



ORIGINAL ARTICLE

The effect of biologically oriented and subgingival horizontal preparation techniques on periodontal health: A double-blind randomized controlled clinical trial



Alkhedhairi Mohammad ^a, Shebin Abraham ^b, Alarami Nada ^{c,*}

^a Consultant Restorative Dentist, Department of Restorative Dentistry, Qassim Regional Dental Centre, Saudi Arabia

^b Specialist Prosthodontic Dentist, Department of Prosthetic Dentistry, Qassim Regional Dental Centre, Saudi Arabia

^c Specialist Restorative Dentist, Department of Restorative Dentistry, Qassim Regional Dental Centre, Saudi Arabia

Received 14 February 2023; revised 11 June 2023; accepted 12 June 2023

Available online 17 June 2023

KEYWORDS

BOPT;
Split-mouth model;
Periodontal health;
Margins;
Crown

Abstract *Purpose:* The aim of this study was to investigate and compare the influence of subgingival horizontal preparation technique (SHPT) and biological oriented preparation technique (BOPT) on periodontal health at a split-mouth model.

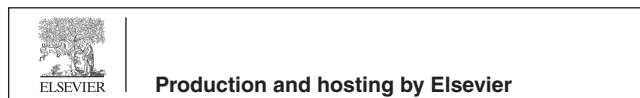
Methods: The sample of 100 patients was divided into two groups using a split-mouth study design; each patient had received two crowns with SHPT and BOPT respectively. The teeth were randomly allocated for the preparation techniques. All prepared teeth were restored with fabricated zirconium cores and ceramic layering. Temporary crowns were delivered after taking an impression and patients were recalled for the final cementation of the crowns. After that, follow-up recalls were set at one month, 3 months, 6 months, one year, and two years to record the following clinical parameters; plaque index, probing depth, bleeding on probing, clinical attachment level and patients' satisfaction with treatment.

Results: SHPT had significantly lower plaque and inflammation index at baseline, which increased significantly at 3 months and 2 years' follow-up compared to BOPT. Patients' satisfaction was significantly higher with SHPT at baseline, and it is reduced significantly at 6 months and two years follow-up ($P < 0.001$). The probing depth was significantly higher in BOPT at baseline and 3 months and decreased significantly at 6 months, 1 year, and 2 years' follow-up.

* Corresponding author at: Department of Restorative Dentistry, Qassim Regional Dental Centre, Saudi Arabia.

E-mail address: alaraminada@gmail.com (A. Nada).

Peer review under responsibility of King Saud University. Production and hosting by Elsevier.



Conclusion: BOPT is a favorable technique with a full crown or veneer, presenting good marginal stability and periodontal behavior.

© 2023 The Authors. Production and hosting by Elsevier B.V. on behalf of King Saud University This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

The regenerative capacity of hard tooth tissues is limited, necessitating the use of various restorative materials to replace congenitally deficient or lost tissues caused by factors such as caries, trauma, or wear (Serra-Pastor et al., 2019). The primary goal of tooth preparation is to minimize biologic impairment and preserve postoperative vitality, sensitivity, and long-term prognosis (Serra-Pastor et al., 2019). In fixed prosthodontics, maintaining the health and aesthetic stability of the gingival margin poses significant clinical challenges (Serra-Pastor et al., 2019; Walton, 2002, 2003). Typically, clinicians establish a finish line on the tooth to support the prosthetic restoration (Orkin et al., 1987; Lanning et al., 2003). Two main techniques for crown and veneer preparations are the horizontal technique and the more recent vertical technique (Shillingburg et al., 2003; Loi and Di Felice, 2013).

