

Vertical Teeth Preparation: A Comprehensive Systematic Review of Patient Outcomes and Clinical Complications



Mohammed M. Al Moaleem^{1,*} 

¹Department of Prosthetic Dental Science, College of Dentistry, Jazan University, Jazan 45142, Saudi Arabia

Abstract:

Objective: This study aimed to evaluate the influence of vertical tooth preparation techniques on tooth-supported fixed restorations, with specific attention to survival and success rates, periodontal outcome, and clinical complications.

Methods: A comprehensive literature search of related randomized controlled trials, prospective/retrospective cohort studies, and clinical trials was accomplished across electronic databases (MEDLINE/PubMed, ScienceDirect, Scopus, and Cochrane Central Library) up to March 2025. Primary outcomes included survival and success rates of tooth-supported fixed prostheses, whereas secondary outcomes encompassed periodontal health indices (bleeding, plaque, and recession), patient satisfaction, and mechanical/biological complications. Studies with a minimum follow-up period of six months were considered. Two reviewers independently conducted studies collection, data extraction, and quality assessment.

Results: This systematic review (12 studies, 2012–2024) evaluated patient outcomes and clinical complications of vertical preparation. Survival rates ranged from 96.5% to 100% across preparation types [biologically oriented preparation technique (BOPT), feather-edge, and chamfer]. Success rates (78%–100%) and periodontal outcomes also varied: plaque indices (57.9%–82% score 0), pocket depths (≤ 3 mm in 80%–97.9% cases), and bleeding on probing (8.4%–55.5%) showed no clear preference for any preparation method. BOPT and feather-edge correlated with lower bleeding rates than chamfer. Mechanical complications (ceramic chipping: 1.4%–15%) were more frequent than biological issues (2%–2.7%). Survival rates and patient satisfaction (80%–100%) were high.

Discussion: The findings of this systematic review supported the use of vertical techniques as a reliable option for fixed prostheses, balancing structural preservation and long-term success, making them a viable, tissue-preserving choice when indicated.

Conclusion: Vertical preparation techniques demonstrated favorable periodontal outcomes, high survival rates, and high patient satisfaction. Manageable mechanical and biological complications supported their viability for tooth-supported prostheses.

Keywords: Vertical preparation, BOPT, Periodontal health, Patient satisfaction.

© 2025 The Author(s). Published by Bentham Open.

This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International Public License (CC-BY 4.0), a copy of which is available at: <https://creativecommons.org/licenses/by/4.0/legalcode>. This license permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

*Address correspondence to this author at the Department of Prosthetic Dental Science, College of Dentistry, Jazan University, Jazan 45142, Saudi Arabia; E-mail: malmoaleem@jazanu.edu.sa

Cite as: Al Moaleem M. Vertical Teeth Preparation: A Comprehensive Systematic Review of Patient Outcomes and Clinical Complications. Open Dent J, 2025; 19: e18742106414012. <http://dx.doi.org/10.2174/0118742106414012250910135948>



Received: May 20, 2025
Revised: July 02, 2025
Accepted: July 08, 2025
Published: September 12, 2025



Send Orders for Reprints to
reprints@benthamscience.net

1. INTRODUCTION

Tooth preparation involves the mechanical modification of diseased and/or healthy tooth structures (enamel, dentin, and cementum) to restore aesthetics, function, and structural integrity [1]. The primary challenge during tooth preparation is balancing aesthetic outcomes with minimally invasive procedures that preserve tooth structure, which enhances crack resistance, stress distribution, and long-term durability [2]. Traditional methods for preparing teeth for fixed dental prostheses, such as horizontal designs (*e.g.*, chamfer or shoulder margins), often necessitate substantial tissue removal. These risks weaken tooth integrity, may trigger gingival margin displacement, and potentially compromise long-term outcomes due to various factors, such as insufficient keratinized tissue, procedural trauma, or chronic inflammation from prosthetic inaccuracies [3]. The designs of preparations as vertical (red bur) and horizontal (blue bur) for anterior teeth are shown in Fig. (1A), while those for posterior teeth are presented in Fig. (1B).

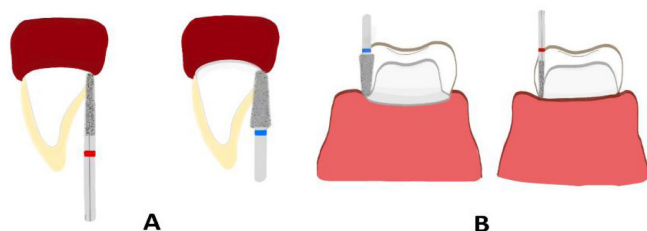


Fig. (1). Designs of vertical and horizontal preparations for anterior teeth (A) and posterior teeth (B).

By contrast, vertical preparation techniques, including feather-edge designs and the BOPT, have emerged as conservative alternatives [4]. These methods minimize structural reduction while addressing aesthetic and biological challenges [5]. Vertical preparations are particularly advantageous for patients with thick or medium periodontal biotypes, periodontal attachment loss, or probing depths exceeding 2 mm, where horizontal approaches could exacerbate tissue loss [5, 6]. Vertical preparations are also effective for managing subgingival caries and adjusting gingival morphology by situating crown margins beneath the gingival level [7]. This strategy is especially beneficial for teeth with insufficient clinical crowns, such as lower anterior incisors, where conventional horizontal reduction could lead to excessive tissue removal [8].

BOPT, a subset of vertical techniques, eliminates defined finish lines through vertical milling and replaces the natural crown emergence profile at the cemento-enamel junction with a prosthetic-defined contour [9]. This process is complemented by rotary curettage of the gingival sulcus, adapted from periodontal protocols [10]. In periodontally healthy patients, this technique removes sulcular epithelium and prompts localized bleeding and subsequent connective tissue reorganization under provisional restorations [9]. The resulting prosthetic cemento-enamel junction mimics natural anatomy and aligns crown

margins 0.5–1 mm from the gingival margin to prioritize tissue stability and aesthetic integration [11, 12].

