Clinical Periodontal Response to Anterior All-Ceramic Crowns with Either Chamfer or Feather-edge Subgingival Tooth Preparations: Six-Month Results and Patient Perception

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Subgingival margins are often required for biologic, mechanical, or esthetic reasons. Several investigations have demonstrated that their use is associated with adverse periodontal reactions, such as inflammation or recession. The purpose of this prospective randomized clinical study was to determine if two different subgingival margin designs influence the periodontal parameters and patient perception. Deep chamfer and feather-edge preparations were compared on 58 patients with 6 months follow-up. Statistically significant differences were present for bleeding on probing, gingival recession, and patient satisfaction. Feather-edge preparation was associated with increased bleeding on probing and deep chamfer with increased recession; improved patient comfort was registered with chamfer margin design. Subgingival margins are technique sensitive, especially when feather-edge design is selected. This margin design may facilitate soft tissue stability but can expose the patient to an increased risk of gingival inflammation.
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Full-coverage restorations should restore the prepared tooth to its initial form following prosthodontic principles for tooth preparation, impression making, crown fabrication, and cementation.[1,2] Subgingival margins may promote adverse inflammatory periodontal reactions, even if bacterial plaque is well controlled.[3,4] Restorations with subgingival margins have been associated with inaccurate margins,[5,6] overcontoured profiles,[7,8] impaired oral hygiene,[9,10] increased pathogenicity of the subgingival dental plaque,[11] and violation of the biologic width.[12,13] Localized gingival inflammation, increased Plaque Index and Gingival Index, and increased probing depths have been recorded around subgingival margins.[3,4,14] Additionally, restorations with subgingival margins have demonstrated increased attachment loss.[15,16] Even if plaque is well controlled, subgingival margins present increased bleeding on probing compared with supragingival ones.[17,18,19]

Subgingival margins are indicated in multiple clinical situations, including presence of existing subgingival restorations, dental caries, tooth fracture, abfraction, abrasion, chemical erosion, tooth discoloration, or to enhance retention and resistance and develop a ferrule effect.[20–22] The esthetic benefits of subgingival margins are well

established and contribute to a better crown contour and more natural gingival scalloping.[23–25] In healthy sites with minimal probing depth, it is important to be cautious not to infringe on the biologic attachment apparatus minimizing to a depth of 0.5 to 0.7 mm into the gingival crevice.[5,12,26,27] Violations of these dimensions might invade the biologic width and result in gingival inflammation or recession.[5,13,28–30]

Restorations with subgingival margins exhibited increased gingival recession, especially with thin gingival biotypes, even if managed properly.[15,19,29–34] It is unlikely that these margins will remain subgingival over time, and exposure of tooth structure might be expected. Recently, improved soft tissue stability, better gingival scalloping, and better esthetics have been reported with the application of feather-edge tooth preparation and a biologically oriented preparation technique.[25] These recent reports use tooth preparation apical to the base of the sulcus, potentially into the attachment to allow space for tissue thickening. Margins are then identified more coronally, verified after a healing period, and limited to 0.5 to 0.7 mm subgingival. However, distinctions must be made between tooth preparations extending 0.5 mm intrasulcular and those extending further subgingivally.

The purpose of this prospective randomized clinical study was to evaluate the influence of a deep chamfer intrasulcular margin design on the periodontal soft tissue parameters when compared with a feather-edge subgingival tooth preparation and intrasulcular margin. The secondary purpose was to determine whether the patient perceives any difference between the two types of finishing lines in terms of esthetics and functional comfort.

Materials and methods

Patient selection

The patient inclusion criteria were as follows: *(1)* patient requiring a single-unit maxillary anterior or first premolar crown restoration; *(2)* periodontal probing depth prior to tooth preparation ≤ 4 mm, with no bleeding on probing; *(3)* > 21 years of age; *(4)* full-mouth plaque score (FMPS) and full-mouth bleeding scores (FMBS) < 20% at study baseline; and *(5)* > 2 mm of keratinized tissue. The patient exclusion criteria were as follows: *(1)* medical history in which any dental intervention would be contraindicated; *(2)* any local or systemic disease, condition, or medication that might compromise healing and affect the periodontium; *(3)* dental caries or periodontal disease in the remaining teeth; *(4)* smoker; and *(5)* inability or unwillingness to return for follow-up visits.

