Dual-Center Cross-Sectional Analysis of Periodontal Stability Around Anterior All-Ceramic Crowns with a Feather-Edge or Chamfer Subgingival Preparation

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Subgingival margins are often associated with adverse periodontal reactions, such as recession and gingival inflammation. The purpose of this cross-sectional dual-center study was to evaluate the periodontal health and stability of intrasulcular margins, comparing two prosthetic margin preparations: subgingival chamfer (SC) and subgingival feather-edge (SF) with gingival curettage. Ninety-six patients with 205 crowns (buccal margin 0.5 mm into the gingival sulcus) were included in the study. SF, gingival curettage, and intrasulcular restorative margin were prepared on 109 crowns; SC was prepared on 96. Restorations were in place for a mean of 55.9 months (range: 12 months to 10 years). No significant differences were found regarding probing depth between the two groups (mean buccal: 1.6 mm; mean interproximal: 2.3 mm). Significant increased recession was present around SCs, showing a higher margin-exposure frequency (buccal: 19.8% vs 3.7%; interproximal: 5.2% vs 1.4%). SC showed 8.5 times the risk of margin exposure compared to SF, men 5.5 times compared to women, and smokers 3.7 times compared to nonsmokers. Follow-up time was not a significant factor. SC sites showed a tendency for reduced buccal bleeding on probing compared to SF sites (3.0% vs 12.1%), but no significant difference was seen in a regression model. Plaque presence increased the risk of bleeding (4.1×), and women presented a higher risk of bleeding than men (3×). Subgingival margins can provide adequate periodontal health and stability if restorative procedures are well controlled and if patients are enrolled in an adequate maintenance program. SF with intrasulcular margin favors facial soft tissue stability, as reduced gingival recession was observed. The technique should be carefully applied to promote an adequate periodontal response.
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One of the challenges of subgingival margins is the maintenance of an adequate periodontal health, which can be influenced by the restorative margin position and design, as well as by the restoration accuracy and emergence profile.[1–9] Subgingival margins must be precisely performed to maintain periodontal health, being no deeper than 0.5 to 0.7 mm into the gingival sulcus.[10,11] If the supracrestal tissue attachment is respected, the restorations have proper fit, and careful prosthetic procedures are applied, a proper periodontal response has been demonstrated.[10,12–15] However, subgingival margins may lead to an inflammatory periodontal reaction, even if bacterial plaque is well controlled.[16,17] Increased Gingival Index, bleeding on probing, probing depth, and attachment loss have been recorded around subgingival margins.[16–19] Defective tooth-restoration interface,[13,20] improper emergence profile,[21,22] plaque accumulation,[23,24] increased pathogenicity of the subgingival microflora,[25] and violation of the biologic width[10] have been reported around subgingival margins. Subgingival margins have also been associated with gingival recession, especially with thin gingival biotypes. Therefore, exposure of the restoration margin might be expected over time.[19,26–29]

Subgingival finish lines can be divided into two main groups: horizontal tooth preparation including shoulder and chamfer, or vertical preparation including feather-edge.[30] In both groups, the restorative margin should be positioned coronal to the bottom of the sulcus.[13] Recently, a preparation technique, termed "biologically oriented," was described, showing benefits for soft tissue stability, gingival scalloping, and esthetics.[2] This technique has been extensively described in the past, with a tooth preparation apical to the base of the sulcus and margins identified more coronally without invading the supracrestal tissue attachment.[2,31,32] Previous studies, conducted in an educational environment with a 12-month follow-up, showed less gingival recession around this type of feather-edge preparation compared to chamfer, recommending this technique when soft tissue level has a crucial esthetic impact.[33,34] Recent papers on this preparation reported gingival thickening, gingival margin stability, and periodontal tissue health, provided the patient maintains adequate oral hygiene.[35] On the other side, increased bleeding on probing was reported, exposing the patient to an increased risk of gingival inflammation.[33,34] This issue could be related to the potential difficulties for clinicians to visualize the subgingival preparation (leading to possible inaccuracy), to identify the restorative margin position (leading to potential violation of the biologic width), and to clear the contoured emergence profile from potential cement residual or plaque accumulation.[10,13,17,27,36,37]

The purpose of this cross-sectional two-center study was to determine whether the prosthetic margin design (chamfer or feather-edge) influences the risk of margin exposure with time and the inflammatory status of the periodontal tissues.