Studies comparing vertical and horizontal techniques have revealed vertical preparation to achieve similar or superior outcomes in periodontal health and clinical performance [13]. Vertical preparation of maxillary and mandibular incisor teeth for full-coverage restorations exhibited impressive longevity with survival rates exceeding 48–72 months, alongside optimal periodontal outcomes, such as stable gingival margins, enhanced tissue thickness, and minimal inflammation [14, 15]. A research study on posterior vertical preparation restorations also demonstrated enhanced marginal stability, reduced plaque accumulation, lower gingival scores, and fewer deep periodontal pockets over 60 months compared to horizontal methods [11]. While complication rates are comparable, vertical preparation cases often show better clinical responses, which positions it as another choice [11].

In addition to the type of preparation, the material used influences the behavior of the surrounding soft tissues. Long-term evaluations of minimally invasive zirconia crowns prepared with vertical preparation demonstrated reliability, no failures or complications over 36 months, and a high survival rate and patient satisfaction [4]. Other studies have exhibited ceramic restorations to achieve vertical marginal gaps falling within the clinically acceptable range [16, 17]. Vertical preparation techniques effectively balance aesthetic and structural preservation, and 84 months of studies have shown stable marginal integrity and favorable esthetic outcomes, minimizing tooth structure removal while delivering durable results [18].

Despite promising evidence, systematic reviews evaluating the vertical preparation efficacy and its influence on periodontal health remain limited. A recent meta-analysis revealed no remarkable differences in periodontal outcomes (*e.g.*, plaque, recession, and restoration success) between BOPT and horizontal techniques [1]. This study aimed to provide a systematic review and evaluation of the clinical performance, periodontal outcomes, patient satisfaction, and clinical complications of vertical preparation as a routine alternative to conventional horizontal preparations in clinical practice, particularly in cases requiring structural preservation, aesthetic integration, and periodontal stability.

2. MATERIALS AND METHODS

2.1. Protocol Registration

This systematic review protocol was developed and registered in PROSPERO (CRD420251025721) in 2025. Its progress has been consistently tracked and reported in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [20]. The procedure and method quality of the present systematic review was evaluated utilizing the AMSTAR 2 instrument [21].

2.2. Search Strategy

An electronic search was accomplished in January 2025 and updated in March 2025. The inclusion of studies

was limited to those published in English, as determined by two independent reviewers (MMA and TAB). The utilized databases included MEDLINE via PubMed (National Library of Medicine), ScienceDirect, Scopus, and Cochrane Central Library (clinicaltrials.gov, US National Library of Medicine). The published gray literature and the bibliography of full-text papers were manually searched to obtain any further articles eligible for inclusion. Boolean operators 'AND' and 'OR' were employed to combine the keywords and generate the search strategy. Table 1 displays the keywords and the complete exploration plan.

Table 1. Search strategy and MeSH/keywords used [19].

Cochrane Central Library	Biological oriented preparation technique OR vertical preparation technique, OR feather-edge, chamfer, knife-edge finishing line in title, abstract, keyword, AND crown or fixed prosthesis
PubMed	(biological oriented) OR (vertical) OR (feather-edge) OR (chamfer) OR (knife edge) OR (finishing line) AND (preparation technique) AND (crown or fixed partial denture)
Scopus	(biological oriented) OR (vertical) OR (feather-edge) OR (finishing line) AND (preparation technique) AND (fixed prosthesis)
ScienceDirect	"Biological oriented preparation technique" OR "vertical preparation technique" OR "feather-edge finishing line" OR "knife edge finishing line" OR "chamfer finishing line"

2.3. Eligibility Criteria

Clinical studies, including randomized controlled trials, prospective clinical trials, and retrospective cohort studies, were covered in this systematic review. The inclusion criteria were as follows: participation: tooth-supported fixed prosthesis, intervention: BOPT or vertical preparation for abutment, comparison: horizontal preparation technique or baseline (non-preparation), and outcome: a minimum of 6 months. Periodontal tissue health status (PDI) was measured as follows: bleeding index, plaque index (PI), gingival recession (GR), patient satisfaction, success or survival rates, and biological and mechanical complications. Non-randomized controlled trials and those not relevant to the review question (periodontal outcome, patient satisfaction, clinical complications), studies with low-quality methodological flow, and studies not published in the English language were excluded from the study. Case reports, case series, research studies without a control group, published papers of earlier prepared teeth, and studies without periodontal health outcomes were also excluded.

2.4. Study Selection

Titles, abstracts, and full-text assessments were performed by two independent reviewers (MMA and TAB). Disagreements between the two assessors were resolved through discussion and agreement, after which the data were extracted into a designed table.

2.5. Data Extraction

Relevant data were extracted according to the Cochrane Handbook for Systematic Reviews of Interventions guidelines [22,23], encompassing the characteristics of published papers, including intervention and comparator, periodontal health clinical outcome measures, and biological and mechanical complications.

2.6. Quality Assessment and Risk of Bias

The quality was estimated utilizing the reviewed Cochrane Risk of Bias Tool for Clinical Randomized Trials (RoB 2.0). The domains calculated and judged were randomization, deviations from the intended interventions, missing outcome data, measurement of the documented result, and overall bias. The nominated published papers were categorized into some or medium concerns and low or high risk of bias [24]. The prospective clinical trials studies were judged utilizing the Newcastle-Ottawa Quality Assessment Scale for cohort studies [25]. Percentages (%) for PI, gingival index (GI), GR, survival, success rate, and biological and mechanical complications were calculated to analyze the outcome of interventions through direct comparison.

3. RESULT

3.1. Study Selection

The PRISMA flow chart of the inclusion, selection, and exclusion criteria for the papers is presented in Fig. (2). The search provided 388 hits; 362 were duplicates, and 19 research studies were related, relevant, and obtained in full-text. Full-paper screening omitted seven references because the implant abutment utilized was not specified. Eventually, 12 studies [4, 10-12, 14, 15, 18, 26-30] were included in the present systematic review.

3.2. Characteristics of Included Studies

Table 2 presents the characteristics of the included studies, including the author (s), publication year, study design, finish line type, material used, and follow-up periods in months. The results covered periodontal outcome (PI, GI, PD, and BoP), patient-related variables (as percentage of survival rate, success rate, and patient satisfaction), and complications (mechanical and biological).