Prosthetic protocol

After a screening appointment to verify patient eligibility, 58 patients were included in the study. All patients signed the informed consent form. The teeth planned for full-coverage restoration were randomly assigned to the treatment groups: group 1 (deep chamfer) or group 2 (feather-edge). Rounded shoulder and feather-edge burs were used for patients of group 1 and 2, respectively (Figs 1 to 3). After recruitment, oral hygiene instructions were given to the patients and a prophylaxis was performed by a periodontist to establish optimal plaque control and gingival health. After 1 week, the following periodontal measurements were registered by two experienced periodontists: periodontal probing depth (PPD) at three different facial sites (mesial, midpoint, distal) with a periodontal probe (UNC periodontal probe, Hu-Friedy), rounding the measurements to the nearest millimeter; plaque index (PI), according to Löe and Silness[35]; gingival index (GI), according to Löe and Silness[35]; gingival bleeding on probing (BoP), according to Ainamo and Bay.[36] Intraexaminer calibration took place before initiation of the study by examination of 10 patients twice, 24 hours apart. The sequence of examiners was random. Measurements were accepted as calibrated if 90% of the recordings could be reproduced within a difference of 1 mm. The interexaminer agreement for the assessment of the variables was determined with the intraclass correlation coefficient (ICC). For the two examiners, *t* test ($\alpha = .05$) revealed no statistically significant differences. All restorative procedures were performed under local anesthesia (articaine with 1:100.000 epinephrine) by a single experienced prosthodontist. A classic preparation for an all-ceramic full-coverage restoration was employed for all teeth, with an initial depth of 0.8 mm and a final depth of

1 mm axially and 1.5 mm incisally. In group 1, the chamfer diamond burs used for the initial preparation had a grit size of 151 µm (6881, Komet), while a grit size of 25 µm (881 EF, Komet) was used for the finishing procedures. The same grit sizes were employed for group 2. However, long flame-shaped diamond burs were used to finalize the tooth preparation closer to the gingiva (6862 and 862 EF, Komet). In group 1, the facial restorative margin was initially prepared equigingivally and then placed 0.5 mm below the gingival margin, using a 40,000-rpm speed (Expertmatic E25L; KaVo) and ×4.5 magnification (EyeMag Pro F, Zeiss). Palatal margins were left equigingival and gradually deepened interproximally to 0.5 mm below the gingival margin (Fig 2). Finally, the tooth surface was polished with an ultrasonic device (SF1LM, Komet). All provisional restorations were fabricated with heat-polymerizing polymethylmethacrylate (PMMA) acrylic resin (C&B-V Dentine; Major Dental) and then relined with autopolymerizing PMMA acrylic resin (Jet, Lang Dental). In group 2, long flame-shaped diamond burs identified a flat subgingival area without a defined finishing line. In a similar way to gingival curettage, minor disruption of the apical sulcular and attached epithelium occurred prior to provisional restoration fitting. The restorative margin was then finalized more coronally and carefully positioned intrasulcularly 0.5 mm below the gingival margin (Fig 3).

Patients were instructed to use a 0.2% chlorhexidine gluconate solution for 7 days until they could perform regular oral hygiene and returned 12 weeks later for the impression procedures, giving enough time for soft tissue adaptation and maturation after the subgingival teeth preparation. Zirconia copings were then tried-in, and margins were examined and carefully verified for fit and extension. In particular, the extension of group 2 copings was carefully verified in relation to the stabilized gingival level, finalized 0.5 mm below the gingival margin facially and interproximally and left equigingival palatally. The zirconia-ceramic restorations (Lava, 3M ESPE) layered for all the teeth were then cemented with a resin-luting agent (RelyX Unicem, 3M ESPE). Cement excess was carefully removed, and occlusion was adjusted. Intrasulcular margin position was verified, and oral hygiene instructions were given to the patients. Patients were recalled 2 weeks later and then 3 months after for evaluation and oral hygiene measures reinforcement.

