Prospective Clinical Evaluation of Periodontal Response to Different Prosthetic Margin Design.

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PROSPECTIVE CLINICAL EVALUATION

OF PERIODONTAL RESPONSE TO

DIFFERENT PROSTHETIC MARGIN DESIGN

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To my family

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ABSTRACT

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Sub-gingival margin placement is sometimes required due to different reasons and is often associated with adverse periodontal reactions. The purpose of this study was to determine if a single restoration with sub-gingival margin on a tooth, in the maxillary anterior zone, would affect its periodontal soft tissue parameters, and whether or not a deep chamfer preparation has a different influence in the periodontium when compared to a feather edge preparation.

Plaque and gingival indexes, periodontal probing depth, bleeding on probing and patient's biotype were registered. 106 teeth were prepared with a deep chamfer, while 94 were prepared with a feather edge finishing line. Six and twelve month after the restorations delivery the same parameters were evaluated. Repeated measure one-way analysis of variance (ANOVA) ($α=0.05$) was used. At six months the patient

A statistically significant difference between baseline and the 6 and 12-month follow up is present in regards to plaque index, gingival index and periodontal probing depth, but no statistically significant difference between chamfer and feather edge finishing lines. There is a statistically significant difference between baseline and the 6 and 12-month follow up in regards to bleeding on probing. Feather edge preparation presents significantly more bleeding on probing and less gingival recession than the chamfer.

Sub-gingival margins do influence the periodontal soft tissue response. Statistically significant difference exists between feather edge and chamfer finishing lines in regards to bleeding on probing and gingival recession. Sub-gingival margins should be carefully selected, especially when feather edge finishing line is utilized.

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ABBREVIATIONS

ABBREVIATIONS

PPD: Periodontal Probing Depth

PI: Plaque Index

GI: Gingival Index

BOP: Gingival Bleeding on Probing

KT: Keratinized Tissue

ANOVA: Analysis of Variance

VAS: Visual Analogue Scale

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INTRODUCTION

INTRODUCTION

Every full coverage restoration should restore the prepared tooth to its initial form in order to address certain mechanical and biological requirements, following the well described principles of tooth preparation. (1-2) Margins should be positioned supra-gingival in order not to harm the periodontal tissues as the literature states clearly that sub-gingival margins might be associated with adverse inflammatory periodontal reactions, even if bacterial plaque is well controlled. Localized gingival inflammation with increased plaque and gingival index scores, as well as increased probing depths, have been recorded around prostheses with sub-gingival margins compared to natural dentition or prostheses with supra-gingival margins. (3)

Hence, it is now well-established that sub-gingivally placed crown margins represent a possible trauma to the gingival health (4-9) and actually they may increase the risk to loose periodontal attachment. (10) It is a common observation that, in some patients and particularly at facial aspects, gingival recession may happen; in other subjects and particularly at inter-proximal sites, increasing levels of inflammation may happen with possible development of periodontal pockets. These findings are well described in the literature and might be due to the thickness of the soft tissues, know as tissue biotype. (11) It is described that a thin tissue, often highly scalloped, has higher chance to recede when irritated, such as when in contact with the margin of an artificial crown. On the other side, thicker tissue may respond with inflammation after prosthetic therapy. (12) This is possibly due to the prosthetic

procedures performed by the dentist, by the accuracy of the prosthesis fit and by the material utilized. (13-14)

However, in multiple clinical situations, (Fig. 1-3) restoration margins have to be positioned sub-gingivally due to the presence of previous sub-gingival restorations, dental caries, crown fracture, abfraction, abrasion, chemical erosion, tooth discoloration, enhancement of retention and resistance form, development of a ferrule effect. (15-17)

Fig.1-2-3 Esthetic treatment of teeth 12, 11 and 21.

In more, (Fig. 4-5) sub-gingival margins are also advocated in order to enhance the final esthetic result with a better crown contour or gingival scalloping. (18-19)
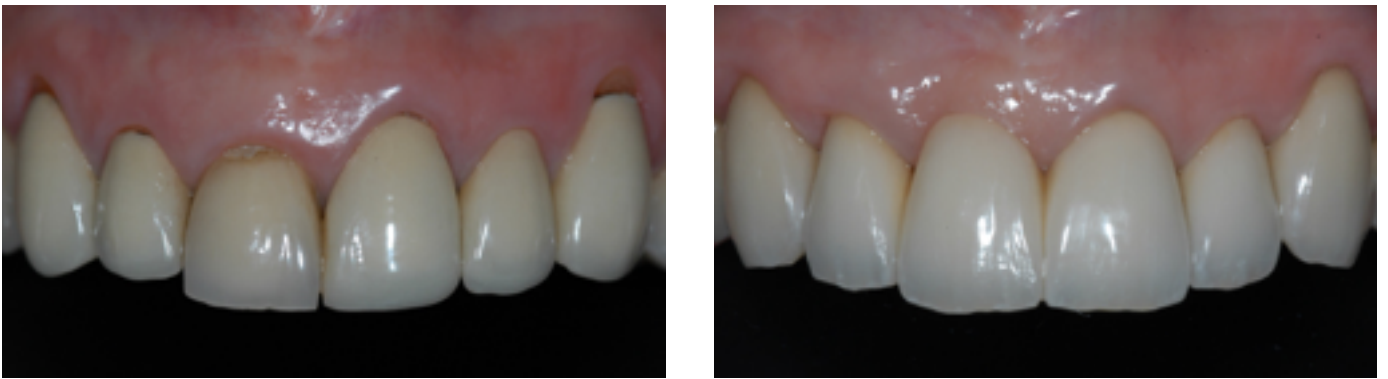
Fig. 4-5 Esthetic treatment of the anterior sextant.

In these cases, since the healthy gingival sulcus is very shallow, the placement of sub-gingival restorative finishing line should be performed extremely cautiously, respecting the junctional epithelium, no deeper than 0.5-0.7 mm into the gingival crevice, 0.5 mm away from the bottom of the sulcus. (20-21) Violations of these dimensions, might results in gingival inflammation or gingival recession. (21-22)

Clinical and histological studies suggest that sub-gingival restorative margins may cause undesired tissue effects, even if bacterial plaque is well controlled. (23-27) Localized gingival inflammation and increased plaque, gingival index scores, as well as probing depths have been recorded around prostheses with sub-gingival margins compared to natural dentition or prostheses with supra-gingival margins. (28-30) Additionally, an in vivo study by Waerhaug has concluded that sub-gingival restorations are associated with attachment loss.   These findings have been confirmed with additional studies. (3,9,31,32) Two studies, one in cast gold, metal ceramic and metal acrylic restorations and another one in all ceramic restorations have demonstrated that

sub-gingival margin placement presented greater chances of bleeding than the supra-gingival finishing lines. (33-34)
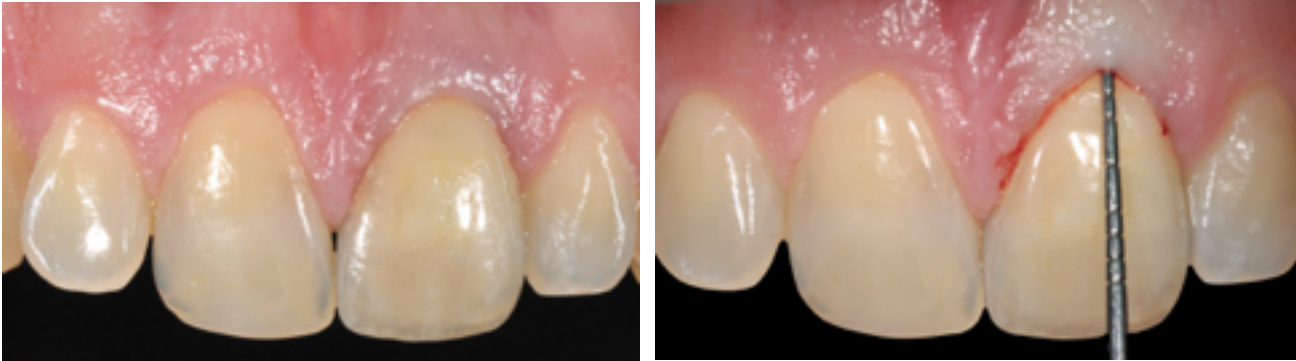
Figure 6-7 Gingival inflammation and bleeding on probing around full-coverage restorations.

Furthermore, the restorations with sub-gingival margins exhibited a gingival recession, especially when these were placed in patients with a thin gingival biotype. (29,31,34, 35-41) Therefore, although sub-gingival margins are many times preferred by many clinicians, due to patients' esthetic concerns, it is highly unlikely that these margins will stay sub-gingivally over time. In addition, it has been demonstrated that a greater mean attachment loss is associated with sub-gingival margins when compared to supra-gingival ones. (10)

Figure 7 Gingival recession around of full-coverage restorations.

Although the literature is clear that whenever possible sub-gingival margins should be avoided, it does not supply a definitive indication as to which type of restorative margin –i.e. chamfer, shoulder, feather edge- should be selected when a sub-gingival margin is placed. Recently, the utilization of vertical tooth preparation with a biologically oriented technique has been suggested. (42) The authors present this as a method with potential benefits on soft tissue stability of the natural gingival architecture both in short- and long-term. However, the literature lacks scientific evidence comparing different types of sub-gingival margins as regards to various periodontal indexes.

Plaque accumulation can be considered one of the reason for the adverse periodontal response and it is agreed that conventional glazed porcelain is the restorative material with the least plaque accumulation and the easiest plaque removal. (43-49)

OBJECTIVES

OBJECTIVES

The primary aim of this study is to evaluate if horizontal finishing line (deep chamfer preparation) have a different influence on periodontal soft tissue in comparison to vertical finishing line (featheredge preparation).

Periodontal probing depth, gingival index, plaque index, bleeding on probing and gingival recession will be evaluated around all-ceramic full coverage restorations at 6 and 12 month follow-up.

The secondary object of this study is to evaluate if horizontal finishing line (deep chamfer preparation) have a different influence on patient perception in comparison to vertical finishing line (featheredge preparation). Patient will be investigated in regard to esthetic perception (esthetic integration of all-ceramic crowns with the surrounding gingival tissue) and functional perception (functional integration of the crown in the patient mouth in terms of tongue feeling).

HYPOTHESIS

HYPOTHESIS

The null-hypothesis of the study is that periodontal soft tissue parameters and patient perception around horizontal finishing line (deep chamfer preparation) are the same of the periodontal soft tissue parameters and patient perception around vertical finishing line (featheredge preparation).