Only 12 papers were included in the current systematic review. The first paper was published in 2012 [30], whereas the last one was published in 2024 [18] with 7 prospective clinical trials [4, 10-12, 14, 15, 26, 28], 3 randomized clinical trials [27, 29], and 2 retrospective cohort studies [18, 30]. In relation to the finish line assessed, the highest type was BOPT, assessed in 6 studies [10, 11, 14, 15, 26, 28], followed by the feather or knife-edge, as well as chamfer finish lines types that were assessed in 4 studies each [12, 26, 27, 29, 30]. Vertical preparation was mentioned in 2 studies only [4, 18]. Most of the studies used monolithic zirconia as a prosthetic material or zirconia core covered by feldspathic ceramic, and one study used PFM [18].

A total of 1,033 cemented prostheses, as a single crown or as a part of fixed prosthodontics (FPD), were observed, and the highest numbers per study were 198 and 196, cemented on all types of teeth (incisors, pre-

molars, and molars) [12, 29]. The minimum follow-up period was 6 months [12], whereas the longest follow-up period was 84 months [18].

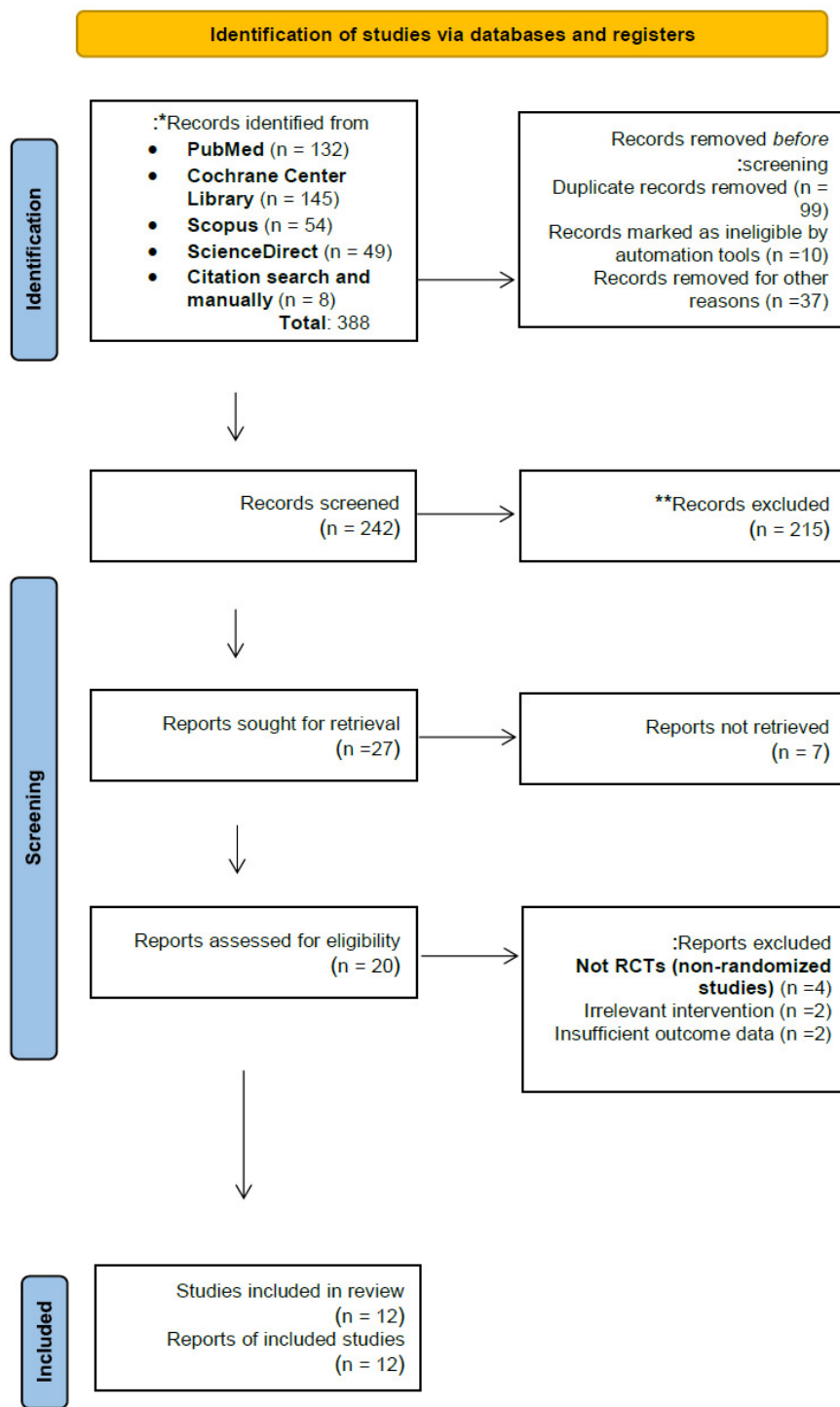


Fig. (2). PRISMA flow diagram representing the selection, inclusion, and exclusion of studies at each screening step.

Table 2. Characteristics of the included studies.