Materials and Methods

Patient Selection

The examined patients, selected from two private practices, had the following inclusion criteria: *(1)* > 18 years of age; *(2)* one or more single-unit maxillary anterior (first premolar to first premolar) all-ceramic, full-coverage restorations with an initial facial margin positioned 0.5 mm subgingivally; *(3)* periodontal probing depth (PPD) ≤ 4 mm prior to tooth preparation, with no bleeding on probing; *(4)* initial full-mouth plaque score (FMPS) and full-mouth bleeding score (FMBS) < 20%; *(5)* > 2 mm of keratinized tissue; and *(6)* signed informed consent for data collection. The patient exclusion criteria were: *(1)* medical history in which any dental intervention was contraindicated; *(2)* any local or systemic disease, condition, or medication that might compromise healing and affecte the periodontium; *(3)* dental caries or periodontal disease in the remaining teeth; and *(4)* patient failure to follow a proper recall system every 6 months.

Prosthetic Procedures

Two clinicians (G.P. and M.Z.), one for each center, have previously performed all the restorative procedures following a strict tooth preparation protocol, as described in a previous study.[33,34] In the chamfer group, chamfer diamond burs (881EF, Komet) are utilized for positioning both the tooth preparation and the restorative margin into the gingival sulcus, 0.5 mm below the gingival margin. In the feather-edge group, long flame-shape diamond burs (862EF, Komet) are utilized for preparing the tooth apically to the base of the sulcus, potentially into the attachment, allowing space for tissue thickening after gingival curettage upon tooth preparation. The facial restorative margin is then carefully finalized 0.5 mm below the gingival margin (Figs 1 to 3).

Data Collection

At the clinical examination, four different periodontal variables were registered at three different facial sites (mesial, facial, and distal), by experienced dental hygienists not aware on the type of prosthetic preparation used. The examiners were previously trained to use a probing force around 25 g on plaster models in the preparation phase.

- PPD, with the utilization of a periodontal probe, rounding the measurements to the nearest millimeter
- Gingival bleeding on probing (BoP), according to Ainamo and Bay[38]
- Plaque presence (PI) at cervical portion of the crown