Traditionally, the Subgingival Horizontal Preparation Technique (SHPT) has been widely used, but it has been associated with complications such as gingival recession (Loi and Di Felice, 2013; Podhorsky et al., 2015; Moretti et al., 2011; Tsitrou et al., 2007; Silness, 1970). In contrast, the Biologically Oriented Preparation Technique (BOPT), introduced by Loi and Di Felice (2013), is considered less invasive, more aesthetic, and promotes a stable soft tissue profile near the prosthesis/tissue interface. Several studies support the influence of SHPT on periodontal health, while the vertical BOPT technique is considered more conservative and facilitates impression-taking due to its finish area rather than a defined finishing line, which improves marginal fit (Patroni et al., 2010; Poggio et al., 2012; Schmitz et al., 2017). However, there is a lack of sufficient scientific evidence to fully support the BOPT technique, highlighting the need for longitudinal clinical trials (Patroni et al., 2010; Poggio et al., 2012; Schmitz et al., 2017). To address this gap, a prospective randomized clinical trial was conducted at the Qassim Regional Dental Centre to investigate the influence of SHPT and BOPT techniques. The purpose of this study was to assess and compare the influence of the SHPT and the BOPT on periodontal health and the stability of treatment outcomes at a split-mouth model.

2. Materials and methods

This clinical trial was approved by the regional research ethics committee of the National Committees of Bio and medical ethics (NCBE) (Registration Number: H-04-Q-001). It was registered in the General Directorate of Health Affairs, Al-Qassim region, and followed the CONSORT statement (Needleman et al., 2008). All the patients gave their informed consent to take part in the trial and signed an informed consent form.

A sample of 100 patients (43 male and 57 female) was selected from individuals visiting the restorative department of Al Qassim Regional Centre in Saudi Arabia. The patients

included in the study met specific inclusion criteria: they needed at least two crowns for either aesthetic purposes or to replace missing teeth. Only adult patients aged 18 years and above were included, and they provided informed consent for their participation. Patients with subgingival restorations and compromised apical tissue were excluded from the study. Additionally, individuals who smoked, had uncontrolled para-functional habits, severe systemic diseases, or were pregnant were also excluded. Before the commencement of the study, all patients underwent conventional oral hygiene procedures performed by a dental hygienist. Baseline periodontal scores were evaluated by a periodontist at both the selected sites. This evaluation aimed to assess the periodontal health of the patients and provide a baseline measurement for comparison throughout the study.

2.1. Study design

In this double-blinded study, the evaluator (periodontist), the patient, and the statistician were unaware of the sites in the patient's mouth assigned to the respective preparation technique. The tooth preparation sites for the 100 study subjects were assigned using a simple randomization technique in which a coin toss was performed for each patient before the commencement of the procedure, and the randomly assigned sites were communicated to the prosthodontist who was going to prepare the teeth. The dental preparation, provisionalization, and laboratory stages of this investigation were carried out in accordance with the simplified BOPT criteria previously published (Agustín-Panadero and Solá-Ruiz, 2015) and all procedures were carried out by the same prosthodontist (SA) who is a specialist and well trained in BOPT technique.

2.2. Clinical and technical procedures

2.2.1. Horizontal preparation technique (SHPT)

A classic preparation with a 0.8 mm initial depth and a 1 mm axial and 1.5 mm incisal final depth was performed for the teeth. The chamfer diamond burs with a grit size of 151 µm (TR13 Mani Diaburs) were used for the initial preparation, while a grit size of 25 µm (TR 25EF Mani diaburs) was used for the finishing procedures.

2.2.2. Biologically oriented preparation technique (BOPT)

The BOPT, as described by Loi and Di Felice (2013), was employed in this study. The BOPT technique consists of seven phases, which were followed during the preparation process. In phase 1, the interdental areas were reduced using a coarse grit 200µm flame-shaped drill from the manufacturer (FG826/012C). This step aimed to create space between the teeth. Phase 2 involved the incisal reduction of 2 mm using a large coarse flame drill (FG826/016C). This reduction was performed to achieve the desired incisal edge dimension. In phase 3, the axial walls were prepared in the occlusal and gingival