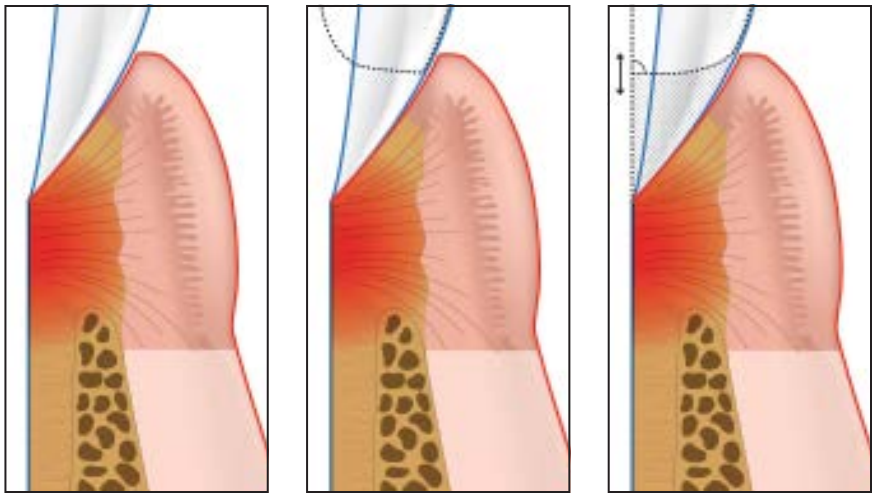

Fig 1 (left) *Schematic representation of periodontium and tooth emergence profile (adapted from Maynard JG Jr, Wilson RD. Physiologic dimensions of the periodontium significant to the restorative dentist. J Periodontol 1979;50:170–174).*

Fig 2 (center) *Schematic representation of periodontium, tooth emergence profile, and chamfer margin design. The dashed black line indicates the tooth preparation line and the restoration emergence profile.*

Fig 3 (right) *Schematic representation of periodontium, tooth emergence profile, and feather-edge margin design. The dashed black lines indicate the tooth preparation line (straight portion) and the restoration emergence profile (curved portion).*

Data collection

At 6 months after crowns cementation, each patient was asked to answer a visual analog scale (VAS) questionnaire to assess their level of satisfaction regarding esthetic and functional aspects of the restorations. First, they answered the question "How would you grade the esthetics of the crown in terms of

Table 1 Sample Characteristics at Baseline and 6 Months

Variable	Baseline (n = 198)	6-mo follow-up (n = 198)	*P*
Age (y)[a]	52.4 (11.0)		
Sex (men)	27 (48.2)		
GI (n[%])			
0	198 (100)	112 (56.6)	NA
1	–	66 (33.3)	
2	–	18 (9.1)	
3	–	2 (1)	
PI (n[%])			
0	198 (100)	173 (87.4)	NA
1	–	25 (12.6)	
BoP (n[%])			
0	198 (100)	121 (61.1)	NA
1	–	77 (38.9)	
PPD mesial, mm[a]	2.43 (0.60)	2.71 (0.78)	0.001[b]
PPD facial, mm[a]	1.96 (0.57)	1.64 (0.59)	0.001[b]
PPD distal, mm[a]	2.37 (0.60)	2.54 (0.72)	0.001[b]

[a]Mean (SD).
[b]Paired *t* test (quantitative variables).
NA = not applicable; GI = Gingival Index; PI = Plaque Index; BoP = bleeding on probing; PPD = periodontal probing depth.

relationship between the white ceramic component and the pink soft tissue?" marking a cross on a straight 100-mm line where the left end read "not satisfied at all" and the right end read "completely satisfied." For the next question, "How would you grade the integration of the crown in the mouth?" patients marked a cross on another line where the left end read "not satisfied at all; I would like to change my crown" and the right end read "completely satisfied; I cannot recognize that I have a crown with my tongue." All the answers were measured from left to right to obtain a numeric value for each patient answer.