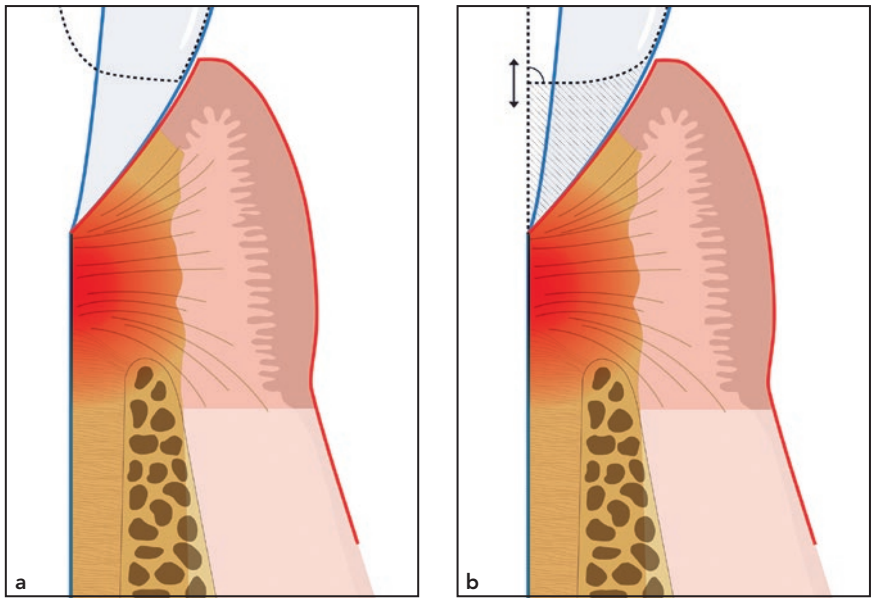

Fig 1 *Schematic representation of periodontium, tooth emergence profile, and* (a) *chamfer margin design (the horizontal dotted line indicates the tooth preparation line, and the vertical dotted line indicates the restoration emergence profile) and* (b) *feather-edge margin design (the straight portion indicates the tooth preparation line, and the curved portion indicates the restoration emergence profile).*

Fig 2 *Case Sample 1. Chamfer preparation on a maxillary right central incisor.* (a) *Intrasulcular chamfer positioned 0.5 mm subgingivally.* (b) *All-ceramic crown.* (c) *Clinical view at the 5-year follow-up.*

Fig 3 *Case Sample 2. Feather-edge preparation on a maxillary left central incisor.* (a) *Subgingival feather-edge.* (b) *All-ceramic crown with margin positioned 0.5 mm subgingivally.* (c) *Clinical view at the 4-year follow-up.*

- Gingival recession, evaluated as subgingival (margin not visible), equigingival (margin slightly visible positioned at the gingival level), or supragingival (margin clearly visible at supragingival position) (Figs 4 and 5)

Parameters were collected for crowns with a minimum follow-up of 12 months (1 year) and maximum of 120 months (10 years). Restoration time of service and vitality of the abutment tooth were also recorded, as well as patient age, sex, smoking habits (self-reported), and type of home care.

Data Analysis

Descriptive statistical analysis was carried out using SPSS software, version 24 (IBM). Frequency analysis was used for categorical and dichotomous variables, while mean and standard deviations were calculated for continuous variables. Mean values and standard deviations were calculated at the patient level. As more than one crown was present in some patients (from one to seven crowns per patient), a multilevel model with crown as the lower level and patient as the highest was built to ensure a correct estimate of the standard error. The main outcome variable, presence of an exposed crown margin on the facial site, was built starting from the three gingival recession values and transformed in a dichotomous one. To explore the

Fig 4 *Case Sample 3. Gingival inflammation around anterior all-ceramic crowns (at buccal and interproximal sites of all incisors).*