MATERIAL&METHODS

MATERIAL AND METHODS

This was a prospective randomized controlled double blind clinical trial, enrolling a sample of patients who needed single full coverage restorations in the anterior maxilla. Patient recruitment took place in the School of Dentistry of the University of Padova, Italy. It started in July 1, 2013 and was completed in November 29, 2013.

Patients were screened by both a prosthodontist (Gianluca Paniz) and a periodontist (Luca Gobbato) for possible inclusion in this study.

The criteria used for including patients were as follows:

(i) ≥ 18 years of age,

(ii) dentate patients planned for single full coverage restorations in the area between the 1st bicuspids,

(iii) periodontal probing depths ≤ 4 mm,

(iv) full mouth plaque (FMPS) and bleeding (FMBS) scores ≤ 20%,

(v) > 2mm of keratinized tissue.

Patients satisfying the above mentioned criteria were not included in the study if one or more of the following conditions were met:

(i) smoking (>10 cigarettes/day),

(ii) substance abuse history,

(iii) severe clenching or bruxing habits,

(iv) local or systemic disease (endocrine, renal, hematologic, hepatic, immunosuppressive),

(v) current steroid/ chemotherapy,

(vi) head and neck irradiation,

(vii) pregnancy,

(viii)inability or unwillingness to return for follow-up visits. (50-54)

This prospective study was performed in accordance with the guidelines of the Declaration of Helsinki and the research protocol was approved by the Ethics Committee of the University of Padova (2737P/2013), prior to patient enrollment. Additionally, this clinical study was registered at the U.S. National Institutes of Health Clinical Trials Registry (NCT02276586). Patients were notified that their data would be collected and used for a statistical analysis. A signed informed consent was obtained from all patients enrolled in this study.

All teeth planned for full-coverage restorations were randomly allocated to one of the two different treatment groups, according to a computer-generated randomization list. The teeth allocation was concealed by means of sealed envelopes until the moment of preparation. The randomized treatment code (Group 1 or 2) was available in closed non-transparent envelopes that were opened before teeth preparation. Patients were assigned to Group 1 (horizontal finishing line) or to Group 2 (vertical finishing line). The time sequence of all procedures is depicted in Figure 9.
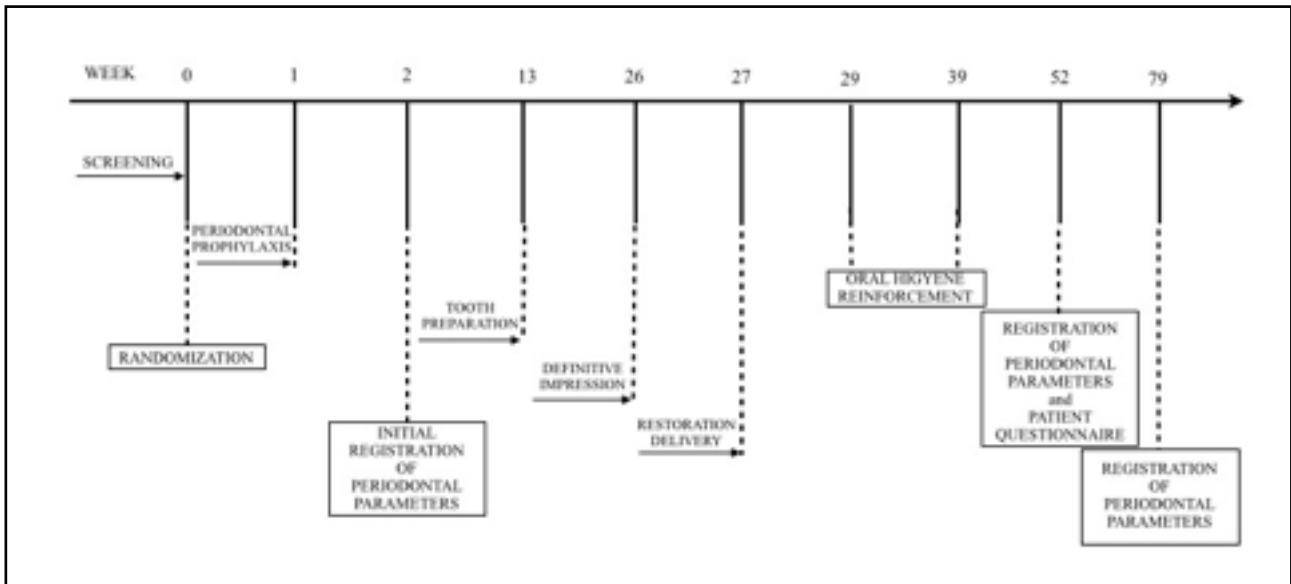
Figure 9 Time sequence of interventions and examinations.

After recruitment, a periodontal prophylaxis was performed by a periodontist and then oral hygiene instructions were given to the patients in order to establish optimal plaque control and gingival health.

Twelve weeks later the following periodontal measurements were registered by two experienced periodontists (Luca Gobbato and Diego Lops): (55)

(i) Periodontal Probing Depth (PPD), at three different facial sites (mesial, midpoint, distal) with the utilization of a periodontal probe (UNC periodontal probe, Hu-Friedy, Chicago, IL), rounding the measurements to the nearest millimeter,

(ii) plaque index (PI), according to Sillness and Loe (56),

(iii) gingival index (GI), according to Silness and Löe (56),

(iv) gingival bleeding on probing (BOP), according to Ainamo and Bay (51).

(v) Additionally, each patient's gingival biotype was assessed and recorded. (57)

All restorative procedures were performed by one experienced prosthodontist (Gianluca Paniz) under local anesthesia (articaine with 1:100.000 epinephrine). 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. (1, 2) The chamfer diamond burs used for the initial preparation of teeth in group 1 had a grit size of 151µ (6881; Komet, Milan, Italy), while a grit size of 25µ (881 EF; Komet, Milan, Italy) was used for the finishing procedures. The same grit sizes were employed for group 2. However, long flame shaped diamond burs were used (6862 and 862EF; Komet, Milan, Italy) for the second group. Finally, the tooth surface was polished with ultrasonic devices (Komet SF1LM, Komet Italia). The facial restorative margin was initially prepared equi-gingivally and was then placed 0.5 mm below the gingival margin, using a 40.000 rpm speed (Expertmatic E25L; KAVO GmbH, Biberach, Germany) and a 4.5× magnification (EyeMag Pro F; Zeiss GmbH, Oberkochen, Germany).

Figure 10. Schematic representation of periodontium and tooth emergence profile.
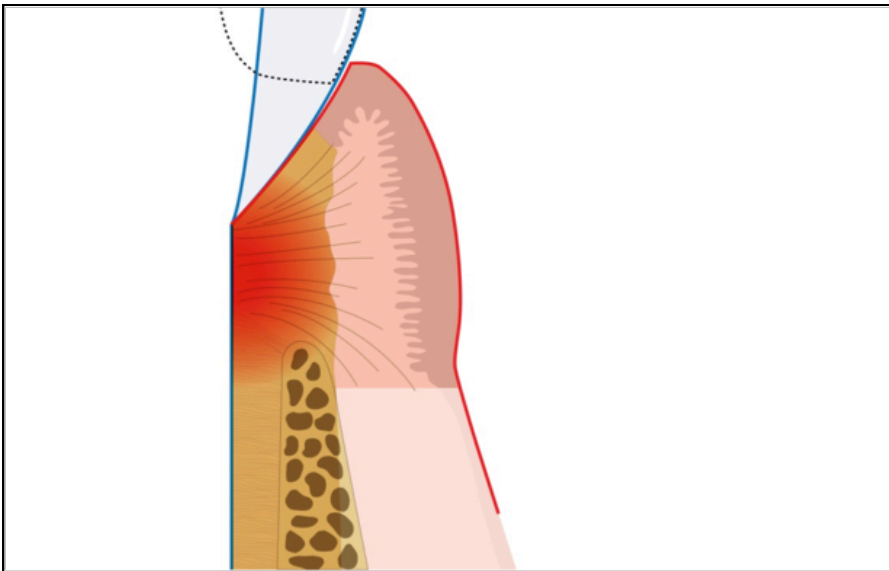
Figure 11. Schematic representation of periodontium, tooth emergence profile and horizontal margin design.
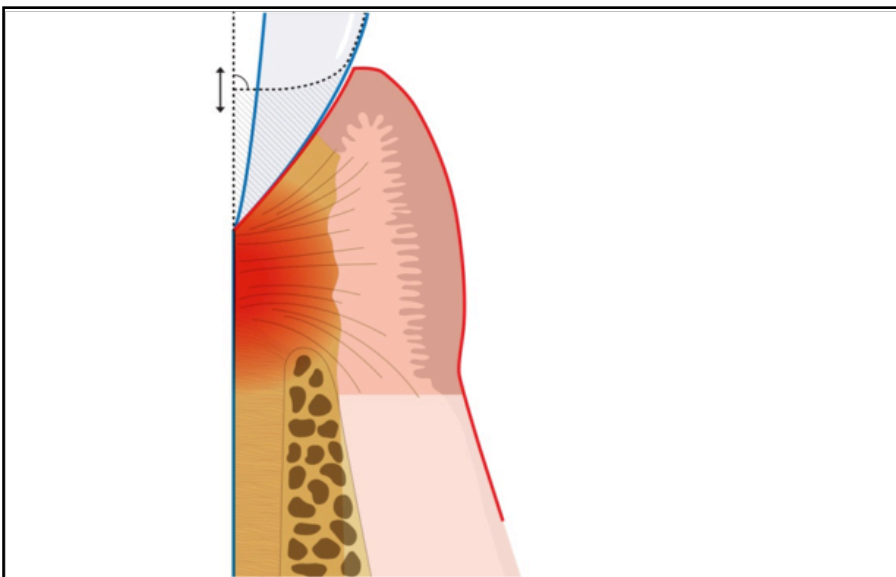
Figure 12. Schematic representation of periodontium, tooth emergence profile and vertical margin design.