After the satisfaction questionnaire, the same clinical measurements registered at baseline were taken again by the two blinded experienced periodontists. The restorative margin position in relation to the gingival margin was also registered. This was classified as subgingival (not visible), equigingival (slightly visible), or supragingival (visible).

Data analysis

Descriptive statistics were expressed as mean (SD) and valid percentage for continuous and categorical data, respectively. The baseline comparisons between study groups were performed using chi-square test (Fisher exact test with observed frequencies < 5) for categorical variables whereas continuous variables were tested using *t* test (U-Mann Whitney test if the variables were not normally distributed). Outcomes were analyzed using analysis of covariance (ANCOVA), once assumptions for the convenience of this analysis were confirmed, with baseline values and age as covariates and study group as independent variable.[37] Least square (LS) mean ± standard error (SE) was calculated for variables involving each outcome. Paired *t* test or McNemar test (if applicable) was used to compare outcomes at 6 months and baseline. Level of significance was set at .05. SPSS version 21 software (IBM) was used for all analyses.

Results

A total of 58 patients (27 men and 31 women, aged 30 to 64 years, mean age 50.3 years) received 200 full-coverage restorations, of which 106 were included in group 1 and 94 in group 2. All participants completed the 6-month follow-up. Of these restorations, 2 were lost prior to the 6-month follow-up, 1 due to abutment root fracture and 1 due to porcelain fracture. These 2 sites were not included in the statistical analysis (Table 1).

At 6 months follow-up, changes from baseline were observed in GI, PI, and BoP. At 6 months, 12.6% of the sites presented dental plaque, while at baseline dental plaque was not present. Patients at baseline did not show any degree of gingival inflamation or BoP, while at 6 months 43.4% of patients scored from 1 to 3 in the GI and about 39% presented bleeding. Statistically significant differences were also present in PPD. PPD at mesial and distal sites

Table 2 Pre-Post Analysis by Study Group

Variable	Baseline (n = 198) Group 1: chamfer (n = 105)	Baseline (n = 198) Group 2: feather-edge (n = 93)	*P*[b]	6 mo (n = 198) Group 1: chamfer (n = 105)	6 mo (n = 198) Group 2: feather-edge (n = 93)	*P*
Age (y)[a]	54.9 (1.05)	49.6 (0.07)	.001			
GI (n[%])						
0	105 (100)	93 (100)	NA	57 (54.3)	55 (59.1)	.485[c]
1	–	–		35 (33.3)	31 (33.3)	
2	–	–		11 (10.5)	7 (7.5)	
3	–	–		2 (1.9)	0	
PI (n[%])						
0	105 (100)	93 (100)	NA	89 (84.8)	84 (90.3)	.240[c]
1	–	–		16 (15.2)	9 (9.7)	
BoP (n[%])						
0	105 (100)	93 (100)	NA	73 (69.5)	48 (51.6)	.010[d]
1	–	–		32 (30.5)	45 (48.4)	
PPD mesial, mm[a]	2.29 (0.04)	2.59 (0.07)	0.001	2.66 (0.07)	2.77 (0.08)	.355[d]
PPD facial, mm[a]	1.90 (0.05)	2.02 (0.06)	0.159	1.58 (0.05)	1.70 (0.06)	.168[d]
PPD distal, mm[a]	2.22 (0.04)	2.54 (0.07)	0.001	2.45 (0.06)	2.64 (0.07)	.058[d]

[a]Mean (SD).
[b]Nonpaired Student *t* test was used for comparisons between groups in baseline measures.
[c]Chi-square test was used for comparisons between groups at 6 months.
[d]ANCOVA (LS mean) was used for comparison of 6 months vs baseline (mean adjusted by baseline value and age).
NA = not applicable; GI = Gingival Index; PI = Plaque Index; BoP = bleeding on probing.