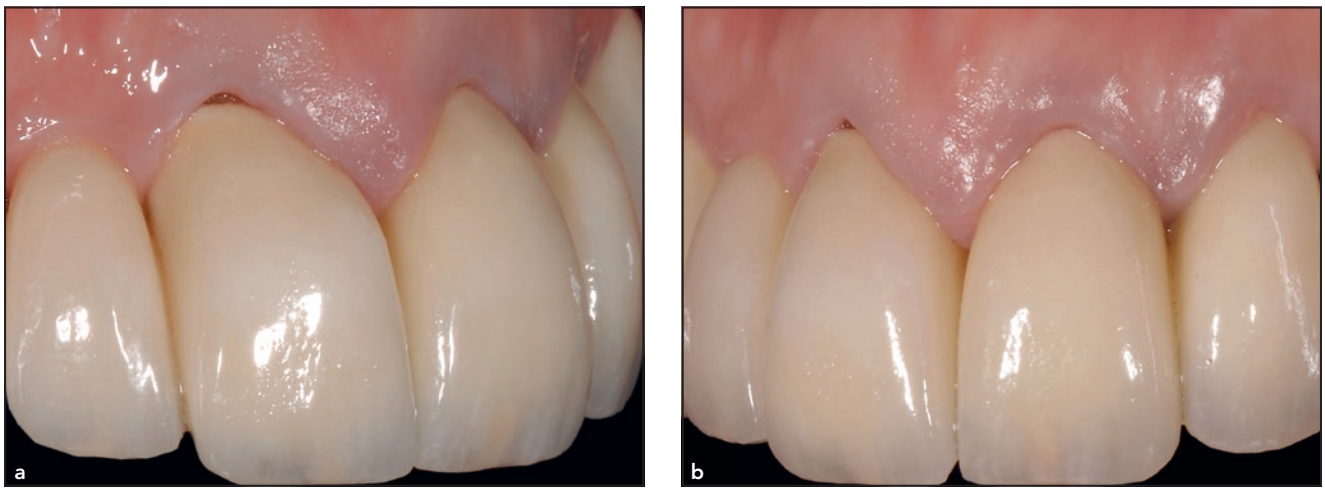

Fig 5 *Case Sample 4. Restorative margins graded as supragingival (maxillary right central incisor, buccal), equigingival (left central incisor, buccal), and subgingival (lateral incisors and interproximal sites).*

influence of the measured independent variables, a logistic model was built, testing each factor one by one and reporting the final model that included all the variables significant in the bivariate analysis. The secondary outcome, presence of BoP at the gingival margin, was also tested with the same model-building strategy in a second logistic model. Multilevel analysis was performed using a specific software (MLwiN 2.26, University of Bristol). The variable related to the main research question (type of preparation) was kept in the model even if not significant, while variables not significant in the final model were removed. Significance was tested by the use of Wald test. $P = .05$ was considered the threshold level of significance.

Sample Size Calculation

Assuming 30% as a clinically relevant difference in terms of frequency of an exposed crown margin at the facial site, and given at least one crown for each subject enrolled, a power calculation revealed that 43 patients per group were needed to have an 80% power to detect as significant with alpha set at .05.

Results

Ninety-six patients (28 men and 68 women) were included in the study for a total of 205 crowns. Horizontal finish line (chamfer)

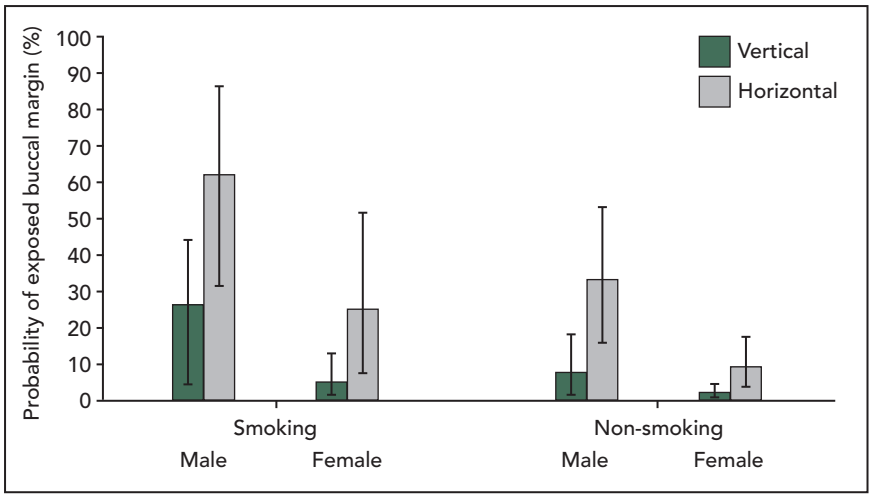

Fig 6 *Predicted probability to have an exposed buccal crown margin depending on the preparation, sex, and smoking status.*

was seen on 96 crowns (mean service of 73.2 months), and a vertical finish line (feather-edge) was seen on 109 crowns (mean service of 41.3 months). Mean population age was 57.2 years old, and 17% of patients were self-reported smokers (Appendix Table 1; all Appendix Tables can be found in the online version of this article at www.quintpub.com/journals).

Mean PPD at follow-up was 2.3 mm at interproximal sites and 1.6 mm at buccal sites, with no statistically significant differences between the two types of finish-line preparation (P = .70) (Appendix Table 2).