All provisional restorations were fabricated with heat-polymerizing polymethylmethacrylate (PMMA) acrylic resin (C&B V Dentine; Major Prodotti Dentari, Moncalieri, Italy) and were then relined with auto-

polymerizing PMMA acrylic resin (Jet; Lang Dental Mfg Co, Wheeling, IL, USA), in order to minimize the adverse effects of free monomer excess and heat transfer to the tooth and the surrounding tissues. (58, 59) The facial restorative margin of second group restorations was finalized and carefully positioned 0.5mm below the gingival margin. Patients were dismissed and advised to use a 0.2% chlorhexidine gluconate solution for 10 days, before returning 12 weeks later for the impression procedures. (60, 61)
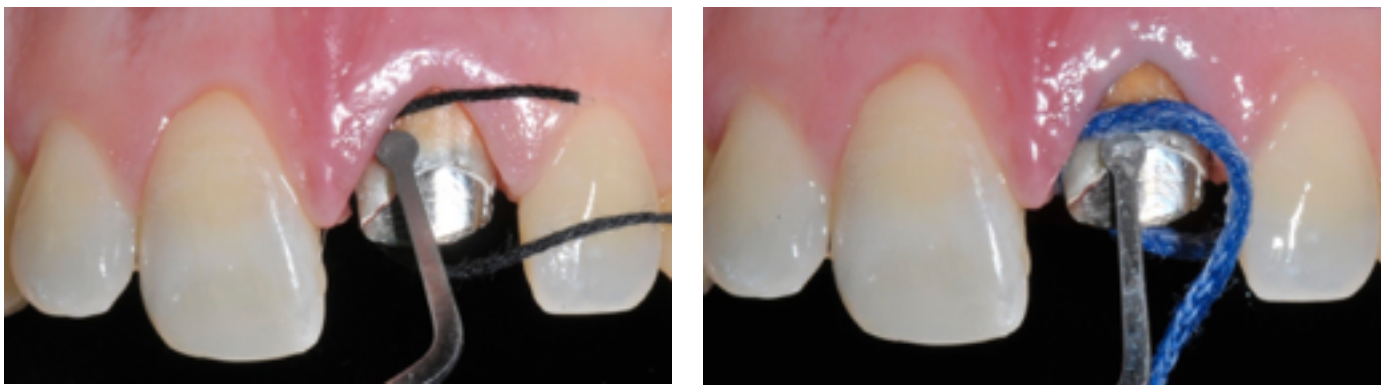
Figure 13-14. Impression procedures with double cord technique.

The zirconia-ceramic restorations (Lava, 3M ESPE, Seefeld, Germany) fabricated for all teeth were cemented with a resin luting agent (RelyX Unicem; 3M ESPE, St. Paul, MN, USA). Cement excess was carefully removed and occlusion was adjusted. Oral hygiene instructions were given to the patients, including use of dental floss and proxabrushes. Patients were recalled two weeks later and then 3 and 6 months after, for evaluation and oral hygiene measures enforcement. No measurements were taken at these appointments.

Six and twelve months after the cementation of the restorations, the same clinical measurements registered before the initiation of the treatment were taken again by two experienced periodontists (Luca Gobbato and Diego Lops). An additional parameter registered at six and twelve months was the restorative margin in relation to the gingival margin. This was classified as: (i) sub-gingival (not visible), (ii) equi-gingival (slightly visible), (iii) supra-gingival (visible).

An intra-examiner 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 inter-examiner agreement for the assessment of the variables was determined with the Intraclass Correlation Coefficient (ICC). For the two examiners, the t-test ($\alpha=.05$) revealed no statistically significant differences.

Repeated measure one-way analysis of variance (ANOVA) (level of significance, $\alpha=0.05$) was used to determine statistically significant differences between different restorative finishing lines and periodontal parameters. All analyses were performed using statistics software (SPSS 22.0; IBM Corp, Armonk, NY, USA).

Six months after crowns cementation, each patient was asked to answer to a Visual Analogue Scale (VAS) questionnaire in order to assess their level of satisfaction regarding esthetic and functional aspects of the restorations. First answering to the question "how would you grade the esthetic of the crown in term of relation between the

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

PAZIENTE: _____

DENTE: _____

Gentile Paziente,

Le chiediamo di quantificare il suo **grado di soddisfazione estetica**, intesa come naturalezza del rapporto tra corona bianca e gengiva rosa, mettendo un segno (I) sul punto che meglio lo rappresenta nella scala sottostante, tenendo in considerazione i due estremi della linea.

|---|

Completamente   Completamente
Insoddisfatto   Soddisfatto

Figure 15. VAS questionnaire for esthetic satisfaction.

Le chiediamo inoltre di quantificare il suo **grado di soddisfazione funzionale**, intesa come integrazione della corona nella sua bocca, mettendo un segno (I) sul punto che meglio lo rappresenta nella scala sottostante, tenendo in considerazione i due estremi della linea.

|--|

Completamente   Completamente
Insoddisfatto   Soddisfatto
Vorrei sostituire   *Non mi accorgo di avere*
la corona   *una corona con la lingua*
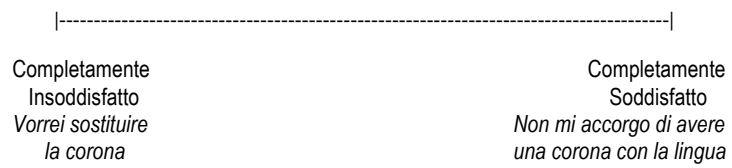
Figure 16. VAS questionnaire for functional satisfaction.

PUBLISHED ARTICLES

ARTICLE 1

Clinical Periodontal Response to Anterior All-ceramic Crowns with either Chamfer or Featheredge Sub-Gingival Margins: 6 month results and patient perception.

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Abstract

Sub-gingival margins are often required due to biological, mechanical or esthetic reasons. Several investigations demonstrated that their utilization 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 sub-gingival margin designs influence the periodontal parameters and patient perception. Deep chamfer and featheredge 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. Featheredge was associated with increased bleeding on probing; deep chamfer with increased recession; improved patient comfort was registered with chamfer margin design. In conclusion sub-gingival margins are technique sensitive especially when featheredge is selected. This margin design may facilitate soft tissue stability but can expose the patient to an increased risk of gingival inflammation.

Introduction

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) Sub-gingival margins may promote adverse inflammatory periodontal reactions, even if bacterial plaque is well controlled.(3, 4) Restorations with sub-gingival margins have been associated with inaccurate margins,(5, 6) over-contoured profiles,(7, 8) impaired oral hygiene,(9, 10) increased pathogenicity of the sub-gingival 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 sub-gingival margins.(3, 4, 14) Additionally, restorations with sub-gingival margins have demonstrated increased attachment loss.(15, 16) Even if plaque is well controlled sub-gingival margins present increased bleeding on probing compared to supra-gingival ones.(17, 18, 19)

Sub-gingival margins are indicated in multiple clinical situations, including presence of existing sub-gingival restorations, dental caries, tooth fracture, abfraction, abrasion, chemical erosion, tooth discoloration, or in order to enhance retention and resistance form and develop ferrule effect. (20-22) The esthetic benefits of sub-gingival margins are well established and contribute to a better crown contour and a 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 0.5-0.7mm into the gingival crevice. (5, 12, 26, 27) Violations of these dimensions might invade the biological width and results in gingival inflammation or gingival recession. (5, 13, 28, 29, 30)

Restorations with sub-gingival margins exhibited increased gingival recession, especially with thin gingival biotypes, even if they are managed properly. (15, 19, 29 30, 31, 32, 33, 34) Therefore it is unlikely that these margins will remain sub-gingival over time and exposure of tooth structure might be expected. Recently, improved soft tissue stability, better gingival scalloping and better esthetics, has been reported with the application of featheredge tooth preparation and a biologically oriented preparation technique. (25) These recent reports utilize tooth preparation apical to the base of the sulcus, potentially into the attachment to allow space for tissue thickening. Margins are then identified more coronal, verified after a healing period and limited from 0.5-0.7 mm sub-gingival. However distinctions, between tooth preparations extending 0.5 mm intra-sulcular and those extending further sub-gingivally, must be taken into consideration.

The purpose of this prospective randomized clinical study was to evaluate whether or not a deep chamfer intra-sulcular margin design has a different influence on the periodontal soft tissue parameters when compared to a featheredge sub-gingival tooth preparation and intra-sulcular margin. The secondary purpose was to understand if the patient perceives any difference between the two types of finishing lines, in terms of esthetics and functional comfort.

Material and methods

Patient selection

The patient inclusion criteria were as follows: 1) patient requiring single unit maxillary anterior or 1st premolar crown restorations; 2) periodontal probing depth prior to tooth preparation ≤4mm, 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; 5) >2mm of keratinized tissue. The patient exclusion criteria were as follows: 1) patient with 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) smokers; 5) inability or unwillingness to return for follow-up visits.

Prosthetic protocol

After a screening appointment to verify the 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 different treatment groups: Group 1 (deep chamfer) or Group 2

(featheredge). Rounded shoulder and featheredge burs were utilized for patients of Group 1 and 2, respectively (Figure 1-3). After recruitment, oral hygiene instructions were given to the patients and a prophylaxis was performed by a periodontist in order to establish optimal plaque control and gingival health. One week later the following periodontal measurements were registered by two experienced periodontists: (i) Periodontal Probing Depth (PPD), at three different facial sites (mesial, midpoint, distal) with the utilization of a periodontal probe (UNC periodontal probe, Hu-Friedy, Chicago, IL), rounding the measurements to the nearest millimeter, (ii) plaque index (PI), according to Löe and Silness,(35) (iii) gingival index (GI), according to Löe and Silness,(35) (iv) gingival bleeding on probing (BOP), according to Ainamo and Bay.(36) An intra-examiner calibration took place before initiation of the study by examination of ten 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 inter-examiner agreement for the assessment of the variables was determined with the Intraclass Correlation Coefficient (ICC). For the two examiners, the t test (α=0.05) revealed no statistically significant differences.

