15% in the study group (BOPT) without statistically significant difference (Fisher test: *P*=1.000). The main complication observed was chipping or fracture of the ceramic veneer; this occurred in 3 restorations (15%) in the control group and 2 (10%) in the study group. As for biological complications, irreversible pulpitis was diagnosed in 1 participant in the study group (BOPT) after tooth preparation, which required endodontic treatment, and 1 vertical root fracture occurred in the control group (with finish line), which meant extraction of the prepared tooth and so failure of the FPD. The clinical survival of the restorations on teeth prepared with BOPT (study group) was 100%, whereas on teeth prepared with finish line (control group), the rate was 95%.

## DISCUSSION

This study assessed the response of posterior FPDs on teeth prepared using the BOPT over a 5-year follow-up period by comparing these with posterior FPDs on

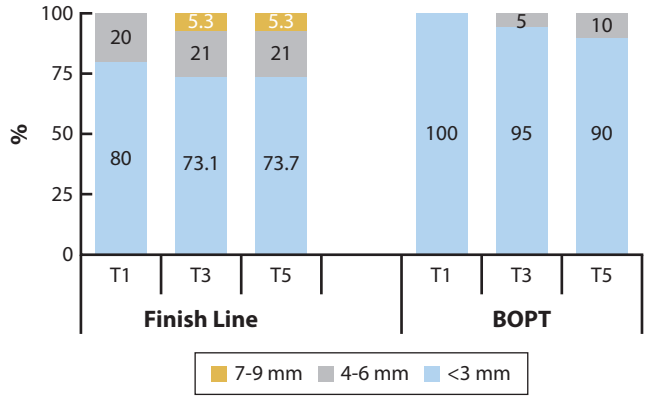


**Figure 5.** Change in probing depth with time. BOPT, biologically oriented preparation technique.

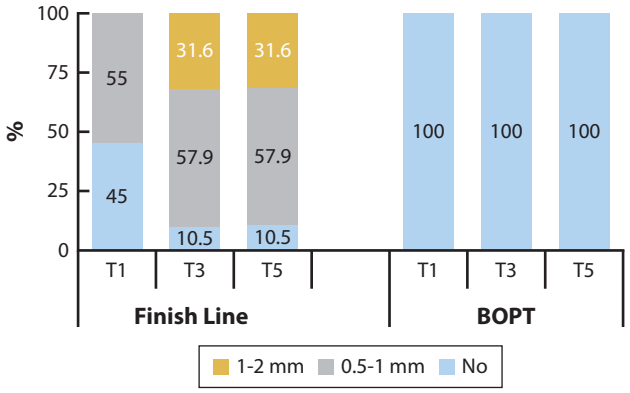


**Figure 6.** Change in marginal stability with time. BOPT, biologically oriented preparation technique.

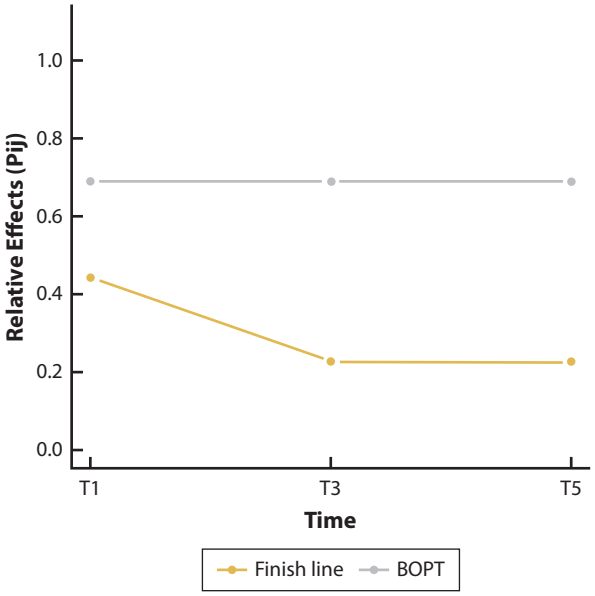


**Figure 7.** Probability that marginal stability value in biologically oriented preparation technique group is higher than in finish line group at each time period.

teeth prepared with traditional chamfered finish lines (control group). On the basis of the results of the present work, the null hypothesis (prostheses on teeth prepared with BOPT would have periodontal outcomes, clinical survival, and mechanical behavior similar to those of restorations on teeth prepared with traditional finish lines) was rejected because teeth prepared with BOPT presented better periodontal outcomes in terms of gingival inflammation than restorations on teeth prepared with conventional finish lines.