Author, Year, Type of Study/Refs.	Finish Line Type	Tooth (restoration and material type)	Follow-up Period	Survival/success Rate	Periodontal Outcome	Patient Satisfaction	Mechanical/biological Complications
Gonzalez-Bonilla <i>et al.</i> , 2024/retrospective cohort study [18]	Vertical preparation	50 molars and premolars (25 zirconia crowns and 25 PFM crowns)	60 and 84 months	NM/zirconia 100% and PFM 86%	PI: 82% score 0, 6% score 1, and 12% having 2 GI: 50% index of 0; 28% index of 1; 20% index of 2 PD: 80% ≤ 3mm - 20% ↔3 and 5 mm	NM	4% chipping of the PFM/NM
Serra-Pastor <i>et al.</i> , 2023/prospective clinical trial [15]	BOPT	70 teeth (25 FPDs)	12, 24, 36, 48, 60, and 72 months	100%/NM	A 100% significant increase in gingival thickness and a stable gingival margin	NM	NM
Kasem <i>et al.</i> , 2023/clinical study [4]	Vertical preparation	40 premolars/20 zirconia and 20 ZL crowns	6, 12, 18, 24, and 36 months	100%/NM	40% scored as 1 and 60% scored as 2	100%	No mechanical complications/NM
Talaat <i>et al.</i> , 2022/clinical study [26]	Chamfer	44 teeth/zirconia crowns	6, 9, and 12 months	NM/NM	40.9% score 0 and 59.1% score 1 in gingival inflammation	NM	NM/NM
	BOPT				36.4% score 0 and 63.6% score 1 in gingival inflammation		
Serra-Pastor <i>et al.</i> , 2021/prospective clinical study [10]	BOPT	74 incisors, canines, and premolars/zirconia core and feldspathic ceramic covering	12, 24, 36, 48, 60, and 72 months	97%/93%	PI: 78.6% score 0; 14.3% score 1; 7.1% score 2 PD of 4–6 mm in 1.7% of cases GR: 2.9% of cases	90%	4.1% decementation and complete crown fracture/2.7% pulpitis and vertical fracture
Agustin-Panadero <i>et al.</i> , 2021/prospective observational study [11]	BOPT	65 posterior teeth in both arches/zirconia FPD	12, 36, and 60 months	100%/95%	PI: 35% of 1	NM	10% chipping of ceramic veneer/2.5% irreversible pulpitis
	Chamfer				GI: 30% of 1 PD: 10% of 3 mm PI: 57.9% of 1 GI: 68.4% of 1, PD: 26.3% of 3mm		
Cagidiaco <i>et al.</i> , 2019/randomized clinical trial [27]	Feather-edge	25 premolars and molars/zirconia crowns	6, 12, 24, 36, and 48 months	96%/80%	BoP: 48% of cases	NM	15% crowns chipped and 5% irreparable fractures/NM
	Chamfer	25 premolars and molars/zirconia crowns		100%/76%	BoP: 55.5% of cases		5 crowns chipped/NM
Serra-Pastor <i>et al.</i> , 2019/prospective study [14]	BOPT	144 all types of teeth (74 crowns and 75 FPDs)/zirconia core and feldspathic ceramic covering	Every 12 months for 48 months	Zirconia crowns 97%; FPDs 96%/97%	Plaque affecting 20% of teeth after 24 months GR: 1.4% after 24 months GI: 12% after 24 months PD: 97.9% 0 to 3 mm; 2.1% 3–6 mm after 24 months	90%	1.4% porcelain veneer chipping and connector fracture in one FPD/2% pulpitis and vertical fracture
Agustin-Panadero, 2018/prospective study [28]	BOPT	149 incisors, canines, premolars (74 crowns and 27 FPDs)/zirconia core and feldspathic ceramic covering	6, 12, and 24 months	100%/NM	80.5% remained without gingival inflammation or bleeding, while 29 (19.5%) showed inflammation and/or bleeding	80%	2% porcelain veneer chipping; 0%

(Table 2) contd....

Author, Year, Type of Study/Refs.	Finish Line Type	Tooth (restoration and material type)	Follow-up Period	Survival/success Rate	Periodontal Outcome	Patient Satisfaction	Mechanical/biological Complications
Paniz <i>et al.</i> , 2017/prospective randomized clinical study [12]	Chamfer	198 incisors, canines, premolars/zirconia crowns	6 months	NM/ NM	GI: 33.3% score 1; 10.5% score 2; 1.9% score 3	91%	NM/NM
	Feather-edge				PI: 15.2% score 1		
				BoP: 30.5% score 1			
				GI: 33.3% score 1; 7.5% score 2; 0% score 3			
Paniz <i>et al.</i> , 2016/prospective randomized controlled double-blind clinical trial [29]	Feather-edge	196 incisors, canines, premolars/zirconia crowns	12 months	NM/NM	PI: 9.7% score 1	NM	1.88% restoration fracture/NM
					BoP: 8.4% score 1		
					GI: 31.5% score 1 and 9.8% score 2		
					PI: 17.4% score 1 and none score 2		
					BoP: 52.2%		
					GR: 3.3%		
	Chamfer			GI: 33.7% score 1; 11.5% score 2; 1.9% score 3			
				PI: 14.4% score 1; 3.8% score 2			
				BoP: 36.5%			
				GR: 11.5%			
Poggio <i>et al.</i> , 2012/retrospective study [30]	Knife-edge	102 (38 incisors, 13 canines, 29 premolars, 22 molars)/zirconia core and feldspathic ceramic covering	72 months	100%/NM	NM	NM	1.02% porcelain chipping/NM

Note: BOPT - Biologically oriented preparation technique; FPD - Fixed partial denture; ZLS - Zirconia-reinforced lithium silicate; PFM - Porcelain fused to metal; PI - Plaque index; NM - Not mentioned; GI - Gingival index; GR - Gingival recession; PD - Pocket depth; BoP - Bleeding on probing; ↔ -between .

Patient satisfaction was recorded in 5 studies only, with 90% overall satisfaction; the lowest percentage was 80% [28], and the highest was 100% [4]. Only 7 studies documented the survival rate and determined it as 100% [4, 11, 15, 28, 30] and an average of 98% (Cagidiaco *et al.*, 2019) and 96.5% (Serra-Pastor *et al.*, 2019) [14, 27]. Similarly, only five studies reported on the success rate, with findings indicating a 100% success rate for zirconia crowns and 86% for FPD [18]. The reported success rates were 93%, 95%, an average of 78%, and 97% in the studies by Serra-Pastor *et al.* (2021), Cagidiaco *et al.* (2019), and Serra-Pastor *et al.* (2019), respectively [10, 11, 14, 27].

3.3. Mechanical and Biological Complications

Nine studies included the mechanical complications. The highest was related to ceramic chipping and represented as 10%–15% [11, 27], and the lowest was only 1.4% [14]. With regard to biological complications, only three studies reported cases of reversible and irreversible pulpitis, as well as vertical root fractures, accounting for between 2% and 2.7% of the follow-up cases [10, 11, 14].