All restorative procedures were performed by one experienced prosthodontist under local anesthesia (articaine with 1:100.000 epinephrine). 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 151µ (6881; Komet, Milan, Italy), while a grit size of 25µ (881 EF; Komet, Milan, Italy) was used for the finishing procedures. The same grit sizes were employed for group 2. However, long flame shaped diamond burs were used for finalizing the tooth preparation closer to the gingiva (6862 and 862EF; Komet, Milan, Italy). On group 1, the facial restorative margin was initially prepared equi-gingivally and then placed 0.5 mm below the gingival margin, using a 40.000 rpm speed (Expertmatic E25L; KAVO GmbH, Biberach, Germany) and a 4.5× magnification (EyeMag Pro F; Zeiss GmbH, Oberkochen, Germany). Palatal margins were left equi-gingival and gradually deepen inter-proximally to 0.5mm below the gingival margin. (Figure 2) Finally, the tooth surface was polished with ultrasonic devices (Komet SF1LM, Komet Italia). All provisional restorations were fabricated with heat-polymerizing polymethylmethacrylate (PMMA) acrylic resin (C&B V Dentine; Major Prodotti Dentari, Moncalieri, Italy) and were then relined with auto-polymerizing PMMA acrylic resin (Jet; Lang Dental Mfg Co, Wheeling, IL, USA). On group 2, long flame shaped diamond burs identified a flat sub-gingival area without a defined finishing line. In a similar way to gingival curretage, 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 intra-sulcular, 0.5mm below the gingival margin during. (Figure 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; enough time for soft tissue adaptation and maturation was left after the sub-gingival teeth preparation. Zirconia coping 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 the stabilized gingival level, finalized 0.5mm below the gingival margin facially and inter-proximally and left equi-gingival palatally. The zirconia-ceramic restorations (Lava, 3M ESPE, Seefeld, Germany) layered for all the teeth were then cemented with a resin-luting agent (RelyX Unicem; 3M ESPE, St. Paul, MN, USA). Cement excess was carefully removed and occlusion was adjusted. Intra-sulcular margin position was verified and oral hygiene instructions were given to the patients. Patients were recalled two weeks later and then three months after for evaluation and oral hygiene measures reinforcement.

Data collection

Six months after crowns cementation, each patient was asked to answer to a VAS questionnaire in order to assess their level of satisfaction regarding esthetic and functional aspects of the restorations. First answering to the question "how would you grade the esthetic of the crown in term of relation between the white ceramic component and the pink soft tissue?" marking a cross on a 100mm straight line where at the left end read "not satisfied at all" and at the right end read "completely satisfied". Then answering to the question "how would you grade the integration of the crown in the mouth?" marking a cross on another line where at the left end read "not satisfied at all, I would like to change my crown" and at the right end read "completely satisfied, I cannot recognize to have a crown with my tongue". All the answers were measured from left to right in order 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 experienced blinded periodontists. The restorative margin position in relation to the gingival margin was additionally registered. This was classified as: (i) sub-gingival (not visible), (ii) equi-gingival (slightly visible), (iii) supra-gingival (visible).

Data analysis

Descriptive statistics were expressed as mean (standard deviations) and valid percentage for continuous and categorical data, respectively. The baseline comparisons between study groups were performed using the Chi-square test (exact Fisher 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 (Miller, G. A., & Chapman, J. P. 2001) After, Least square (LS) mean ± standard error (SE) was calculated for variables involving each outcome. Paired T-Test or McNemar test (if applicable) were used to compare outcomes at week 6 months vs. baseline. Level of significance was set at 0.05. The SPSS v. 21 software (SPSS Inc., Chicago, IL, USA) was used for all analyses.

Results

Fifty-eight patients (27 males and 31 females, aged 30-64 years, mean age50.3 years, received two hundred full coverage restorations, of which 106 were included in group 1 and 94 in group 2. All participants completed the 6-month follow-up period. Two restorations were lost prior to the 6-month follow-up, one restoration due to abutment root fracture and one due to porcelain fracture. These 2 sites were not included in the statistical analysis and finally 198 restorations were considered. (Table 1)

At 6-month follow-up changes from baseline were observed in Gingival Index, Plaque Index and Bleeding on Probing. There were 12.6% of the sites that presented dental plaque at 6 months while at baseline dental plaque was not present. Patients at baseline did not show any degree of gingival inflamation or bleeding on probingwhile at 6-month follow-up 43.4% of patients scored from 1 to 3 in the gingival index and about 39% of patients presented bleeding. Statistically significant differences were present also in regards to the Periodontal Probing Depth. PPD at mesial and distal sites increased compared to baseline (p=0.001) while PPD at facial sites decreased (p=0.001). (Table 1)

Considering the two different preparation groups, no differences for PPD were identified in Least Square(LS)mean change from baseline to 6-month follow-up for mesial, facial or distal site (p=0.355; p=0.168; p=0.058 respectively). Plaque and gingival index at 6-month follow-up were similar in both the groups (p=0.240 and p=0.485). Significantly more sites of group 2 had bleeding on probing (48.4%) versus group 1 (30.5%) (p=0.010). (Table 2)

Significant differences were shown in gingival margin position between groups. (Table 3) At 6-month follow-up, group 1 showed more recession with higher frequency of restorations with equal or supra gingival margin position compared to group 2 (7.6% vs. 1.1%; Fisher test =0.027).

Patient satisfaction was evaluated in terms of esthetic and of function, as described above. The median VAS value for the esthetic satisfaction and functional satisfaction was 96,5 and 98,0 respectively. Statistically significant differences were present between the two groups in patient perception of the esthetic result (p-value=0,002) and of function (p-value=0,002), with higher VAS median values for patients of group 1. (Table 4)

Discussion

The present research focused on sub-gingival margins in the esthetic zone since margins are often sub-gingival in order 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 prosthetic literature in regards to finish line form, but at the end the selection criteria should be based on personal preferences, esthetics, formation ease and type of restoration. (21) In the present research, two different restorative margins, deep chamfer and featheredge, were compared in regards to periodontal tissue response.

Deep chamfer was prepared intra-sulcular, featheredge was also positioned intra-sulcular but after a deeper sub-gingival tooth preparation. A comparison with intra-sulcular featheredge tooth preparation was not performed. At the 6-month evaluation, plaque and gingival indexes were increased similarly to the previous literature, (11) with no statistically significant differences between the two types of finishing lines. (Table 2) From the comparison of the two groups, statistically significant differences were found in regard to bleeding on probing. In accordance to published articles, a general increased bleeding on probing was noticed around sub-gingival margins. (28, 32, 38) More specifically, even if the gingival tissues appear similar at the 6-month follow-up (similar gingival index), increased bleeding on probing was present with featheredge when compared to chamfer. While at baseline no differences were present between the groups, at 6-month follow-up 48.4% of sites of group 2 had bleeding on probing versus 30.5% of sites of group 1 (p=0.010). (Table 2)

The same clinical and laboratory procedures were adopted in the fabrication of all the restorations, the only difference was the tooth preparation technique. (Figure 2-3) Hence potential difficulties might be related to sub-gingival featheredge technique, as clinicians might not be able to see the preparation finish line. Intra-sulcular margin position during provisional fabrication and definitive restoration finalization might be extremely difficult and time-consuming with potential invasion of the biological width. (5, 13, 30, 34) In this regard, the communication between clinicians and technicians must be clear to overcome the technician's inability to visualize the exact position of the

intra-sulcular margin in the finishing area. In a similar way, the emergence profile could be challenging to determine, both for the provisional and for the definitive restorations. (39, 40) 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 over contouring might be expected. (4, 41, 42, 43)

Restorations with sub-gingival margins have been associated with increased gingival recession, especially with thin gingival biotypes. (29-34). Sub-gingival margins, examined for a mean period of 4 to 12 years, presented gingival recession in 34% of the restorations, much more than around supra-gingival 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 sub-gingival margins had a 2.65 times greater chance of gingival recession when compared to the contra lateral teeth. (32) In the present research, 6 months after the delivery of the restorations, 4.5% of them had gingival recession limited to 0.5 mm, with restorative margins exposure. It is significant to notice that featheredge preparation performed statistically better than chamfer since only 1 crown of group 1 had gingival recession versus 8 of the chamfer group. (Table 3) This potential benefit might be related to the described increased thickness of the periodontal biotype, consequence of the rotary curettage during sub-gingival featheredge tooth preparation. However, as increased bleeding on probing was noticed, longer-term data will be needed in order to rule out the potential negative effect of gingival inflammation in term of tissue stability. For this reason, the results of the present study might be considered as preliminary, as longer observational periods are probably needed in order to establish better correlations between the examined parameters.

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. (44, 45) The results of our study suggest that the interaction between all-ceramic restorations and the gingival tissue is well graded by patients. (Table 4) Considering both the esthetic and functional perceptions, patients did prefer chamfer preparation (p-value<0,001). These results could be explained with the possibility that chamfer follows more closely the tooth emergence profile without interfering too much with the periodontium, while sub-gingival featheredge preparations are more related to a newly developed emergence profile. Thus, the described benefits determined by the modification of the emergence profile with improved esthetic results and better soft tissue stability, do not seem to be experienced by patients.

Conclusions

Within the limitations of this study, more bleeding on probing is present around featheredge margins and significantly more gingival recession is present around deep chamfer margins.

Intra-sulcular margins are technique sensitive especially when sub-gingival tooth preparation with a featheredge margin is selected.

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Figures
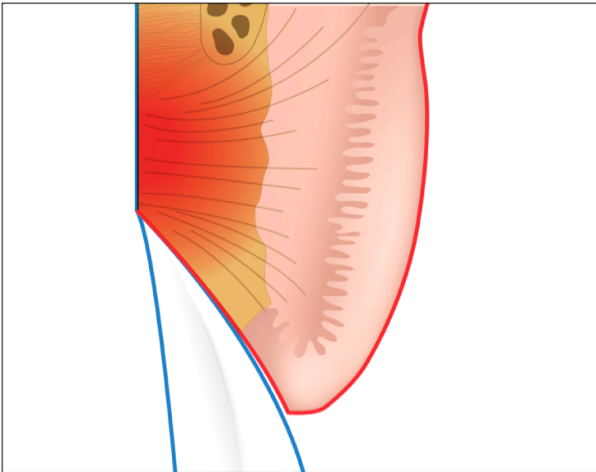
Figure 1. Schematic representation of periodontium and tooth emergence profile (adapted from Maynard JG, Wilson RDK. Physiologic Dimensions of the Periodontium Significant to Restorative Dentist. J Periodontol 1979; 50:170-174).
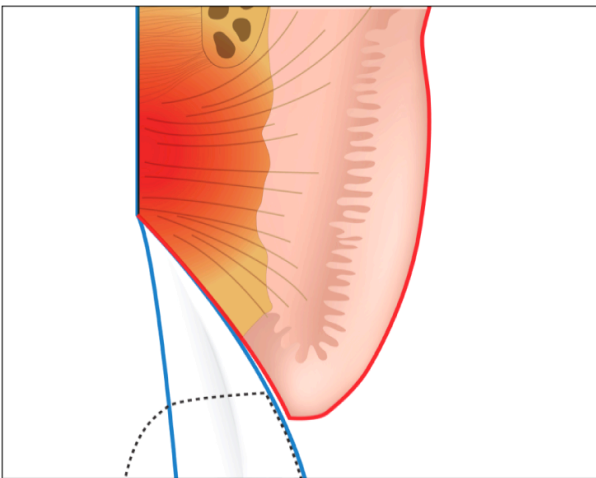
Figure 2. Schematic representation of periodontium, tooth emergence profile and chamfer margin design. The dashed black line indicates the tooth preparation line and the restoration emergence profile.
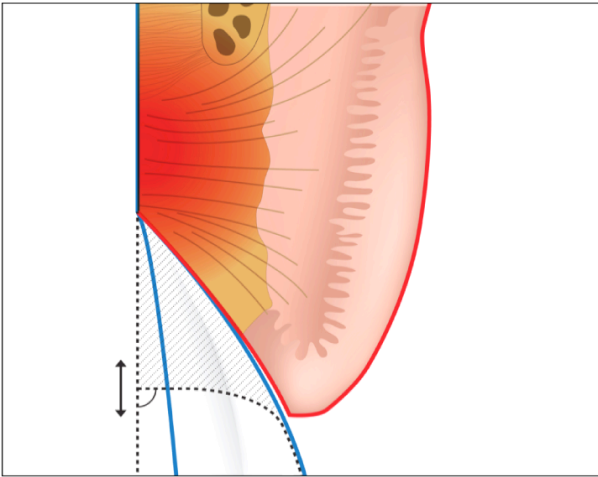
Figure 3. Schematic representation of periodontium, tooth emergence profile and featheredge margin design. The dashed black lines indicate the tooth preparation line (straight portion) and the restoration emergence profile (curved portion).