On average, marginal plaque was present on 11.3% of feather-edge crowns and on 8.0% of chamfer crowns. No statistically significant difference was present between preparation groups overall or for interproximal sites. A statistically significant difference was present for percent of mean buccal plaque between feather-edge and chamfer crowns (Appendix Table 2).

The mean BoP score was 21.6% for feather-edge crowns and 12.4% of the facial sites; the difference did not reach statistical significance (P = .08). Chamfer showed significantly (P = .047) reduced BoP at buccal sites when compared to feather-edge preparation (12.1% vs 3.0%, respectively).

All the restorative margins were initially positioned 0.5 mm subgingivally. After being in service for a mean period of 55.9 months (4.5 years), 3.2% of the interproximal sites and 11.2% of the facial sites were recorded as supragingival, thus with a recession > 0.5 mm. Around chamfer preparations, statistically significantly more recession was present, especially at buccal sites. Feather-edge resulted in less buccal (3.7% vs 19.8%; chi-square P < .01) and inter-proximal (1.4% vs 5.2%; chi-square P = .04) recession (Appendix Table 3).

Two multilevel models were built. The first model was made to explore factors related to the probability of having an exposed prosthetic margin on the buccal aspect of the crown (Appendix Table 4). The logistic parsimonious model included three significant factors: Chamfer preparation showed 8.5 times the risk of margin exposure compared to feather-edge preparation, men presented 5.5 times the risk of margin exposure, and smokers had 3.7 times the risk compared to nonsmokers. Time of follow-up was not a significant factor, nor was toothbrushing device. Figure 6 illustrates the relationship between the probability of having an exposed buccal margin and the preparation technique, smoking status, and sex. According to the R2 value, the model explained 45% of outcome variance. The second model explored factors affecting the probability of having a BoP-positive site (Appendix Table 5). The type of preparation was not significant in the final model, but was maintained in the table as it represented the main variable to answer the research question. According to the R2 value, the model explained 26% of outcome variance. PI at a site increased the risk of bleeding by 4.1 times, and women presented a 3-times-higher risk of bleeding compared to men. The other factors for BoP were PPD at site (the greater the PPD, the higher the risk) and age. Figure 7 illustrates the relationship between PPD increase and probability of BoP-positive sites, separating sex and PI.

Discussion

In the present investigation, two different subgingival restorative margins, chamfer and feather-edge, were compared. The clinical examination confirmed a higher risk for recession in the chamfer group, but failed to demonstrate a higher risk for bleeding in the feather-edge group when controlling for confounding factors.

The periodontal response to subgingival margins was positive, as mean interproximal PPD was 2.3 mm, mean buccal PPD was 1.4 mm, and BoP was present at 6.8% of the buccal sites and 21.2% of the interproximal sites (Appendix Table 2). In the general population, there is a wide range of BoP (7% to 60%) according to individual oral hygiene standards,[12,14,15,39] and the present research confirms that if adequate restorative procedures and maintenance protocols are adopted, subgingival margins can favor an adequate periodontal response.

Tissues were stable in the majority of the cases (more than 75% of sites), but recession was present in a significant percentage of the study population (Appendix Table 3). Reduced risk of recession was recorded at the buccal aspect of crowns prepared with feather-edge, confirming the enhanced periodontal tissue stability described by several authors.[2,7,33,34] Buccal recession > 0.5 mm was present only in 3.7% of the restorations with feather-edge preparation, while buccal recession was present on 19.8% of the restorations with chamfer preparation (Appendix Table 3). As previously described, this could be related to the combination of two factors: the reduced facial emergence profile, obtained with the subgingival preparation within the attachment, and the potential tissue thickening consequent to the gingival curettage, the tooth profiles modification, and the contoured provisional restoration[2,31–34] (Fig 1b). Time of follow-up was not a significant factor, suggesting that recession may happen at an early stage after crown cementation and not at a later follow-up. Considering the tissue-stability benefits, subgingival feather-edge should be selected in cases where esthetics are important and when minimal recession represents a reason for prosthetic failure.