3.4. Periodontal Outcome

Regarding periodontal outcome, PI was documented in 6 studies, and scores ranged from 82% of cases scoring 0

(no plaque) [18] to 57.9% scoring 1 (mild plaque) under chamfer preparations [11]. The lowest plaque accumulation was observed in the study by Serra-Pastor *et al.* (2021) [10] with 78.6% scoring 0, whereas the highest occurred under BOPT in the study by Agustin-Panadero *et al.* (2021) with 35% scoring 1 [11]. Gingival health, assessed via GI, was reported in 6 studies. Healthy gingiva (score 0) ranged from 36.4% [26] to 68.4% with a score of 1 (mild inflammation) under chamfer preparation [11]. Severe inflammation (score 3) was rare and noted in only 1.9% of cases [12]. Serra-Pastor *et al.* (2019) demonstrated improvement over time, with GI reduced to 12% after 24 months [14].

The GR was recorded in 3 studies, with rates as low as 1.4% after 24 months [14] and up to 11.5% under chamfer preparations [12]. PD outcomes were favorable, as documented in 4 studies. The majority (80%–97.9%) of the cases showed PD ≤3 mm [14, 18]. Deeper pockets (4–6 mm) were rare and occurred in 1.7%–2.1% of the cases [10, 14]. Bleeding on probing (BoP) was reported in 4 studies and varied by preparation technique. The lowest BoP (8.4%) was observed with feather-edge [12], whereas higher rates (36.5–55.5%) were associated with chamfer preparations [12, 27]. BOPT demonstrated intermediate results and 19.5% inflammation/bleeding [28].

Table 3. Risk of bias appraisal for the included clinical studies.

Authpr/Refs.	Randomization Process	Deviations from Interventions	Missing Outcome Data	Measurement of Outcomes	Selection of Reported Results	Overall Risk of Bias
Gonzalez-Bonilla <i>et al.</i> , 2024 [18]	√	√	√	√	√	√
Serra-Pastor <i>et al.</i> , 2023 [15]	√	√	√	√	√	√
Kasem <i>et al.</i> , 2023 [4]	√	√	√	√	√	√
Talaat <i>et al.</i> , 2023 [26]	-	√	√	-	√	x
Serra-Pastor <i>et al.</i> , 2021 [10]	√	√	√	√	√	√
Agustín-Panadero <i>et al.</i> , 2021 [11]	√	√	√	√	√	√
Cagidiaco <i>et al.</i> , 2019 [27]	√	√	√	√	√	√
Serra-Pastor <i>et al.</i> , 2019 [14]	√	√	√	√	√	√
Agustín-Panadero <i>et al.</i> , 2018 [28]	√	√	√	√	√	√
Paniz <i>et al.</i> , 2017 [12]	√	√	√	√	√	√
Paniz <i>et al.</i> , 2016 [29]	√	√	√	√	√	√
Poggio <i>et al.</i> , 2012 [30]	√	-	√	√	√	x

Note: Where, √ means low, x means high, and - means neutral bias.

3.5. Risk of Bias Appraisal

Most of the reviewed clinical studies provided information about sample randomization, deviations from interventions, and assessments of outcomes, except for a single study that focused on randomization and measurements of outcomes [26] and deviations from interventions [30], as shown in Table 3. Parameters, including missing outcome data and the selection of reported results, were present in all studies. However, the overall risk of bias was low in 10 studies [4, 10-12, 14, 15, 18, 27-29] and high in 2 studies [26, 30].

4. DISCUSSION

Establishing an optimal relationship between prosthetic restorations and the periodontium is essential for achieving long-term functional and aesthetic success in FPDs [31]. Historically, horizontal finishing lines have led to issues, such as marginal discrepancies, biological complications, and affected aesthetics due to crown adaptation difficulties [3]. Vertical preparation designs have been proposed to enhance precision at the restoration-tooth interface [5]. These preparations, which lack a defined finishing line, may improve marginal seal and soft tissue stability compared to traditional horizontal designs [27].

The majority of systematic reviews and meta-analyses of existing literature have examined the effect of cemented fixed maxillary and mandibular prostheses on the status of gingival and periodontal health as GI and PI, and concentrated on the category and form of the cemented prosthesis, finishing line location, and prosthesis materials [31-33]. One published meta-analysis study focused on the effect of horizontal, traditional, or conventional preparation on soft tissue surrounding associated with natural, unprepared sound teeth [34]. The impact of vertical preparation designs on patient outcomes and clinical complications in fixed prosthodontics remains inconsistent across the literature, making it difficult to draw definitive conclusions.

Previous studies have characterized survival rate as the duration of the fixed prosthesis *in situ*, regardless of adjustments made during follow-up, whereas success rate has been referred to as prostheses remaining intact without any clinical intervention [19]. In this review, the average survival rate was 98%. These results have been found to align with prior reviews and meta-analyses that have indicated vertical techniques to demonstrate excellent long-term survival potential when performed correctly [13, 19]. Success rates have been found to exhibit more variability, especially for horizontal preparations. Cagidiaco *et al.* (2019) reported a success rate of 76%, influenced by factors, such as material selection (zirconia versus metal-ceramic), biomechanical challenges, and occlusal loading variations [27]. These discrepancies highlight the importance of evaluating case-specific factors, such as masticatory forces and parafunctional habits, in the choice of preparation design [33].

In this review, six studies [10-13, 26, 27, 29] compared BOPT with chamfer finishing lines. Agustín-Panadero *et al.* (2021) and Paniz *et al.* (2017) reported lower PI and GI for BOPT than chamfer with 60 months of follow-up [11, 12]. Talaat *et al.* (2022) found comparable gingival inflammation outcomes between BOPT (63.6%; score 1) and chamfer (59.1%; score 1) [26]. For BoP, Cagidiaco *et al.* (2019) reported 48% BoP with feather-edge versus 55.5% with chamfer, suggesting the superiority of BOPT [27]. Moreover, Paniz *et al.* (2017) observed lower BoP (8.4%) with the feather-edge technique than with chamfer (30.5%) at 6 months [12]. However, Paniz *et al.* (2016) observed higher BoP (52.2%) with the feather-edge technique than with chamfer (36.5%) at 12 months [29]. GR outcomes also varied; Serra-Pastor *et al.* (2021) [10] reported 2.9% GR with BOPT, whereas Paniz *et al.* (2016) noted 11.5% GR with chamfer [29].