Figure 4a. Case 1, chamfer margin design: initial condition.

Figure 4b. Case 1, chamfer margin design: tooth preparation.

Figure 4c. Case 1, chamfer margin design: provisional restoration.

Figure 4d. Case 1, chamfer margin design: definitive restoration at 6-month follow-up.

Figure 5a. Case 2, featheredge margin design: initial condition.

Figure 5b. Case 2, featheredge margin design: tooth preparation.

Figure 5c. Case 2, featheredge margin design: provisional restoration

Figure 5d. Case 2, featheredge margin design: definitive restoration at 6-month follow-up.

Tables:

Variable	Baseline (n=198)	6 months follow-up (n=198)	P value
Age, years*	52.4 (11.0)		
Gender (male)	27 (48.2)		
Gingival index, *n(%)* 0 1 2 3	198 (100) - - -	112 (56.6) 66 (33.3) 18 (9.1) 2 (1)	NA
Plaque index, *n(%)* - 0 - 1	198 (100) -	173 (87.4) 25 (12.6)	NA
Bleeding, *n(%)* - 0 - 1	198 (100) -	121 (61.1) 77 (38.9)	NA
PPD mesial, mm *	2.43 (0.60)	2.71 (0.78)	**0.001[1]**
PPD facial, mm*	1.96 (0.57)	1.64 (0.59)	**0.001[1]**
PPD distal, mm*	2.37 (0.60)	2.54 (0.72)	**0.001[1]**

*Mean (standard deviation);[1]Paired T-test (quantitative variables) or [2]Mc Nemar test (qualitative variables). NA: not applicable

Table 1. Sample characteristics pre-post (n=198)

Variable	Baseline	(n=198)		6 months	(n=198)	
	Group 1 chamfer N=105	Group 2 featheredge N=93	P[1]	Group 1 chamfer N=105	Group 2 featheredge N=93	P
Age, years*	54.9 (1.05)	49.6 (0.07)	**0.001**			
Gingival index, *n(%)* 0 1 2 3	105 (100) - - -	93 (100) - - -	NA	57 (54.3) 35 (33.3) 11 (10.5) 2 (1.9)	55 (59.1) 31 (33.3) 7 (7.5) 0	0.485[3]
Plaque index, *n(%)* - 0 - 1	105 (100) -	93(100) -	NA	89 (84.8) 16 (15.2)	84 (90.3) 9 (9.7)	0.240[3]
Bleeding, *n(%)* - 0 - 1	105 (100) -	93 (100) -	NA	73 (69.5) 32 (30.5)	48 (51.6) 45 (48.4)	**0.010[2]**
PPD mesial, mm *	2.29 (0.04)	2.59 (0.07)	**0.001**	2.66 (0.07)	2.77 (0.08)	0.355[2]
PPD facial, mm*	1.90 (0.05)	2.02 (0.06)	0.159	1.58 (0.05)	1.70 (0.06)	0.168[2]
PPD distal, mm*	2.22 (0.04)	2.54 (0.07)	**0.001**	2.45 (0.06)	2.64 (0.07)	0.058[2]

*Quantitative data are showed as mean (standard error)
NA: Not applicable
[1] Non Paired T- Student test: comparisons between groups in baseline measures
[2] ANCOVA (LS mean): comparison 6 months vs. baseline*(mean adjusted by baseline value and age)*
[3] Chi Square test: comparisons between groups at 6 months follow up

Table 2. Pre-post analysis according study groups

Margin design	Baseline	6-month follow-up	
	Sub-gingival margin	Sub-gingival margin	Equa- or Supra-gingival
Group 1 (chamfer)	105 (100%)	97 (92.4%)	8 (7.6%)
Group 2 (featheredge)	93 (100%)	92 (98.9%)	1 (1.1%)
Total	198 (100%)	189 (95.5%)	9 (4.5%)

Table 3: Restorative margin design in relation to gingival margin position

Margin Design	Group 1 (chamfer=105)		Group 2 (featheredge=93)		Total (198)	
VAS	VAS Values (median)	Inter-quartile ranges	VAS Values (median)	Inter-quartile ranges	VAS Values (median)	Inter-quartile ranges
Esthetic	98,0	94,5-100	92,4	80,6-100	96,5	89,7-100
Function	98,0	95,2-100	88,7	81,2-100	98,0	90,3-100

Table 4: Patient esthetic satisfaction ("how would you grade the esthetic of the crown in term of relation between the white ceramic component and the pink soft tissue?") and functional satisfaction ("how would you grade the integration of the crown in the mouth?") in relation to crowns prepared with different margin design.

ARTICLE 2

Periodontal response to two different subgingival restorative margin designs: A 12-month randomized clinical trial.

Abstract

Objectives: subgingival margin placement is sometimes required due to different reasons and is often associated with adverse periodontal reactions. The purpose of this study was to determine if a single restoration with subgingival margin on a tooth, in the maxillary anterior zone, would affect its periodontal soft tissue parameters, and whether or not a deep chamfer preparation has a different influence in the periodontium when compared to a feather edge preparation.

Material and methods: plaque and gingival indexes, periodontal probing depth, bleeding on probing and patient's biotype were registered. 106 teeth were prepared with a deep chamfer, while 94 were prepared with a feather edge finishing line. Twelve months after the restorations delivery the same parameters were evaluated. Repeated measure one-way analysis of variance (ANOVA) (α=0.05) was used.

Results: a statistically significant difference between baseline and the 12-month follow up is present in regards to plaque index, gingival index and periodontal probing depth, but no statistically significant difference between chamfer and feather edge finishing lines. There is a statistically significant difference between baseline and the 12-month follow up in regards to bleeding on probing. Feather edge preparation presents significantly more bleeding on probing and less gingival recession than the chamfer. **Conclusions:** subgingival margins do influence the periodontal soft tissue response. Statistically significant difference exists between feather edge and chamfer finishing lines in regards to bleeding on probing and gingival recession.

Clinical relevance: subgingival margins should be carefully selected, especially when feather edge finishing line is utilized.

Keywords: subgingival margin, periodontal response, recession, bleeding on probing, all-ceramic restoration

Introduction

Every full coverage restoration should restore the prepared tooth to its initial form in order to address certain mechanical and biological requirements, including maximum surface area, adequate thickness of the restorative material, conservation of tooth structure, establishment of anatomic contours and proper location of the finishing line [1]. Furthermore, if the restoration is located in the anterior zone, the esthetic requirements should be fulfilled as well, especially if the patient has a high lip line [2]. Therefore, adequate thickness of porcelain is required along with equi- or sub-gingival margin placement [3,4]. Additional reasons for subgingival margin placement include removal of previous restorations or dental caries, crown fracture, abfraction, abrasion, chemical erosion, susceptibility to root caries, enhancement of retention and resistance form, development of a ferrule effect when a post and core is utilized, or provision of a better crown contour if needed [5-10].

Subgingival restorative margin placement should be very cautiously used and should be limited only in the labial area, from one proximal point to the other. It has been demonstrated in the past that use of subgingival margins is associated with adverse inflammatory periodontal reactions due to the defective tooth-restoration interface [11-16], restoration overcontouring [17-19], difficulty in application of oral hygiene measures [20,21], increased pathogenicity of the subgingival dental plaque [22,23], and violation of the biologic width [24,25].

Clinical and histological studies suggest that subgingival restorative margins may cause undesired tissue effects, even if bacterial plaque is well controlled [21, 26-29]. Localized gingival inflammation and increased plaque, gingival index scores, as well as probing depths have been recorded around prostheses with subgingival margins compared to natural dentition or prostheses with supra-gingival margins [30-34]. Additionally, an in vivo study by Waerhaug has concluded that subgingival restorations are associated with attachment loss. These findings have been confirmed with additional studies [35-38]. Two studies, one in cast gold, metal ceramic and metal acrylic restorations and another one in all ceramic restorations have demonstrated that subgingival margin placement presented greater chances of bleeding than the supragingival finishing lines [39,40]. Furthermore, the restorations with subgingival margins exhibited a gingival recession, especially when these were placed in patients with a thin gingival biotype [33,36,39,41-48]. Therefore, although subgingival margins are many times preferred by many clinicians, due to patients' esthetic concerns, it is highly unlikely that these margins will stay subgingivally over time. In addition, it

has been demonstrated that a greater mean attachment loss is associated with subgingival margins when compared to supragingival ones [49].

Although the benefits of supragingival margin placement are well documented, intracrevicular restorative finishing lines are often unavoidable [37]. In those cases, establishment of a healthy periodontium seems to be of utmost importance, as healthy gingival tissues are stable and less likely to be affected by future recession [6]. Since the healthy gingival sulcus is very shallow, subgingival placement of the restorative finishing line should be performed extremely cautiously, respecting the junctional epithelium [25]. Therefore, placement of the restorative margin should be no deeper than 0.5-0.7 mm into the gingival crevice in order to minimize the deleterious effects caused by even minimal encroachment on the subgingival tissues [50]. Furthermore, an animal study has demonstrated that in that depth a meticulous toothbrushing can effectively remove dental plaque [51].