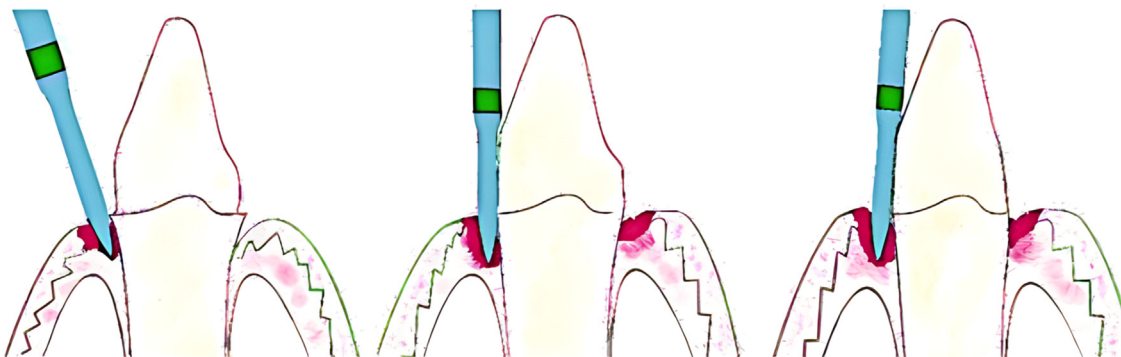


Fig. 1 BOPT preparation steps (a) The bur is first introduced with an angle of 10–15 with respect to the dental axis (tip facing the tooth); (b), the bur is introduced parallel to the dental axis; and (c), the bur is introduced with an angle of 3–6 with regard to the dental axis.

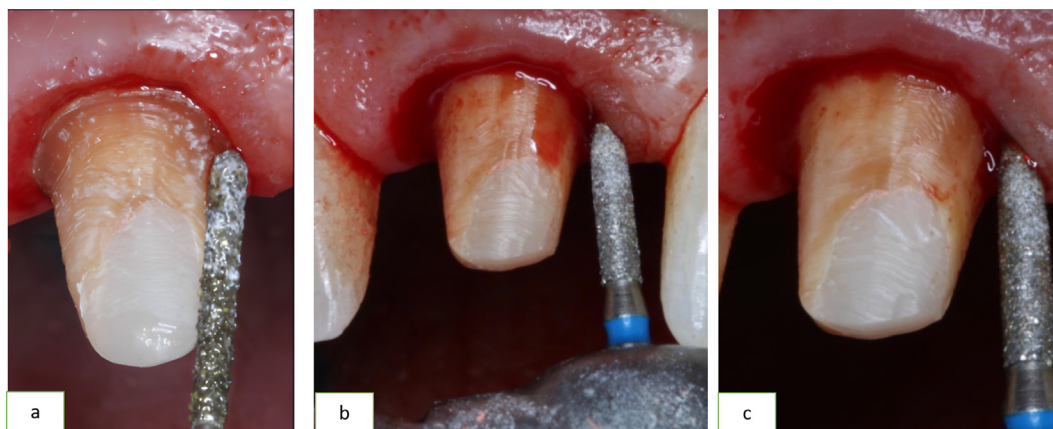


Fig. 2 (a) Tooth with a SHPT preparation. (b) and (c) tooth being prepared with the BOPT.



Fig. 3 Occlusal view of split mouth preparation using SHPT (left) and BOPT (right).



Fig. 4 Provisional restorations the chairside using temporary composite material.

thirds. The occlusal third was reduced at a 45-degree inclination from the axis of the teeth. Moving on to phase 4, the vestibular preparation in the gingival third of the axial wall was carried out. Care was taken to keep the preparation supragingival, ensuring that it did not come into contact with the gingiva. Phase 5 involved the intrasulcular preparation using a flame-shaped bur provided in the kit (FG826/012C, FG826/016C). The bur was inserted into the sulcus in an

oblique direction, avoiding vertical placement to prevent the formation of grooves or indentations. Gradually, the bur was straightened to achieve axial parallelism in the preparation (Fig. 1). Finally, the preparation was finished using polishing burs. The clinical preparations for both the BOPT and the comparison technique were illustrated in Fig. 2, and the final preparations were shown in Fig. 3.