Throughout the follow-up intervals, both groups showed a trend of increasing PD while remaining within clinically acceptable ranges (≤ 3 mm), particularly with

BOPT. Over 80% of cases in the studies carried out by Gonzalez-Bonilla *et al.* (2024) and Serra-Pastor *et al.* (2019) had PD \leq 3 mm, which indicated stable periodontal health [14, 18]. Deeper pockets (4–6 mm) were rare but more common in chamfer cases [11]. This outcome has been found to be in accordance with other studies that have demonstrated that the placement of margins within the supracrestal tissue can lead to gingival inflammation and possible recession or pocket formation [3, 32]. Despite various clinical factors influencing periodontal health, effective assessment, treatment, self-care instructions, and adherence to maintenance protocols are crucial to mitigating the negative effects of fixed restorations.

The reviewed studies have indicated a high overall patient satisfaction rate of 90%, though mechanical complications, such as ceramic veneer chipping, have remained a concern, with reported incidence rates ranging from 1.4% (14) to 15% [11, 27]. BOPT demonstrated lower mechanical failures of 10% for ceramic chipping and 15% for chamfer [11], whereas feather-edge demonstrated higher mechanical failures of 15% for ceramic chipping and 5% for chamfer [27]. Other studies focused on vertical preparations have reported a 4% PFM chipping rate over 60–84 months as the most common complication (González-Bonilla *et al.*, 2024). Serra-Pastor *et al.* (2021) have found 4.1% crown fractures to be associated with teeth prepared using BOPT [10]. Knife-edge preparations have shown lower complication rates, with Poggio *et al.* (2012) reporting 1.02% porcelain chipping over 72 months [30]. Biological failures, though less frequent, have included irreversible pulpitis and vertical root fractures associated with chamfer and BOPT [10, 11, 14].

In addition to the clinical trials and cohort studies included in this systematic review, numerous case reports and observational studies have further underscored the promising efficacy of vertical tooth preparation techniques [35]. Agustín-Panadero and Solá-Ruiz (2015) have highlighted the biological advantages of BOPT in maintaining gingival health and stability through controlled tissue remodeling, particularly in aesthetic zones [36]. Recent case reports have further illustrated the efficacy of vertical techniques in achieving optimal aesthetic and functional outcomes for patients with limited clinical crown height, underscoring them as a minimally invasive approach and their adaptability to advanced materials, such as zirconia [37, 38]. These findings have been found to align with the broader literature, which frequently associates vertical preparation with reduced procedural trauma, enhanced marginal adaptation, and improved soft tissue integration [39–41].

The collective evidence reinforces the clinical potential of BOPT techniques, particularly in complex cases requiring structural preservation or periodontal rehabilitation [3, 7]. This growing body of evidence supports the paradigm shift toward vertical preparation as a viable alternative to conventional methods, though its broader adoption necessitates further high-quality, long-term investigations.

5. LIMITATIONS

Only literature published in the English language was included in this study, which represents a limitation. This language restriction may have excluded relevant data and limited the exchange of knowledge from studies published in other languages. The small sample size and limited number of studies on certain outcomes, such as success rates and level of patient satisfaction, may further limit the generalizability of the results. The evidence obtained from the current analysis has supported the usage of vertical preparation, especially BOPT, because it is associated with better periodontal health status, increased patient satisfaction, and lower complications. Future research should focus on periodontal health parameters with similar case selection criteria, larger sample sizes, and long-term follow-ups, and should compare various vertical preparation techniques. This approach could enhance the evidence base for promoting vertical preparation as a standard practice or maintaining it as a specialized approach.

CONCLUSION

This systematic review has demonstrated vertical preparation techniques, such as BOPT and feather-edge designs, to be associated with favorable periodontal outcomes, including reduced plaque accumulation, gingival inflammation, and recession. Survival rates (\geq 95%) and patient satisfaction (\geq 90%) have also been found to be high. Mechanical complications, primarily ceramic chipping (1.4%–15%), and rare biological issues (2%–2.7%) have underscored their reliability. While longer-term studies are needed, vertical preparation emerges as a promising approach for tooth-supported fixed prostheses and for balancing periodontal health and prosthetic success.

AUTHORS' CONTRIBUTIONS

The author confirms sole contribution to the paper as follows: study conception and design, data collection, analysis and interpretation of results, and drafting of the manuscript. The author has reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

BOPT	=	Biologically Oriented Preparation Technique
PI	=	Plaque Index
GR	=	Gingival Recession
FPD	=	Fixed Prosthodontics

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA guidelines and methodology were followed.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

FUNDING

None.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

SUPPLEMENTARY MATERIAL

PRISMA checklist is available as supplementary material on the publisher's website along with the published article.