The authors are unaware of another study evaluating the long-term response of posterior FPDs using vertical BOPT. However, Paniz et al[6] conducted a similar study of zirconia crowns on anterior teeth prepared with the BOPT, comparing them with crowns on teeth prepared with finish line.

The clinical parameters evaluated in the present clinical trial were periodontal status (PI, GI, PD, and MS and/or recession) and mechanical and biological complications, these being parameters evaluated in similar published research.[6-10] Different factors affect the periodontal status of fixed prosthesis abutments, including the emergence profile of the restoration, the type of dental preparation (finish line, knife edge), the location of the margin (subgingival, supragingival), and the level of adjustment of the restoration. Restorations with excessive contour have been reported to be associated with increased gingival inflammation, PD, and bone loss because of plaque retention and increased difficulty in hygiene maintenance.[20] The prosthesis should be contoured to replicate the natural emergence of the tooth and not exceed the contour of the cementoenamel junction. Excessive contour is a common problem with conventional dental preparations if the clinician does not provide an adequately prepared tooth. The dental laboratory technician is then forced to create a restoration with excessive contour.[20,21] However, with the BOPT technique, the emergence of the cementoenamel junction is eliminated with the preparation, thus creating the necessary space for a restoration without excessive contour. The preparation geometry is intimately linked to the marginal adjustment of the subsequent restoration. Poor prosthetic fit has been reported to lead to plaque retention and inflammation, as well as subsequent bone loss.[21,22] Vertical preparations (knife edge or BOPT) have less likelihood of a poor fit than traditional horizontal finish lines.[23]

Tooth preparation with finish line had statistically similar PI values after 5 years (57.9% with index 1) in comparison with BOPT (35% with index 1). These results for teeth prepared with finish line are similar to those reported by Pelaez et al[7] but are higher than those reported by Håff et al[8] (13.8%) or Sailer et al[10] (8.3%). PI has been shown to be closely related to oral hygiene, so this parameter may not depend only on the type of restoration.

A higher percentage of participants (68.4%) with a GI of 1 (slight inflammation) was found in the control group

(with finish line) after 5 years (T5) in comparison with the study group (BOPT) ($P$=.007). Pelaez et al,[7] comparing zirconia and metal-ceramic crowns, reported similar results (70% GI 1 slight and 5% GI 2 moderate). Sailer et al[10] reported a smaller proportion of participants with gingival inflammation (32.8%), although they all presented an index of 2 (moderate inflammation).

PD tended to increase over the follow-up period in both groups ($P$=.065), although 26.4% of teeth prepared with finish line obtained PDs of more than 3 mm after 5 years compared with 10% of teeth with BOPT. These results were similar to those reported by Nicolaisen et al[12] but differ from those of Zenthöfer et al,[9] who reported PDs of less than 1 mm in 100% of the participants.

All of teeth prepared with BOPT remained stable without gingival recession, whereas 89.5% of teeth prepared with finish line presented increasing recession over the follow-up period (T1, T3, and T5). The occurrence of recession around teeth prepared with finish lines has been reported previously.[7,13,14]

The mechanical response of the restorations over the 5-year follow-up was similar in both groups, with 20% of mechanical complications in the control group and 15% in the BOPT group. The most frequent complication was chipping of the ceramic veneer, which affected 15% of restorations in the control group and 10% in the BOPT group. Similar results have been reported previously with 10% to 20% of restorations affected by these complications.[7,9,11,15] However, some studies report higher rates, reaching chipping rates of 30% to 40%.[12,16,17] An important limitation of this study was not having a longer follow-up time and a larger sample.

## CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. The survival rate of posterior zirconia FPDs placed on teeth prepared with a finish line was 90% to 95%.
2. The mechanical response of posterior zirconia FPDs on teeth prepared with finish line or BOPT was similar.
3. The GI and PDs were similar in both groups over a 5-year follow-up period.
4. Gingival inflammation was more prevalent among teeth prepared with a finish line than teeth prepared with the BOPT over a 5-year follow-up period.
5. Gingival margins remained stable around teeth prepared with the BOPT, with no recession over a 5-year follow-up period.

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