Impressions were taken with a wash-step Imprint materials made of a-silicon or polyether (Express, 3M ESPE; Affinis,

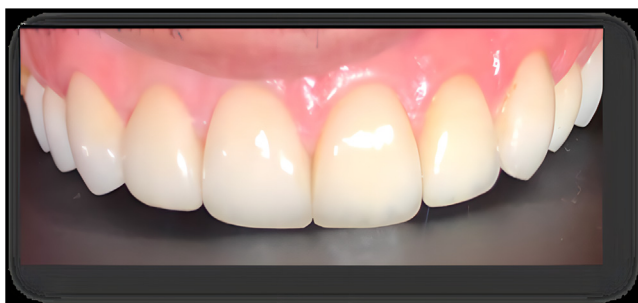


Fig. 5 Final prostheses.

Coltene Whaledent; Impregum Penta, 3M ESPE). Provisional restorations were done on the chairside using temporary composite materials and glued with temporary luting agents (Temp Bond Clear, Kerr Dental, Orange, CA, USA) (Fig. 4). With respect to the biological width, the temporary prosthesis establishes a new cement-enamel-prosthetic connection in the gingival sulcus at a depth of 0.5–0.8 mm. The removal of interim restorations was delayed until the soft tissues had fully matured, which took up to 12 weeks.

The final restorations (Fig. 5) were made with a zirconia core. (Zirkonzahn, South Tyrol, Italy) and feldspathic ceramic covering (Vita VM9, Vita Zahnfabrik, Bad Säckingen, Germany) applied in layers with a stratification technique. cementation was performed with glass ionomer cement (Ketac Cem, 3M Espe).

2.3. Clinical assessment & follow-up

A procedure was created whereby patients were evaluated 3 Months after final cementation (M1), 6 Months (M2), one year (T1), and two years (T2). The patients continued to attend their regular follow-up appointments, independently of appointments for review of prosthetic treatment and periodontal health status (periodontal revisions and maintenance, as

well as oral hygiene). The following parameters were evaluated: bleeding when probing, presence or absence of plaque by visual inspection with a conventional dental exploratory probe (Hu-Friedy EPD6578XTS, Hu-Friedy, Chicago, IL, USA); periodontal probing depth around each tooth using a millimeter-calibrated periodontal probe (Hu-Friedy PCPUNC156); biological or mechanical complications; and a visual analogue scale (VAS) to measure the patient's level of satisfaction. There was no attrition or drop in all patients.

2.4. Statistical analysis

IBM SPSS Statistics for Windows, version 26 was used to analyze the data (IBM Corp., Armonk, NY, USA). The Chi-square test was used to determine and detect the differences in plaque and inflammation presence, as well as patients' satisfaction between two tooth preparation techniques at different follow-up times. Cochran's Q test was used to detect the differences in patients' satisfaction, plaque, and inflammation presence at various follow-up times for both preparation techniques separately. To detect the significant differences between follow-up time intervals multiple comparisons of McNemar's test with Bonferroni correction were applied. Non-parametric Wilcoxon test was used to detect the differences in probing depth between the two preparation techniques at different follow-up times. Multiple comparison Wilcoxon tests with Bonferroni correction were performed to detect the differences between follow-up times for each preparation technique individually.

3. Results

3.1. Influence of preparation techniques on periodontal health

The Chi-square test showed there were significant differences in plaque and inflammation presence between two preparation techniques at baseline, 3 months, one year and two years ($P < 0.001$). While no significant difference was detected at

Table 1 Comparison in frequencies of Plaque and inflammation presence, patients' satisfaction and probing depth between two preparation techniques at different follow up times.