REFERENCES

- [1] Alahmari NM, Al-Haboob M, Gadah TS, *et al.* Knowledge and practice of dental professionals regarding vertical teeth preparation techniques. *BMC Med Educ* 2024; 24(1): 1482. <http://dx.doi.org/10.1186/s12909-024-06520-w> PMID: 39696324
- [2] Yu H, Zhao Y, Li J, *et al.* Minimal invasive microscopic tooth preparation in esthetic restoration: A specialist consensus. *Int J Oral Sci* 2019; 11(3): 31. <http://dx.doi.org/10.1038/s41368-019-0057-y> PMID: 31575850
- [3] Rinaldi T, Santamaria-Laorden A, Orejas Pérez J, Godoy Ruíz L, Serrano Granger C, Gómez Cogolludo P. Periodontal healing with fixed restorations using the biologically oriented preparation technique combined with a full digital workflow: A clinical case report. *Healthcare* 2023; 11(8): 1144. <http://dx.doi.org/10.3390/healthcare11081144> PMID: 37107978
- [4] Kasem AT, Ellayeh M, Özcan M, Sakrana AA. Three-year clinical evaluation of zirconia and zirconia-reinforced lithium silicate crowns with minimally invasive vertical preparation technique. *Clin Oral Investig* 2023; 27(4): 1577-88. <http://dx.doi.org/10.1007/s00784-022-04779-1> PMID: 36383297
- [5] Łabno P, Drobnik K. Comparison of horizontal and vertical methods of tooth preparation for a prosthetic crown. *J Pre Clin Clin Res* 2020; 14(1): 25-8. <http://dx.doi.org/10.26444/jpccr/116672>
- [6] Loi I, Di Felice A. Biologically oriented preparation technique (BOPT): a new approach for prosthetic restoration of periodontally healthy teeth. *Eur J Esthet Dent* 2013; 8(1): 10-23. PMID: 23390618
- [7] Abad-Coronel C, Villacís Manosalvas J, Palacio Sarmiento C, Esquivel J, Loi I, Pradies G. Clinical outcomes of the biologically oriented preparation technique (BOPT) in fixed dental prostheses: A systematic review. *J Prosthet Dent* 2024; 132(3): 502-8. <http://dx.doi.org/10.1016/j.prosdent.2022.07.010> PMID: 36192194
- [8] Singh N, Dua P, Thiruvalluvan N, Kumar S, Yangchen S. Vertical tooth preparation technique in aesthetic zone: Report of two patients. *IP Ann Prosthodont Restor Dent* 2023; 9(1): 39-43. <http://dx.doi.org/10.18231/j.aprd.2023.008>
- [9] Noè G, Toffoli A, Bonfiglioli R, *et al.* Emergence profile creation with CAD technology on vertical edgeless preparation (VEP). *Prosthesis* 2023; 5(4): 1369-81. <http://dx.doi.org/10.3390/prosthesis5040094>
- [10] Serra-Pastor B, Bustamante-Hernández N, Fons-Font A, Fernanda Solá-Ruiz M, Revilla-León M, Agustín-Panadero R. Periodontal behavior and patient satisfaction of anterior teeth restored with single zirconia crowns using a biologically oriented preparation technique: A 6-year prospective clinical study. *J Clin Med* 2021; 10(16): 3482. <http://dx.doi.org/10.3390/jcm10163482> PMID: 34441778
- [11] Agustín-Panadero R, Serra-Pastor B, Loi I, Suárez MJ, Pelaez J, Solá-Ruiz F. Clinical behavior of posterior fixed partial dentures with a biologically oriented preparation technique: A 5-year randomized controlled clinical trial. *J Prosthet Dent* 2021; 125(6): 870-6. <http://dx.doi.org/10.1016/j.prosdent.2020.03.031> PMID: 32580920
- [12] Paniz G, Nart J, Gobatto L, *et al.* Clinical periodontal response to anterior all-ceramic crowns with either chamfer or feather-edge subgingival tooth preparations: Six-month results and patient perception. *Int J Periodontics Restorative Dent* 2017; 37(1): 61-8. <http://dx.doi.org/10.11607/prd.2765> PMID: 27977819
- [13] Bonfanti-Gris M, Pradies G, Moron-Conejo B, Gil A, Martínez-Rus F. Vertical versus horizontal finishing lines for dental preparations: A systematic review with meta-analysis. *J Esthet Restor Dent* 2024. <http://dx.doi.org/10.1111/jerd.13360> PMID: 39620436
- [14] Serra-Pastor B, Loi I, Fons-Font A, Solá-Ruiz MF, Agustín-Panadero R. Periodontal and prosthetic outcomes on teeth prepared with biologically oriented preparation technique: a 4-year follow-up prospective clinical study. *J Prosthodont Res* 2019; 63(4): 415-20. <http://dx.doi.org/10.1016/j.jpor.2019.03.006> PMID: 30975559
- [15] Serra-Pastor B, Bustamante-Hernández N, Fons-Font A, Solá-Ruiz MF, Revilla-León M, Agustín-Panadero R. Periodontal outcomes of anterior fixed partial dentures on teeth treated with the biologically oriented preparation technique: A 6-year prospective clinical trial. *J Prosthet Dent* 2023; 129(5): 703-9. <http://dx.doi.org/10.1016/j.prosdent.2021.07.009> PMID: 34702586
- [16] Kotb Salem S, Sayed Asaad R. MARGINAL INTEGRITY OF DIFFERENT CAD/CAM MONOLITHIC CERAMIC CROWNS WITH VERTICAL, AND HORIZONTAL FINISH LINE PREPARATIONS. *Egypt Dent J* 2024; 70(2): 1761-59. <http://dx.doi.org/10.21608/edj.2024.269678.2936>
- [17] Alwadai GS, Al Moaleem MM, Dagher AA, *et al.* A comparative analysis of marginal adaptation values between lithium disilicate glass ceramics and zirconia-reinforced lithium silicate endocrowns: A systematic review of *in vitro* studies. *Med Sci Monit* 2023; 29: e942649. <http://dx.doi.org/10.12659/MSM.942649> PMID: 38148601
- [18] Gonzalez-Bonilla M, Berrendero S, Moron-Conejo B, Martínez-Rus F, Salido MP. Clinical evaluation of posterior zirconia-based and porcelain-fused-to-metal crowns with a vertical preparation technique: An up to 5-year retrospective cohort study. *J Dent* 2024; 148: 104953. <http://dx.doi.org/10.1016/j.jdent.2024.104953> PMID: 38554803
- [19] Al-Haddad A, Arsheed NAA, Yee A, Kohli S. Biological oriented preparation technique (BOPT) for tooth preparation: A systematic review and meta-analysis. *Saudi Dent J* 2024; 36(1): 11-9. <http://dx.doi.org/10.1016/j.sdentj.2023.10.004> PMID: 38375394
- [20] Page MJ, McKenzie JE, Bossuyt PM, *et al.* The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* 2021; 372(71): n71. <http://dx.doi.org/10.1136/bmj.n71> PMID: 33782057
- [21] Shea BJ, Reeves BC, Wells G, *et al.* AMSTAR 2: A critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ* 2017; 358: j4008. <http://dx.doi.org/10.1136/bmj.j4008> PMID: 28935701
- [22] Sterne JAC, Savović J, Page MJ, *et al.* RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ* 2019; 366: l4898. <http://dx.doi.org/10.1136/bmj.l4898> PMID: 31462531
- [23] Cumpston M, Li T, Page MJ, *et al.* Updated guidance for trusted systematic reviews: A new edition of the cochrane handbook for systematic reviews of interventions. *Cochrane Libr* 2019; 10(10): ED000142. <http://dx.doi.org/10.1002/14651858.ED000142> PMID: 31643080
- [24] Higgins JPT, Altman DG, Gøtzsche PC, *et al.* Cochrane Bias Methods Group; Cochrane Statistical Methods Group. The cochrane collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011; 343(oct18 2): d5928. <http://dx.doi.org/10.1136/bmj.d5928> PMID: 22008217
- [25] Wells GASB, Shea B, O'Connell D, *et al.* The Newcastle-Ottawa Scale (NOS) for assessing the quality of non-randomised studies