Table 3 Restorative Margin Design in Relation to Gingival Margin Position

Margin design	Baseline Subgingival margin (n[%])	6 mo Subgingival margin (n[%])	6 mo Equa- or supragingival (n[%])
Group 1 (chamfer)	105 (100)	97 (92.4)	8 (7.6)
Group 2 (feather-edge)	93 (100)	92 (98.9)	1 (1.1)
Total	198 (100)	189 (95.5)	9 (4.5)

increased compared with baseline (*P* = .001), while at facial sites it decreased (*P* = .001) (Table 1).

Considering the two different preparation groups, no differences were identified for PPD in mean LS change from baseline to 6 months for mesial (*P* = .355), facial (*P* = .168), or distal sites (*P* = .058). PI and GI at 6 months were similar in both groups (*P* = .240 and *P* = .485, respectively). Significantly more sites in group 2 had BoP (48.4%) compared with group 1 (30.5%) (*P* = .010) (Table 2).

Significant differences were found in gingival margin position between groups (Table 3). At the 6-month follow-up, group 1 showed more recession with higher frequency of restorations with equa- or supragingival margin position compared with group 2 (7.6% and 1.1%, respectively; Fisher test = 0.027).

Patient satisfaction was evaluated in terms of esthetics and function, as described above. The median VAS values for esthetic and functional satisfaction were 96.5 and 98.0, respectively. Statistically significant differences were present between the two groups in patient perception of the esthetic result (*P* = .002) and function (*P* = .002), with higher VAS median values for patients in group 1 (Table 4).

Table 4 Patient Esthetic and Functional Satisfaction in Relation to Crowns Prepared with Different Margin Design

Margin design	Group 1 (chamfer; n = 105)		Group 2 (feather-edge; n = 93)		Total (n = 198)	
VAS	Median	Interquartile range	Median	Interquartile range	Median	Interquartile range
Esthetics	98.0	94.5–100.0	92.4	80.6–100.0	96.5	89.7–100.0
Function	98.0	95.2–100.0	88.7	81.2–100.0	98.0	90.3–100.0

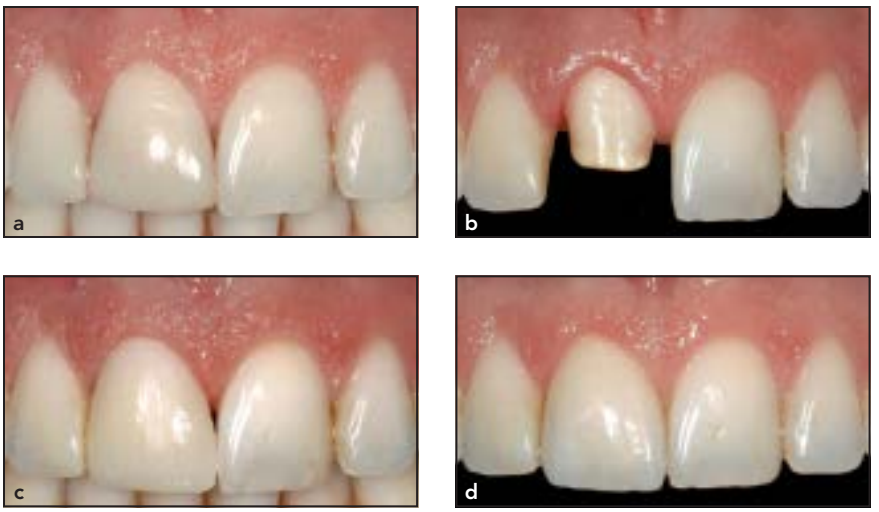

Fig 4 Case 1. *Chamfer margin design.* (a) *Initial condition.* (b) *Tooth preparation.* (c) *Provisional restoration.* (d) *Definitive restoration at 6-month follow-up.*

Discussion

The present research focused on subgingival margins in the esthetic zone since margins are often positioned subgingivally to improve the treatment outcome[1,2,4,21,22] and especially to enhance the natural esthetic result and the gingival architecture.[20,23,24] Different indications have been described in the literature in regard to finish line form, but at the end the selection criteria should be based on personal preference, esthetics, formation ease, and type of restoration.[21] In the present research, two different restorative margins, deep chamfer and feather-edge, were compared in regard to periodontal tissue response.