Although the literature is clear that whenever possible subgingival margins should be avoided, it does not supply a definitive indication as to which type of restorative margin –i.e. chamfer, shoulder, feather edge- should be selected when a subgingival margin is placed. Recently, the utilization of vertical tooth preparation with a biologically oriented technique has been suggested [52]. The authors present this as a method with potential benefits on soft tissue stability of the natural gingival architecture both in short- and long-term. However, the literature lacks scientific evidence comparing different types of subgingival margins as regards to various periodontal indexes.

The purpose of this study was to determine if placement of a single restoration with subgingival margin on a tooth in the maxillary anterior zone would affect its periodontal soft tissue parameters, and whether or not a deep chamfer preparation has a different influence in periodontal soft tissue parameters, when compared to a feather edge preparation. The null hypothesis was that the examined periodontal indexes would not be affected by neither placement of a restoration nor of the type of preparation utilized.

Materials and methods

Study design.

This was a prospective randomized controlled double blind clinical trial, enrolling a sample of patients who needed single full coverage restorations in the anterior maxilla. Patient recruitment

took place in the School of Dentistry of the University of Padova, Italy. It started in July 1, 2013 and was completed in November 29, 2013.

Patients were screened by both a prosthodontist (GP) and a periodontist (LG) for possible inclusion in this study. The criteria used for including patients were as follows: (i) $\geq$ 18 years of age, (ii) dentate patients planned for single full coverage restorations in the area between the 1st bicuspids, (iii) periodontal probing depths $\leq$ 4 mm, (iv) full mouth plaque (FMPS) and bleeding (FMBS) scores $\leq$ 20%, (v) > 2mm of keratinized tissue. Patients satisfying the above mentioned criteria were not included in the study if one or more of the following conditions were met: (i) smoking (>10 cigarettes/day), (ii) substance abuse history, (iii) severe clenching or bruxing habits, (iv) local or systemic disease (endocrine, renal, hematologic, hepatic, immunosuppressive), (v) current steroid/ chemotherapy, (vi) head and neck irradiation, (vii) pregnancy, (viii) inability or unwillingness to return for follow-up visits [53-57].

This prospective study was performed in accordance with the guidelines of the Declaration of Helsinki and the research protocol was approved by the Ethics Committee of the University of Padova (2737P/2013), prior to patient enrollment. Additionally, this clinical study was registered at the U.S. National Institutes of Health Clinical Trials Registry (NCT02276586). Patients were notified that their data would be collected and used for a statistical analysis. A signed informed consent was obtained from all patients enrolled in this study.

Randomization and allocation concealment procedure

All teeth planned for full-coverage restorations were randomly allocated to one of the two different treatment groups, according to a computer-generated randomization list. The teeth allocation was concealed by means of sealed envelopes until the moment of preparation. The randomized treatment code (Group 1 or 2) was available in closed non-transparent envelopes that were opened before teeth preparation. Patients were assigned to Group 1 (horizontal finishing line) or to Group 2 (vertical finishing line).

Treatment procedures

The time sequence of all procedures is depicted in Fig. 1. After recruitment, a periodontal prophylaxis was performed by a periodontist and then oral hygiene instructions were given to the patients in order to establish optimal plaque control and gingival health. Twelve weeks later the following periodontal measurements were registered by experienced periodontists (LG and DL) [58]: (i) Periodontal Probing Depth (PPD), at three different facial sites (mesial, midpoint, distal)

with the utilization of a periodontal probe (UNC periodontal probe, Hu-Friedy, Chicago, IL), rounding the measurements to the nearest millimeter, (ii) plaque index (PI), according to Sillness and Loe [59], rounded at the highest score, (iii) gingival index (GI), according to Löe and Silness [60], rounded at the highest score, (iv) gingival bleeding on probing (BOP), according to Ainamo and Bay [54]. Additionally, each patient's gingival biotype was assessed and recorded [61].

All restorative procedures were performed by one experienced prosthodontist (GP) under local anesthesia (articaine with 1:100.000 epinephrine). 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 [1]. The chamfer diamond burs used for the initial preparation of teeth in group 1 had a grit size of 151μ (6881; Komet, Milan, Italy), while a grit size of 25μ (881 EF; Komet, Milan, Italy) was used for the finishing procedures. The same grit sizes were employed for group 2. However, long flame shaped diamond burs were used (6862 and 862EF; Komet, Milan, Italy) for the second group. Finally, the tooth surface was polished with ultrasonic devices (Komet SF1LM, Komet Italia). The facial restorative margin was initially prepared equi-gingivally and was then placed 0.5 mm below the gingival margin, using a 40.000 rpm speed (Expertmatic E25L; KAVO GmbH, Biberach, Germany) and a 4.5× magnification (EyeMag Pro F; Zeiss GmbH, Oberkochen, Germany). All provisional restorations were fabricated with heat-polymerizing polymethylmethacrylate (PMMA) acrylic resin (C&B V Dentine; Major Prodotti Dentari, Moncalieri, Italy) and were then relined with auto-polymerizing PMMA acrylic resin (Jet; Lang Dental Mfg Co, Wheeling, IL, USA), in order to minimize the adverse effects of free monomer excess and heat transfer to the tooth and the surrounding tissues [62, 63]. The facial restorative margin of second group restorations was finalized and carefully positioned 0.5mm below the gingival margin. Patients were dismissed and advised to use a 0.2% chlorhexidine gluconate solution for 10 days, before returning 12 weeks later for the impression procedures [64, 65].

The zirconia-ceramic restorations (Lava, 3M ESPE, Seefeld, Germany) fabricated for all teeth were cemented with a resin luting agent (RelyX Unicem; 3M ESPE, St. Paul, MN, USA). Cement excess was carefully removed and occlusion was adjusted. Oral hygiene instructions were given to the patients, including use of dental floss and proxabrushes. Patients were recalled two weeks later and then 3 and 6 months after, for evaluation and oral hygiene measures enforcement. No measurements were taken at these appointments.

Twelve months after the cementation of the restorations, the same clinical measurements registered before the initiation of the treatment were taken again by two experienced periodontists (LG and DL). An additional parameter registered at twelve months was the restorative margin in relation to

the gingival margin. This was classified as: (i) sub-gingival (not visible), (ii) equi-gingival (slightly visible), (iii) supra-gingival (visible).

An intra-examiner 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 inter-examiner agreement for the assessment of the variables was determined with the Intraclass Correlation Coefficient (ICC). For the two examiners, the t-test (α=.05) revealed no statistically significant differences.

Repeated measure one-way analysis of variance (ANOVA) (level of significance, α=0.05) was used to determine statistically significant differences between different restorative finishing lines and periodontal parameters. All analyses were performed using statistics software (SPSS 22.0; IBM Corp, Armonk, NY, USA)

Results

Fifty-eight patients (27 males and 31 females, aged 30-64 years, mean age 50.3 years) received two hundred full coverage restorations, of which 106 were included in group 1 and 94 in group 2. All participants completed the 12-month follow-up period. However, four restorations were lost due to either fracture of the root (n=2) or the restoration (n=2), prior to the 12-month follow-up. The fractured roots were removed and implants were placed, while the fractured restorations were replaced with new ones. Nevertheless, these 4 sites were not included in the statistical analysis. Therefore, 196 restorations were included in the statistical analysis. Plaque and gingival indexes, gingival recession, BOP, and PPD were analyzed in relation to different finishing lines and patient's biotype.

Plaque index

At baseline, all sites had a plaque index of 0. Twelve months after, 14.4% of the restorations in group 1 presented an increase from 0 to 1, while 3.8% presented an increase from 0 to 2. In group 2, the increase from 0 to 1 was 17.4%. No restorations presented a plaque index of 2 in group 2. There was a statistical significant difference between baseline and the 12-month follow up (p<0.001), regarding plaque index. However, no statistical significant differences were revealed between the two types of preparation (p=0.148) (Table 1).

Gingival index

Similarly, at baseline all sites had a gingival index of 0. Twelve months post-treatment, 33.7% of the restorations in group 1 increased from 0 to 1, 11.5% presented an index of 2, while 1.9%

increased from 0 to 3. In group 2, the increase from 0 to 1 was 31.5%, while 9.8% presented an index of 2. No restorations presented a gingival index of 3 in group 2. There was a statistical significant difference between baseline and the 12-month follow up ($p<0.001$), regarding gingival index. Nevertheless, no statistical significant differences were found between the two types of preparation ($p=0.518$) (Table 2).

PPD

Periodontal probing depths increased at mesial and distal sites, while a reduction was noted at the facial (mid-distance) site from baseline to the 12-month follow-up (Table 3). One-way ANOVA revealed statistical significant differences for all registered sites ($p<0.001$), while the combined effect of *"PPD measurement differences × preparation type"* was not statistically significant for none of the measured sites ($p=0.467$, $p=0.486$, $p=0.833$).

BOP

At baseline, all tested sites were free of bleeding on probing. One-way ANOVA revealed statistically significant differences ($p<0.001$) between the two preparation types. ANOVA also demonstrated that the combined effect of *"BOP measurement differences × preparation type"* was also statistically significant ($p=0.028$). An important finding was that 52.2% of the restorations with a vertical finishing line presented bleeding on probing, while only 36.5% of the restorations with a horizontal finishing line presented bleeding on probing at the 12-month follow-up (Table 4 a and 4b).

Gingival recession

All restorative finishing lines were positioned 0.5mm sub-gingivally. The position of the margins in relation to the gingival level was re-evaluated at the 12-month follow-up and is reported on Table 5. A statistically significant difference was found between the types of preparation ($p=0.03$). No gingival recession was noted in 96.7% of the restorations prepared with a vertical margin design compared to 88.5% of the restorations prepared with a horizontal margin design.

Biotype

Patients' biotype did not have an influence on the PPD and on BOP, as the combined effect of *"PPD measurement differences × biotype"* was not statistically significant for none of the measured sites (mesial $p=0.951$, facial $p=0.193$, distal $p=0.390$). Furthermore, the combined effect *"PPD measurement differences × preparation type × biotype"* did not present statistical significance either (mesial $p=0.548$, facial $p=0.922$, distal $p=0.382$). Regarding the BOP, the combined effect *"BOP measurement differences × biotype"* was not statistically significant ($p=0.08$). Additionally, the

combined effect *"BOP measurement differences × preparation type × biotype"* did not present statistical significance either (*p*=0.181).

Discussion

The results of the present randomized clinical trial suggest that placement of a single restoration in the maxillary anterior zone affects the periodontal soft tissue parameters. Therefore, the first part of the null hypothesis has to be rejected. Instead, the type of the restorative finishing line presented a statistically significant influence only on BOP and recession.