- in meta-analyses. 2011. Available from: www.ohri.ca/programs/clinical_epidemiology/oxford.asp
- [26] Talaat K, Zaki A, Kotb S, Sami R. Kareem Talaat, Amina Zaki, Samaa Kotb, Rasha Sami. One year clinical evaluation of translucent zirconia crowns in dental esthetic zone with biologically oriented preparation technique versus conventional preparation (RCT). *J Pharm Negat Results* 2023; 13(3): 4042-50. <http://dx.doi.org/10.47750/pnr.2022.13.S08.511>
- [27] Cagidiaco EF, Discepoli N, Goracci C, Carboncini F, Vigolo P, Ferrari M. Randomized clinical trial on single zirconia crowns with feather-edge vs chamfer finish lines: Four-year results. *Int J Periodontics Restor Dent* 2019; 39(6): 817-26. <http://dx.doi.org/10.11607/prd.4270> PMID: 31613942
- [28] Agustín-Panadero R, Serra-Pastor B, Fons-Font A, Solá-Ruiz MF. Prospective clinical study of zirconia full-coverage restorations on teeth prepared with biologically oriented P preparation technique on gingival health: Results after two-year follow-up. *Oper Dent* 2018; 43(5): 482-7. <http://dx.doi.org/10.2341/17-124-C> PMID: 29513640
- [29] Paniz G, Nart J, Gobato L, Chierico A, Lops D, Michalakis K. Periodontal response to two different subgingival restorative margin designs: A 12-month randomized clinical trial. *Clin Oral Investig* 2016; 20(6): 1243-52. <http://dx.doi.org/10.1007/s00784-015-1616-z> PMID: 26445857
- [30] Poggio CE, Dosoli R, Ercoli C. A retrospective analysis of 102 zirconia single crowns with knife-edge margins. *J Prosthet Dent* 2012; 107(5): 316-21. [http://dx.doi.org/10.1016/S0022-3913\(12\)60083-3](http://dx.doi.org/10.1016/S0022-3913(12)60083-3) PMID: 22546309
- [31] Dragomir LP, Nicolae FM, Gheorghe DN, *et al.* The influence of fixed dental prostheses on the expression of inflammatory markers and periodontal status—narrative review. *Medicina* 2023; 59(5): 941. <http://dx.doi.org/10.3390/medicina59050941> PMID: 37241173
- [32] Merchán KE, Grossi ML, Kunrath MF, Teixeira ER. Periodontal tissue responses to restorations with and without cervical finish line: A systematic review and meta-analysis. *Int J Periodontics Restorative Dent* 2024; 0(0): 1-22. <http://dx.doi.org/10.11607/prd.7037> PMID: 38820274
- [33] Pjetursson BE, Sailer I, Makarov NA, Zwahlen M, Thoma DS. All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part II: Multiple-unit FDPs. *Dent Mater* 2015; 31(6): 624-39. <http://dx.doi.org/10.1016/j.dental.2015.02.013> PMID: 25935732
- [34] León-Martínez R, Montiel-Company JM, Bellot-Arcís C, Solá-Ruiz MF, Selva-Otaolaurruchi E, Agustín-Panadero R. Periodontal behavior around teeth prepared with finishing line for restoration with fixed prostheses. A systematic review and meta-analysis. *J Clin Med* 2020; 9(1): 249. <http://dx.doi.org/10.3390/jcm9010249> PMID: 31963494
- [35] Kakka A, Gavriil D, Whitworth J. Treatment of cracked teeth: A comprehensive narrative review. *Clin Exp Dent Res* 2022; 8(5): 1218-48. <http://dx.doi.org/10.1002/cre2.617> PMID: 35809233
- [36] Agustín-Panadero R, Solá-Ruiz MF. Vertical preparation for fixed prosthesis rehabilitation in the anterior sector. *J Prosthet Dent* 2015; 114(4): 474-8. <http://dx.doi.org/10.1016/j.prosdent.2015.05.010> PMID: 26213268
- [37] Granell-Ruiz M, Rech-Ortega C, Oteiza-Galdón B, Bouazza-Juanes K. Case report: Vertical preparation protocol for veneers. *J Clin Exp Dent* 2023; 15(4): e346-50. <http://dx.doi.org/10.4317/jced.60223> PMID: 37152495
- [38] Morón-Conejo B, Gil A, Bonfanti-Gris M, Salido MP, Martínez-Rus F. Esthetic and functional rehabilitation: Retreatment of anterior fixed dental prosthesis with biologically oriented preparation technique and digital workflow. *J Esthet Restor Dent* 2025; 37(3): 761-70. <http://dx.doi.org/10.1111/jerd.13393> PMID: 39704451
- [39] Noè G, Toffoli A, Foce E, *et al.* Vertical edgeless preparation: Periodontal dominance in prosthetic crown preparation. *Prosthesis* 2023; 5(2): 358-67. <http://dx.doi.org/10.3390/prosthesis5020026>
- [40] Solá-Ruiz MF, Del Rio Highsmith J, Labaig-Rueda C, Agustín-Panadero R. Biologically oriented preparation technique (BOPT) for implant-supported fixed prostheses. *J Clin Exp Dent* 2017; 9(4): 0. <http://dx.doi.org/10.4317/jced.53703> PMID: 28469832
- [41] Andrea T, Giolanta LM, Roberto PR. Biologically oriented preparation technique through a digital workflow, a case report. *J Esthet Restor Dent* 2024; 36(12): 1657-65. <http://dx.doi.org/10.1111/jerd.13318> PMID: 39395026