Variables	Time	SHPT		BOPT		P value
		Yes	No	Yes	No	
Plaque and inflammation presence	Baseline	0	51 (100%)	16 (41.4)	35(68.6)	< 0.001*
	3 months	21(41.2%)	30 (58.8%)	51(100%)	0	< 0.001*
	6 months	35 (68.6%)	16 (31.4%)	35(68.6%)	16(31.4%)	1
	1 year	51 (100%)	0	0	51 (100%)	< 0.001*
	2 years	45 (88.2%)	6 (11.8%)	9 (17.6%)	42(82.4%)	< 0.001*
Patient satisfaction	Baseline	51 (100%)	0	14 (27.5%)	37(72.5%)	< 0.001*
	3 months	30(58.8%)	21 (41.2%)	30(58.8%)	21 (41.2%)	1
	6 months	0	51(100%)	51 (100%)	0	< 0.001*
	1 year	0	51(100%)	51 (100%)	0	< 0.001*
	2 years	6(11.8%)	45(88.2%)	45(88.2%)	6 (11.8%)	< 0.001*
Probing depth		Mean (SD)		Mean (SD)		
	Baseline	2.3 (0.47)		2.6 (0.94)		< 0.001*
	3 months	2.3 (0.47)		3 (0)		< 0.001*
	6 months	3(0)		2.7 (0.47)		< 0.001*
	1 year	3.3 (0.47)		2 (0)		< 0.001*
	2 years	4.2 (1.03)		2.5(1.0)		< 0.001*

* Significant value is set at $p < 0.05$.

6 months ($p > 0.05$). The Chi-square test showed there was a significant difference in patients' satisfaction between two preparation techniques at baseline, 6 months, one year and two years follow up ($P < 0.001$). However, the Satisfaction of the patients was similar for both preparation techniques with no significant difference at 3 months ($P > 0.05$). Wilcoxon test showed there were significant differences in probing depth between two preparation techniques at baseline, 3 months, 6 months, 1 year, and 2 years. The probing depth was within the healthy measurement, however, SHPT resulted in unhealthy probing depth > 3 mm at 1- and 2-years' assessment (Table 1).

3.2. Success and stability of two different preparation techniques on periodontal health

There were significant differences in plaque and inflammation presence and patients' satisfaction among different follow-up times for each preparation technique ($p < 0.001$). For SHPT, the plaque and inflammation presence increased significantly ($p < 0.001$) over follow-up time till it reached 100 % at one year and it dropped to 88.2% at 2 years' follow-up time with no significant difference between 2 years and both 6 months and 1 year ($p > 0.05$).

For BOPT preparation, the plaque and inflammation presence increased significantly at 3 months ($p < 0.001$) and afterward, it reduced significantly at 6 months and it significantly completely vanished at 1 year ($p < 0.001$). Nevertheless, at 2 years the plaque and inflammation presence is increased significantly compared to 1 year but it is significantly lesser than that at 3 and 6 months. Regarding patients' satisfaction, there was a significant difference among follow-up time for each preparation technique ($p < 0.001$). Patients' satisfaction was decreased significantly ($p < 0.001$) from the baseline assessment and it significantly became 100% unsatisfied at 6 months and maintained up to 1 year. At 2 years' assessment the patients' satisfaction increased to 11.8% but it was not significant compared to 6 months and 1 year with SHPT. Conversely, Patients' satisfaction was increased significantly ($p < 0.001$) from baseline and it significantly became 100% satisfied at 6 months and maintained up to 1 year with BOPT. There was a non-significant decrease in patients' satisfaction (11.8%) at 2 years' follow-up compared to 6 months and 1 year for BOPT. For SHPT, there was no significant difference in probing depth between baseline and 3 months' assessment ($p > 0.05$). Then, the probing depth increased significantly ($p < 0.001$) and it reached a maximum mean of 4.2 mm at 2 years. In contrast, probing depth with BOPT increased significantly from baseline to 3 months ($p = 0.048$) and afterward, it reduced significantly at 6 months compared to 3 months' assessment ($p < 0.001$). There was no significant difference in probing depth between baseline and 6 months ($p > 0.05$). The probing depth is enhanced and reduced significantly at 1 year ($p < 0.001$). However, at 2 years' assessment, the probing depth is increased to 2.5 mm which was significant compared to the 1 year' assessment.