Although there is some controversy in the literature, as to whether or not subgingivally placed restorative materials (i.e. amalgam, glass ionomer, composite resin) may or may not adversely affect the periodontal clinical parameters [66,67], a 26-year longitudinal study has demonstrated that full coverage restorations with subgingivally placed finishing lines have a detrimental effect on periodontal health [68]. Moreover, that study confirmed that the deterioration of the clinical periodontal parameters was evident 1 to 3 years after the delivery of the restorations. Previous studies have also reported on this issue [23,32,49,69]. It has been suggested that the negative effect of subgingivally placed margins is associated to inflammation due to plaque increase [23,70]. Furthermore, it has been advocated that there is a change in the subgingival microflora from a profile related with health to one associated to disease, namely Gram-negative anaerobic bacteria, black-pigmented Bacteroides and an increased anaerobe [22]. Besides the defective margins which can create an environment favoring changes in subgingival microflora, other factors influencing gingival inflammation include: a) improper emergence profile, b) lack of attached gingiva, and c) violation of the biologic width [37,70]. Every effort was made so that these factors could be ruled out, in order not influence the clinical outcome of the present study. In particular, every definitive impression captured the surface of the prepared tooth below the finishing line and the dies were trimmed by the same laboratory master technician under a microscope in order to preserve the anatomy of the root immediately below the margin. The second factor was eliminated by including in the study only patients who had more than 2 mm of attached keratinized gingiva. The third factor was taken care of by carefully measuring the sulcus depth before treatment and placing the finishing line only 0.5 mm below the gingival margin, as suggested by Nevins and Skurow [25], with the help of 4.5× magnification loops.

Plaque and gingival indexes presented a slight increase at the 12-month evaluation, with no statistically significant differences between the two types of finishing lines. This finding is consistent with the results presented by Flores-de-Jacoby et al, who found that 1 year post-delivery

subgingival margins presented increased plaque, gingival index scores and probing depths [23]. Additionally, in that study subgingival margins were associated with an increase in spirochetes, rods, fusiforms and filamentous bacteria. It should be mentioned however that, all ceramic restorations present a smaller plaque index than metal-ceramic crowns, natural teeth, cast gold restorations, and acrylic resin veneer crowns [73]. Therefore, the increase in plaque and gingival indexes registered in the patients of the present study are probably associated with the restorative procedures and the subgingival margin placement than with the all ceramic material used.

As already mentioned in the results, an increase in the PPD index was found for the mesial and distal sites, while a decrease was noted for the facial (mid-distance). This finding could be related to patient's difficulty to clean effectively the interproximal surfaces, as compared to the facial one. Furthermore, the restorative procedures - i.e. preparation, impression, and removal of luting agent's excess - are more difficult in these areas [74,75]. It has been demonstrated in the past that plaque accumulation and gingivitis are more evident in proximal areas with well-adapted subgingival amalgam restorations compared to non-restored tooth surfaces [74]. It has also been stated that restorations with subgingival margins can contribute to plaque accumulation, especially in areas that are hard to be efficiently treated with scaling instruments [76,77].

Regarding BOP the results of the present study are in accordance with the majority of the studies reporting on that subject [30-34], but they are in contrast with those reported by Loi et al [10]. A statistically significant higher rate of BOP was associated with the vertical finishing line when compared to the horizontal one. As discussed earlier in this paper, these findings are probably associated with technical difficulties encountered during the fabrication of restorations on teeth prepared with a feather edge finishing line, including a possible improper emergence profile at the provisionalization phase, technician's inability to visualize the exact position of the margin, difficult communication between clinician and technician in determining the exact finishing line position, as well as overcontouring of the definitive restoration in order to improve the gingival scalloping and also to increase the strength of the ceramic material at the cervical area. In addition, Dragoo and Williams have demonstrated that beveled margins are associated with a compromised healing, when compared to shoulder preparations [78,79]. Although, the finishing line associated with increased BOP in the present study was not a bevel by definition, it can be understood that the feather edge preparation can be considered as a long bevel. Thus, with teeth prepared with feather edge, by establishing a new emergence profile with increased contour, potential problems might be expected. This has been proved to be an important factor for the presence or absence of gingival health, as a

study has demonstrated that as the facial and lingual cervical contours of an artificial crown are increased, so does the plaque and sub-gingival microflora [37,70,71,72].

Sub-gingival margin placement presents a problem not only for the periodontal health but for soft tissue stability, as well [28-30]. In a clinical study, Valderhaug et al have examined crowns with sub-gingival margins for a mean period of 4 to 12 years, and found that gingival recession occurred in 34% of the restorations, while it affected only 6% of the crowns with supra-gingival margins [33]. Similarly, a longitudinal study with a 15-year follow-up has demonstrated that crowns with subgingival margins had a 2.65 times higher chance of gingival recession when compared with the contralateral teeth [39]. The present clinical research confirmed this risk, since 12 months after delivery of the restorations 7.7% of them presented a gingival recession which exposed the restorative margins. It should be mentioned however that, in the present clinical trial only 1,5% of the restorations presented supra-gingival margins at least in one portion of their facial aspect, at the 12-month follow-up examination [44,45]. The gingival recession registered was in the range of 0.5 mm, and was associated with the horizontal (chamfer) finishing line. This finding seems to favor the vertical (feather edge) finishing line in regards to gingival recession. However, a closer look to the results reveals that vertical finishing line demonstrated increased BOP, which along with edema is a sign of inflammation [80,81]. This may be the explanation as to why the restorations with feather edge preparation did not present a gingival recession.

The importance of gingival biotype in treatment planning and in the final esthetic outcome has been discussed by several authors in the past [82-86]. It has been demonstrated that different periodontal biotypes respond in a different way to surgical and restorative procedures. Siebert and Lindhe have categorized the gingiva into "thin-scalloped" and "thick-flat", while Becker et al suggested three distinct periodontal biotypes, namely "flat", "scalloped" and "pronounced scalloped" [84,85]. Besides the differences in their morphologic characteristics, "thin-scalloped" biotypes are not considered as resistant, since they respond to surgical trauma or restorative procedures with recession, while the "thick-flat" type is resistant to trauma and responds with infra bony defect and pocket formation. Patients' gingival biotype was also registered, using Kan classification, in an effort to reveal its potential influence on the measured clinical parameters [61]. However, a relationship between the gingival biotype and the clinical outcome could not be established by the present study. A larger sample size is maybe required to reveal whether or not such a relationship exists.

The results of the present study may be considered as preliminary, as a bigger sample size and longer observational periods are probably needed in order to establish possible unidentified correlations between the examined parameters.

Conclusions

Within the limitations of the present randomized clinical trial the following conclusions can be drawn:

1. Sub-gingival margins should be carefully selected and managed, as there is a statistically significant difference between baseline and the 12-month follow up in regards to plaque index, gingival index, and periodontal probing depth but there is no statistically significant difference between chamfer and feather edge finishing lines in regards to these parameters.

2. Vertical tooth preparations could represent a potential risk for periodontal tissues and need particular care when selected during tooth preparation, provisional restoration fabrication, impression procedures and cementation, as there is a statistically significant difference between baseline and the 12-month follow up in regards to bleeding on probing. Feather edge preparation presents significantly more bleeding on probing than the chamfer.

3. Vertical tooth preparation might be preferred when soft tissue level has a crucial esthetic impact, as a statistically significant difference exists between feather edge and chamfer finishing lines in regards to gingival recession. Increased recession was noticed around chamfer preparation.

4. A correlation between gingival biotype, periodontal probing depth, bleeding on probing and the two finishing lines could not be established.

Compliance with ethical standards: This prospective study was performed in accordance with the guidelines of the 1964 Declaration of Helsinki and the research protocol was approved by the Ethics Committee of the University of Padova (2737P/2013), prior to patient enrollment. Additionally, this clinical study was registered at the U.S. National Institutes of Health Clinical Trials Registry (NCT02276586). Patients were notified that their data would be collected and used for a statistical

analysis. A signed informed consent was obtained from all patients enrolled in this study. This article does not contain any studies with animal performed by any of the authors.

Conflict of interest: None of the participating authors has any affiliation with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials presented in this manuscript.

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Tables

Table 1: Plaque index score scores in relation to margin design features (12-month-data).

Plaque index		0	1	2	3	Total
Horizontal (H)	Number of crowns	85	15	4	0	104
	Percentage of crowns	81.7	14.4	3.8	0.0	100
Vertical (V)	Number of crowns	76	16	0	0	92
	Percentage of crowns	82.6	17.4	0.0	0.0	100
Total	Number of crowns	161	31	4	0	196
	Percentage of crowns	82.1	15.8	2.0	0.0	100

Table 2: Gingival index scores in relation to margin design features (12-month-data).

Gingival index		0	1	2	3	
Horizontal (H)	Number of crowns	55	35	12	2	104
	Percentage of crowns	52.9	33.7	11.5	1.9	100
Vertical (V)	Number of crowns	54	29	9	0	92
	Percentage of crowns	58.7	31.5	9.8	0.0	100
Total	Number of crowns	109	64	21	2	196
	Percentage of crowns	55.6	32.7	10.7	1.0	100

Table 3: PPD in relation to margin design features and different sites (12-month-data).

Mesial Site	Sample number	Mean PPD (mm)
Horizontal (H)	104	2.3
Vertical (V)	92	2.5
Total (H+V)	196	2.4
Facial Site	**Sample number**	**Mean PPD (mm)**
Horizontal (H)	104	1.9
Vertical (V)	92	2.0
Total (H+V)	196	2.0
Distal Site	**Sample number**	**Mean PPD (mm)**
Horizontal (H)	104	2.2
Vertical (V)	92	2.4
Total (H+V)	196	2.3

Table 4a: Bleeding on probing score and margin design features (Chi-square 4.846, p-value 0.028).

Bleeding on probing		H (Horizontal)	V (Vertical)	Total
NO	Number of crowns	66	44	110
	%	63.5	47.8	56.1
YES	Number of crowns	38	48	86
	%	36.5	52.2	43.9
Total	Number of crowns	104	92	196
	%	100.0	100.0	100.0

Table 4b. One-way ANOVA for BOP from baseline to 12 month follow-up.

Tests of Within-Subjects Contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Baseline to 12-month follow-up	19.209	1	19.209	158.334	<0.001
Baseline to 12-month follow-up × preparation type	.597	1	.597	4.918	.028
Error (Baseline to 12-month follow-up)	23.536	194	.121		

Table 5: Restorative margin design in relation to gingival margin position (*p*=0.03).