A regression model, controlling for confounding variables, failed to show a significant impact of margin technique preparation on BoP (Appendix Table 5). The factors that showed significant increased probability of BoP were sex, increased PPD, age, and PI at the site, which is in line with previously published data on gingivitis.[40] Nevertheless, a tendency for higher buccal BoP was recorded around feather-edge compared to chamfer preparations (Appendix Table 2). As previously mentioned,[33,34] subgingival feather-edge might be technique sensitive and potentially traumatic for the soft tissues. Clinicians might not be able to clearly visualize the deepest portion of the subgingival preparation, preventing them from creating adequate smoothness.[17,37] Second, potential invasion of the biologic width might happen, and the communication between clinicians and technicians must be clear enough to overcome the technician's inability to visualize the exact position of the intrasulcular margin and to determine the proper restoration emergence profile.[10,13,27,29] Third, the contoured restoration could represent a potential risk for plaque accumulation or residual cement.[18]

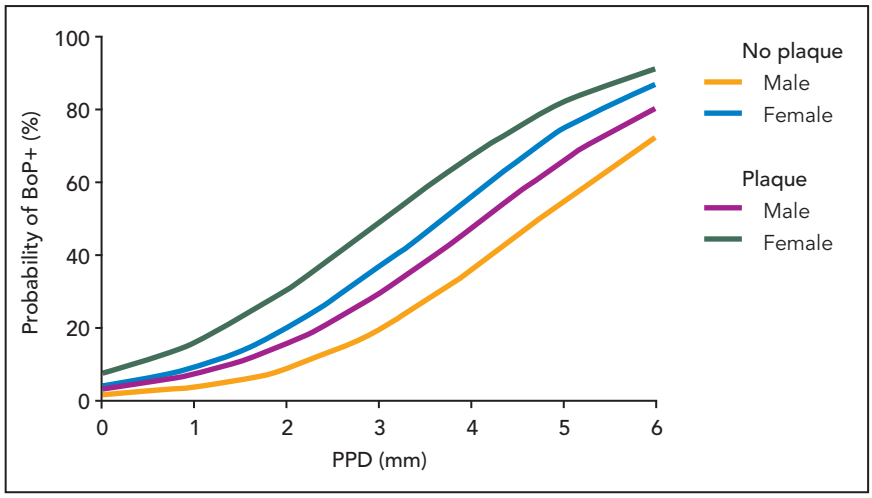

Fig 7 *Predicted probability to have a positive BoP score depending on sex and presence of plaque.*

Considering these potential risks, subgingival feather-edge preparation should be performed carefully in selected cases, and with a clear understanding of the supracrestal tissue attachment as well as the root morphology.

Conclusions

Within the limitations of the present cross-sectional study, subgingival margins can provide adequate periodontal health and stability if restorative procedures are well controlled and if patients are enrolled in adequate maintenance programs. Subgingival feather-edge margins with gingival curettage favor facial soft tissue stability, as less gingival recession was observed than with intrasulcular horizontal chamfer preparation. However, careful application of the technique should be applied in order to promote an adequate periodontal response. Sex and smoking were also confirmed as significant factors for recession, as well as sex and plaque accumulation for BoP.

Acknowledgments

The authors declare no conflicts of interest.

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Appendix

Appendix Table 1 Patient Characteristics According to Preparation

	Feather-edge 62 patients 109 crowns	Chamfer 45 patients 96 crowns	Total 96 patients 205 crowns
Age, y			
Mean (SD)	57.9 (12.5)	56.3 (10.0)	57.2 (11.4)
Range	18–89	32–89	18–89
Sex, %			
Male	30	30	30
Female	70	70	70
Smokers, %	13	21	17
Toothbrush type, %			
Manual	47	53	50
Electric	53	47	50
Interdental cleaning method, %			
Flossing	37	53	44
Brushing	48	35	43
None	15	12	13
Follow-up time, mo			
Mean (SD)	41.3 (30.0)	73.2 (35.9)	55.9 (35.3)
Range	12–118	12–120	12–120

SD = standard deviation.