4. Discussion

Many clinical studies have described the differences between conventional and BOPT preparation techniques (Serra-Pastor et al., 2019, Loi and Di Felice, 2013, Agustín-

Panadero and Solá-Ruiz, 2015, Agustín-Panadero et al., 2018). However, there was no double-blind study with a split-mouth study design published previously. Thus, this study was planned as a double-blind randomized controlled with split-mouth design. The split-mouth randomized clinical trials have the advantage of removing most of the outcome variability among patients from the estimated intervention effect and have a potential increase in statistical power since each subject is its own control as well as it could also be better suited to define the patient preferences (Lesaffre et al., 2009). BOPT is a complicated technique that requires prior training by the dental technician, as there is a well-defined finishing line and the level of crown margins is determined based on the patients' teeth situation following a discussion between the dental technician together with the clinician. Before commencing the procedures, a careful esthetic and functional evaluation of the patient was performed. A prudent defined treatment plan and good communication between the clinician and the technician helped to maximize the efficiency of the treatment and the predictability of the esthetic outcome (Coachman and Calamita, 2012). In this study, oral hygiene was managed before the treatment and emphasized in each follow-up visit with oral hygiene instructions and professional scaling and this is in accordance with previous studies in the literature (Paniz et al., 2016, Pelaez et al., 2012). Different parameters for periodontal health were evaluated during the follow-up: plaque index, probing depth, bleeding on probing, and patients' satisfaction with treatment. These parameters have been assessed in other studies by Valderhaug and Birkeland (1976), Müller (1986), and Tanner et al. (2018). In the current study, an increase in probing depth (> 3 mm) was observed in SHPT at 2 years. This is in agreement with Tunner et al. (2018) who got higher rates of probing depth with a 23% of the sample with > 5 mm after 6 years. In BOPT, there is no increase in probing depth at 2 years and this is in accordance with the previous studies (Eliasson et al., 2007, Paniz et al., 2016, Serra-Pastor et al., 2019), in which periodontal status did not change over time. This could be attributed to the feather-edge finishing line used as it has a favorable effect on probing depth (Paniz et al., 2016). For BOPT the plaque and inflammation presence increased significantly at 3 months, it reduced significantly at 6 months and it significantly completely vanished at 1 year. In BOPT there is no discrepancy between the crown and finishing line so this reduces the plaque since there is no finishing line. This fact also helps to reduce plaque retention in this area. Serra et al reported only 20% of samples had plaque after 4 years (Serra-Pastor et al., 2019). Nevertheless, at 2 years the plaque and inflammation presence is increased significantly compared to 1 year but it is significantly lesser than that at 3 and 6 months. This is in agreement with previous studies that reported a higher plaque index of 60% and 28% respectively (Silness, 1970, Sjögren et al., 1999). Although the four-week waiting period in the provisional phase of the BOPT may be considered a disadvantage due to the prolonged treatment time, it serves an important purpose. This waiting period allows for gingival recovery, subsequent stability, and proper tissue adaptation to the new prosthesis morphology.

In terms of gingival stability, a study conducted by Agustín-Panadero et al. (2018) observed changes in gingival thickness around restorations placed on teeth prepared using the BOPT during long-term follow-up. The researchers found that the BOPT procedure led to gingival thickening, with a mean thick-

ening of 0.41 mm for crowns and 0.38 mm for fixed partial dentures (FPDs). Moreover, the study reported gingival margin stability in 100% of the samples. It is worth noting that the success of this technique relies on the patient's maintenance of good dental hygiene. When patients maintain proper oral care, the BOPT method can result in excellent periodontal tissue and gingival margin stability.