Deep chamfer was prepared intrasulcularly. Feather-edge was also positioned intrasulcularly, but after a deeper subgingival tooth preparation. A comparison with intrasulcular feather-edge tooth preparation was not performed. At the 6-month evaluation, PI and GI were increased as in the previous literature,[11] with no statistically significant differences between the two types of finishing lines (Table 2). In the comparison of the two groups, statistically significant differences were found in BoP. In accordance with published articles, a general increased BoP was noticed around subgingival margins.[28,32,39] More specifically, even when the gingival tissues appeared similar at the 6-month follow-up (similar GI), increased BoP was present with feather-edge compared with chamfer. While no differences were present between the groups at baseline, at the 6-month follow-up 48.4% of sites in group 2 had BoP versus 30.5% in group 1 ($P = .010$) (Table 2).

The same clinical and laboratory procedures were used in the fabrication of all the restorations; the only difference was the tooth preparation technique (Figs 4 and 5). Hence, potential difficulties might be related to subgingival feather-edge technique, as clinicians might not be able to see the preparation finish line. Intrasulcular margin position during provisional fabrication and definitive restoration finalization might be extremely difficult and time-consuming with potential invasion of the biologic width.[5,13,30,34] In this regard, communication between clinicians and technicians must be clear to overcome the technician's inability to visualize the exact position of the intrasulcular margin in the finishing area. In a similar way, the emergence profile could

be challenging to determine, for both the provisional and the definitive restoration.[40,41] To improve the gingival scalloping, especially on teeth with triangular-shape roots, or to increase the strength of the ceramic at the cervical area, potential overcontouring might be expected.[4,42–44]

Restorations with subgingival margins have been associated with increased gingival recession, especially with thin gingival biotypes.[29–34] Subgingival margins, examined for a mean period of 4 to 12 years, presented gingival recession in 34% of the restorations. This was much more than around supragingival margins, where recession occurred only on 6% of the crowns.[31] Similarly, in a longitudinal study by the same authors with a 15-year follow-up, crowns with subgingival margins had a 2.65 times greater chance of gingival recession when compared with the contralateral teeth.[32]

In the present study at 6 months after delivery of the restorations, 4.5% had gingival recession limited to 0.5 mm, with restorative margins exposure. Feather-edge preparation performed statistically better than chamfer: only 1 crown in group 1 had gingival recession compared with 8 in the chamfer group (Table 3). This potential benefit might be related to the described increased thickness of the periodontal biotype, a consequence of the rotary curettage during subgingival feather-edge tooth preparation. However, as increased BoP was observed, longer-term data will be needed to rule out the potential negative effect of gingival inflammation in terms of tissue stability. For this reason, the results of the present study might be considered preliminary, as longer observational periods are needed to establish better correlations between the examined parameters.

Fig 5 Case 2. *Feather-edge margin design.* (a) *Initial condition.* (b) *Tooth preparation.* (c) *Provisional restoration.* (d) *Definitive restoration at 6-month follow-up.*

As a secondary level of analysis, patient functional and esthetic satisfaction has been investigated. The focus has been centered on one of the most crucial aspects in the esthetic zone: the cervical portion and its interaction with the gingival tissues.[45,46] The results of this study suggest that the interaction between all-ceramic restorations and the gingival tissue is well graded by patients (Table 4). Considering both esthetic and functional perceptions, patients preferred chamfer preparation ($P < .001$). This result could be explained by the possibility that chamfer follows more closely the tooth emergence profile without interfering too much with the periodontium, while subgingival feather-edge preparations are more related to a newly developed emergence profile. Thus, patients do not seem to experience the described benefits determined by the modification of the emergence profile with improved esthetic results and better soft tissue stability.

Conclusions

Within the limitations of this study, more BoP is present around feather-edge margins and significantly more gingival recession is present around deep chamfer margins. Intrasulcular margins are technique sensitive, especially when subgingival tooth preparation with a feather-edge margin is selected.

Acknowledgments

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