Appendix Table 2 Clinical Characteristics at the Patient Level

	Feather-edge		Chamfer			Total	
	Mean	SD	Mean	SD	*P*	Mean	SD
Plaque, %	11.3	27.3	8.0	19.0	.46	9.9	24.1
Interproximal	11.7	28.6	11.9	30.9	.96	11.8	28.4
Buccal	10.5	30.2	0.0	0.0	.01	6.0	23.5
BoP, %	21.6	30.1	12.4	23.2	.08	17.7	25.7
Interproximal	26.4	35.3	17.1	30.9	.16	22.5	33.7
Buccal	12.1	30.7	3.0	15.6	.047	8.3	25.7
PPD, mm	2.1	0.6	2.0	0.8	.85	2.1	0.7
Interproximal	2.3	0.8	2.3	0.8	.65	2.3	0.8
Buccal	1.6	0.6	1.6	0.9	.70	1.6	0.7

SD = standard deviation; BoP = bleeding on probing; PPD = periodontal probing depth.

Appendix Table 3 Margin Position: Subgingival, Equigingival, or Supragingival

	Feather-edge 62 patients 109 crowns			Chamfer 45 patients 96 crowns				Total 96 patients 205 crowns		
	Sub	Equi	Supra	Sub	Equi	Supra	*P*	Sub	Equi	Supra
Interproximal, %	91.3	7.3	1.4	80.2	14.6	5.2	.04	86.1	10.7	3.2
Buccal, %	85.3	11.0	3.7	65.6	14.6	19.8	< .001	76.1	12.7	11.%

Sub = subgingival (margin not visible, no recession); Equi = equigingival (margin visible at the gingival level, recession < 0.5 mm); Supra = supragingival (margin visible, recession > 0.5 mm).

Appendix Table 4 Multilevel Logistic Model with Buccal Margin Exposure as the Outcome Variable

	Value	SE	OR	95% CI	*P*
Explanatory variables					
Preparation (reference: feather-edge)	2.15	0.74	8.54	1.99–36.65	.004
Sex (reference: female)	1.71	0.56	5.53	1.84–16.57	.002
Smoking (reference: nonsmoker)	1.32	0.62	3.74	1.12–12.54	.03
Fixed part					
Intercept	–3.65	0.79			
Random part					
Subject-level variance	0.00	0.11			
ICC	0.00				
R^2	0.45				

SE = standard error; OR = odds ratio; CI = confidence interval; ICC = intraclass correlation coefficient.
Parsimonious model was used. The following variables were tested but removed from the model as nonsignificant: age, time of follow-up, type of toothbrush, type of interdental device, plaque at site, tooth vitality, and periodontal probing depth.

Appendix Table 5 Multilevel Logistic Model with Bleeding on Probing as the Outcome Variable

	Value	SE	OR	95% CI	*P*
Explanatory variables					
Preparation (reference: feather-edge)	0.33	0.35	1.39	0.70–2.76	.35
Sex (reference: male)	1.12	0.44	3.06	1.29–7.26	.011
Plaque (reference: nonsmoker)	1.41	0.41	4.10	1.83–9.15	.001
Age (centered on 45 y)	0.044	0.02	1.04	1.01–1.08	.005
PPD (centered on 3 mm)	1.11	0.17	3.03	2.17–4.23	< .0001
Fixed part					
Intercept	–2.27	0.54			
Random part					
Subject-level variance	1.27	0.47			
Tooth-level variance	0.04	0.38			
ICC	0.22				
R^2	0.26				

SE = standard error; OR = odds ratio; CI = confidence interval; PPD = periodontal probing depth; ICC = intraclass correlation coefficient.
Parsimonious model was used. The following variables were tested but removed from the model as nonsignificant: smoking, time of follow-up, type of toothbrush, type of interdental device, and tooth vitality.
Preparation type was maintained, as it represents the main comparison for the study.