The recovery of tissues after vertical preparation proceeds as the same mechanisms of wound healing this is the physiological explanation of how there were increases in gingival thickness (Rodríguez et al., 2017). In the healing stage new blood vessels, fibroblasts, myofibroblasts are created of the granulation tissue to grow and fill the space caused by the rotary curettage. During the healing time there is a contraction of the myofibroblasts around the tooth appreciations to the conical dental preparation there is a migration of the soft tissues towards the coronal (from the area of the greater diameter (apical) to the area of the minor (coronal). In this stage, it has been described that tissue growth occurs due to a transduction mechanism (Serra-Pastor et al., 2019, Rodríguez et al., 2017, Chiquet et al., 2009). The connective tissue fibroblasts perceive mechanical stimuli such as lip pressure when speaking, chewing, and provisional pressure in their extracellular matrix; these stimuli are transformed into chemical information that encourages cell growth and proliferation (Serra-Pastor et al., 2019, Chiquet et al., 2009).

Patient satisfaction with restorative treatment was evaluated using a Visual Analog Scale (VAS) ranging from 0 to 100 in this study. The results showed a mean satisfaction rate of 100% after a 2-year for patients treated with the Biologically Oriented Preparation Technique (BOPT). Similarly, Paniz et al. (2016) conducted a study with a 6-month follow-up and reported high satisfaction rates of 96.5% for esthetics and 98% for function. Another study by Serra-Pastor et al. (2019) found that patients' satisfaction with restorative treatment was 80.73% after a 4-year.

BOPT has shown promise as a preferred technique in cases requiring retreatment with veneers or crowns, especially in situations involving gingival recession, particularly in the teeth zone. This technique has the ability to increase soft tissue thickness, achieve favorable esthetic outcomes, and promote the development of healthy and stable soft tissues, particularly during the first-year period. However, it is important to note that further clinical studies with longer durations are necessary to validate the findings of these clinical reports.

5. Conclusion

Notwithstanding the study's limitation, the BOPT preparation technique shows good periodontal behavior and stability compared to the SHPT.

CRedit authorship contribution statement

Alkhedhairi Mohammad: Conceptualization, Supervision. **Shebin Abraham:** Investigation, Methodology. **Alarami Nada:** Writing – original draft, Writing – review & editing.

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.

References

- Agustín-Panadero, R., Serra-Pastor, B., Fons-Font, A., et al, 2018. Prospective clinical study of zirconia full-coverage restorations on teeth prepared with biologically oriented preparation technique on gingival health: results after two-year follow-up. *Oper. Dent.* 43, 482–487.
- Agustín-Panadero, R., Solá-Ruiz, M.F., 2015. Vertical preparation for fixed prosthesis rehabilitation in the anterior sector. *J. Prosthet. Dent.* 114, 474–478.
- Chiquet, M., Gelman, L., Lutz, R., et al, 2009. From mechanotransduction to extracellular matrix gene expression in fibroblasts. *BBA* 1793, 911–920.
- Coachman, C., Calamita, M., 2012. Digital Smile Design: A tool for treatment planning and communication in esthetic dentistry. *QDT*, 103–111.
- Eliasson, A., Arnelund, C.F., Johansson, A., 2007. A clinical evaluation of cobalt-chromium metal-ceramic fixed partial dentures and crowns: a three- to seven-year retrospective study. *J. Prosthet. Dent.* 98, 6–16.
- Lanning, S.K., Waldrop, T.C., Gunsolley, J.C., et al, 2003. Surgical crown lengthening: evaluation of the biological width. *J. Periodontol.* 74, 468–474.
- Lesaffre, E., Philstrom, B., Needleman, I., et al, 2009. The design and analysis of split-mouth studies: what statisticians and clinicians should know. *Stat. Med.* 28, 3470–3482.
- Loi, I., Di Felice, A., 2013. Biologically oriented preparation technique (BOPT): a new approach for prosthetic restoration of periodontically healthy teeth. *Eur. J. Esthet. Dent.* 8, 10–23.
- Moretti, L.A., Barros, R.R., Costa, P.P., et al, 2011. The influence of restorations and prosthetic crowns finishing lines on inflammatory levels after non-surgical periodontal therapy. *J. Int. Acad. Periodontol.* 13, 65–72.
- Müller, H.P., 1986. The effect of artificial crown margins at the gingival margin on the periodontal conditions in a group of periodontally supervised patients treated with fixed bridges. *J. Clin. Periodontol.* 13, 97–102.
- Needleman, I., Worthington, H., Moher, D., et al, 2008. Improving the completeness and transparency of reports of randomized trials in oral health: The CONSORT Statement. *Am. J. Dent.* 21, 7–12.
- Orkin, D.A., Reddy, J., Bradshaw, D., 1987. The relationship of the position of crown margins to gingival health. *J. Prosthet. Dent.* 57, 421–424.
- Paniz, G., Nart, J., Gobbato, L., et al, 2016. Periodontal response to two different subgingival restorative margin designs: a 12-month randomized clinical trial. *Clin. Oral Invest.* 20, 1243–1252.
- Patroni, S., Chiodera, G., Caliceti, C., et al, 2010. CAD/CAM technology and zirconium oxide with feather-edge marginal preparation. *Eur. J. Esthet. Dent.* 5, 78–100.
- Pelaez, J., Cogolludo, P.G., Serrano, B., et al, 2012. A four-year prospective clinical evaluation of zirconia and metal-ceramic posterior fixed dental prostheses. *Int. J. Prosthodont.* 25, 451–458.
- Podhorsky, A., Rehmann, P., Wöstmann, B., 2015. Tooth preparation for full-coverage restorations—a literature review. *Clin. Oral Invest.* 19, 959–968.
- Poggio, C.E., Dosoli, R., Ercoli, C., 2012. A retrospective analysis of 102 zirconia single crowns with knife-edge margins. *J. Prosthet. Dent.* 107, 316–321.

- Rodríguez, X., Vela, X., Segala, M., 2017. Cutting-edge implant rehabilitation design and management: a tapered abutment approach. *Compend. Contin. Educ. Dent.* 38, 482–491.
- Schmitz, J.H., Cortellini, D., Granata, S., et al, 2017. Monolithic lithium disilicate complete single crowns with feather-edge preparation design in the posterior region: a multicentric retrospective study up to 12 years. *Quintessence Int. (Berl.)* 20, 601–608.
- Serra-Pastor, B.I., Loi, A.-F., et al, 2019. Periodontal and prosthetic outcomes on teeth prepared with biologically oriented preparation technique: a 4-year follow-up prospective clinical study. *J. Prosthodont. Res.* 63, 415–420.
- Shillingburg Jr, H.T., Hobo, S., Fisher, D.W., 2003. Preparation design and margin distortion in porcelain-fused-to-metal restorations. *J. Prosthet. Dent.* 89, 527–532.
- Silness, J., 1970. Periodontal conditions in patients treated with dental bridges. 3. The relationship between the location of the crown margin and the peri-odontal condition. *J. Periodontal Res.* 5, 225–229.
- Sjögren, G., Lantto, R., Tillberg, A., 1999. Clinical evaluation of all-ceramic crowns (Dicor) in general practice. *J. Prosthet. Dent.* 81, 277–284.
- Tanner, J., Niemi, H., Ojala, E., et al, 2018. Zirconia single crowns and multiple-unit FDPs—an up to 8-year retrospective clinical study. *J. Dent.* 79, 96–101.
- Tsitrou, E.A., Northeast, S.E., van Noort, R., 2007. Evaluation of the marginal fit of three margin designs of resin composite crowns using CAD/CAM. *J. Dent.* 35, 68–73.
- Valderhaug, J., Birkeland, J.M., 1976. Periodontal conditions in patients 5 years following insertion of fixed prostheses: pocket depth and loss of attachment. *J. Oral Rehabil.* 3, 237–243.
- Walton, T.R., 2002. An up to 15-year longitudinal study of 515 metal-ceramic FPDs: part 1. Outcome. *Int. J. Prosthodont.* 15, 439–445.
- Walton, T.R., 2003. An up to 15-year longitudinal study of 515 metal-ceramic FPDs: part 2. Modes of failure and influence of various clinical characteristics. *Int. J. Prosthodont.* 16, 177–182.