Margin design	Baseline	12-month follow-up	
	Sub-gingival margin	Sub-gingival margin	Equa- or Supra-gingival
Horizontal (H)	106 (100%)	92 (88.5%)	12 (11.5%)
Vertical (V)	94 (100%)	89 (96.7%)	3 (3.3%)
Total (H+V)	200 (100%)	181 (92.3%)	15 (7.7%)

ARTICLE 3

Implicaciones clínicas de la preparación vertical a nivel subgingival del diente en la zona estética.

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Resumen

En ciertas situaciones los clínicos nos vemos obligados a utilizar márgenes subgingivales, especialmente en la zona estética, pero su aplicación, en particular cuando la terminación es una línea vertical, puede presentar un riesgo de trauma para los tejidos periodontales.

El caso clínico presentado subraya las ventajas y desventajas relacionadas con la preparación de márgenes verticales en posición subgingival.

Introducción

Cada restauración completa tiene que reconstruir el diente preparado a su forma inicial para poder obtener determinadas dimensiones mecánicas y biológicas requeridas, siguiendo los principios básicos de la preparación del diente (Rosenstiel y cols. 2006; Shillinburg y cols. 1987). Los márgenes deben situarse supragingivalmente para evitar daños a los tejidos periodontales, como la literatura nos indica claramente, los márgenes subgingivales pueden estar relacionados a reacciones adversas con inflamación periodontal aun que hay un buen control de la placa bacteriana. La inflamación gingival localizada con un índice de placa y sangrado elevado y presencia de bolsas periodontales, ha sido detectado alrededor de las prótesis con márgenes subgingivales en comparación con la dentición natural o con prótesis con márgenes supragingivales (Bader y cols. 1991; Padbury y cols. 2003). Las restauraciones con márgenes subgingivales también han sido asociadas con perdida de inserción, incluso con un buen control de la placa (Koke y cols. 2003; Giollo y cols. 2007). Hay varios estudios que han demostrado que los márgenes subgingivales presentan mas probabilidad de tener sangrado al sondaje comparado con los márgenes supragingivales (Gemalmaz y Ergin 2002; Valderhaug y Birkeland 1976).

Sin embargo, en múltiples situaciones clínicas, (Figuras 1, 2 y 3) los márgenes de la futura restauración se deben de posicionar subgingivalmente debido a la presencia de una restauración antigua, caries dental, fractura de la corona, abfracción, abrasión, erosión o descoloración del diente (Chiche y Pinault 1994; Goodacre y cols. 2001; Tan y cols. 2005). La preparación de márgenes subgingivales (Figuras 4 y 5) se utiliza también para optimizar

la estética con una corona definitiva con un correcto contorno o festoneado gingival (Rufenacht 1990; Kois 1994).

En estos casos, como el surco gingival es muy poco profundo, la preparación subgingival se tiene que realizar de una forma muy prudente, respetando el epitelio de unión, situarlo no mas profundo que 0.5mm – 0.7mm dentro del surco gingival, con una distancia de 0.5mm alejado del fondo del surco (Gargiulo y cols. 1961; Waerhaug 1960).

Si no respetamos dichas dimensiones podemos causar inflamación gingival o una recesión (Nevins y Skurow 1984; Waerhaug 1975).

Es interesante remarcar que las restauraciones con márgenes subgingivales exhiben en general un aumento en recesión gingival, especialmente en pacientes con un biotipo gingival fino (Valderhaug y cols. 1993; Koke y cols. 2003; Tao y cols. 2014).

Aunque muchas veces los márgenes subgingivales son la elección del odontólogo, debido a la preocupación estética del paciente, es muy probable que dichos márgenes no se mantengan subgingivalmente a lo largo del tiempo y que se puede esperar que parte de la estructura dental no preparada quedara expuesta. Recientemente, la aplicación de una técnica biológicamente orientada, con la preparación vertical del diente, para mejorar la estabilidad de los tejidos blandos y conseguir mejor festoneado gingival y estética, ha sido descrita (Loi y Di Felice 2013). Aunque en la literatura científica hay suficiente evidencia que hay que evitar los márgenes subgingivales, no nos da una indicación definitiva de cual es el tipo de margen que se tendría que seleccionar cuando se realiza un margen subgingival (chamfer, hombro, 'feather edge').

Presentamos un caso clínico para resumir posibles beneficios, pero también los efectos negativos de una preparación vertical del diente.

Presentación del caso

Un paciente de 33 años presenta como motivo de consulta una queja estética relacionada con uno de sus incisivos anteriores en el maxilar superior. La pieza 21, tratada con una endodoncia, muestra una descoloración severa y una fractura en su parte coronal. Se planifica una restauración completa. A nivel del cuello del diente observamos una recesión de 1.5mm (Figura 6). Bajo anestesia local (articaina con 1:100.000 epinefrina), una preparación clásica para una corona metal-cerámica se realiza con una profundidad inicial

de 1 mm y una profundidad final a nivel axial de 1.5mm. La preparación inicial se ejecute al mismo nivel de la encía con una fresa diamantada en chamfer (tamaño del grano de 151micron; 6881, Komet, Milan, Italia). El margen se movió a nivel subgingival con fresas diamantadas de forma llama larga (6862 y 862EF; Komet, Milan, Italia) utilizando una velocidad de 40.000 revoluciones por minuto (rpm) (Expertmatic E25L; KAVO GmbH, Biberach, Alemania) y con una magnificación de 4,5x (EyeMag Pro F; Zeiss GmbH, Oberkochen, Alemania). La superficie se pulió con instrumentos ultrasónicos (Komet SF1LM, Komet, Milan, Italia). La restauración provisional se elaboró con una resina acrilica polymerizable por calor de polymethylmethacrylate (C&B V Dentine; Major Prodotti Dentari, Moncalieri, Italia) y se rebaso con resina auto-polimerizable (Jet; Lang Dental Mfg Co, Wheeling, IL, USA). La línea provisional de la preparación se finalizó 0.5mm debajo del margen gingival excepto en la zona donde se presentó la recesión; en dicha área la restauración provisional se finalizó algo supra-gingival, siguiendo la arquitectura gingival del incisivo central contralateral (Figura 7). La maduración de los tejidos blandos se monitorizó a 1 y 6 semanas, con una mejora significativa (Figuras 8 y 9). 12 semanas tras la preparación del diente se tomó una impresión definitiva con un material poli-ether Tras la colocación de un hilo retractor no impregnado de un calibre de 000 y 1 (Ultrapack; Ultradent, Sur Jordania, UT), que se quedaron en el surco durante 5 minutos (Figuras 10, 11 y 12). 14 semanas después de la preparación inicial del diente una corona definitiva de metal-ceramica se cementó encima del muñón con un cemento de resina (Rely Unicem; 3M ESPE, St. Paul, MN, USA) (Figuras 13 y 14). Seguimos el caso durante 5 años. A nivel del incisivo central contralateral se produjo una pequeña recesión, sin embargo se observó una estabilidad de los tejidos alrededor de la restauración metal-ceramica,   por otro lado, el diente con la corona presentó inflamación gingival con sangrado al sondaje (Figuras 15 y 16).

Discusión

La preparación vertical de un diente se recomienda únicamente en situaciones clínicas especificas, y su aplicación no esta recomendada en la zona estética. De hecho, la preparación horizontal del diente esta considerada como la preparación de elección, debido a que proporciona un incremento de espacio para el material en la parte cervical con una

mejor estabilidad estructural, mejor estética y un perfil de emergencia mas adecuado (Conrad y cols. 2007; Paniz y cols. 2013). En los últimos años, la popularidad de la preparación vertical del diente, una técnica que se ha utilizado desde hace muchos años, se ha incrementado de manera significativa, especialmente en la zona estética (Carnevale y cols. 1990). Una preparación biológicamente dirigida, con una preparación vertical del diente y el margen de la corona finalizada en relación a nivel de los tejidos periodontales, ha demostrado unos beneficios potencialmente significativos en la zona estética (Loi y Di Felice 2013).

En el caso presentado, la técnica de preparación vertical del diente con la aplicación del concepto B.O.P.T, ha sido seleccionado para mejorar la calidad de los tejidos periodontales blandos y el resultado estético a largo plazo. Este tipo de preparación dental a nivel marginal ha sido utilizada para poder favorecer la migración coronal de los tejidos blandos vestibulares. Fresas largas diamantadas en forma de llama han sido utilizadas para reducir el perfil de emergencia del diente en la parte vestibular, actuando como un 'gingitage' sobre los tejidos periodontales blandos (Ingraham y cols. 1981). La profundidad de la fresa ha sido controlada utilizando lupas de aumento de 4,5x y con fresas coloreadas con marcas de profundidad; el margen de la restauración provisional se posicionó a una profundidad máxima de 0.5mm subgingival excepto en la parte vestibular del diente, donde la restauración provisional se posicionó 0,5mm subgingival a los niveles deseados de los tejidos blandos. De esta manera beneficiamos de dos aspectos significativos: el primero, relacionado con la reducción del contorno del diente, muy bien descrito en implantes, y el segundo relacionado al 'gingitage' de los tejidos blandos (Rompen y cols. 2007; Ingraham y cols. 1981).

Tras un periodo de 3 semanas, la maduración de los tejidos blandos mejoraba significativamente y la recesión gingival se resolvió. Los resultados del tratamiento se monitorizaron durante 5 años y se observó que mientras los tejidos blandos estaban estables alrededor de la restauración, se podía observar una ligera retracción de los tejidos blandos alrededor del incisivo central contralateral, un diente vital y sin restauración. Los resultados preliminares recogidos por los autores, están confirmando los beneficios de la estabilidad de los tejidos, con una mejora del festoneado gingival, mejora estabilidad de los tejidos y en algunos casos el potencial crecimiento vertical de los tejidos blandos.

De otro lado, otro aspecto significativo se observó a los 5 años. Mientras que no se presentó sangrado al sondaje en la dentición natural del paciente, encontramos sangrado al sondaje

por vestibular del diente restaurado, debido a la presencia de inflamación gingival (Figura 16). Esta presencia de sangrado al sondaje es consistente con resultados que encontramos en la literatura científica, en la que los márgenes subgingivales de una restauración están relacionados con inflamación gingival y sangrado al sondaje (Bader y cols. 1991; Padbury y cols. 2003; Koke y cols. 2003; Giollo y cols. 2007). Dichos resultados son igualmente coherentes con resultados de una investigación preliminar dirigido por los mismos autores de la publicación, en la cual confirman presencia de inflamación gingival y sangrado al sondaje cuando la pieza restaurada tiene unos márgenes subgingivales, especialmente cuando se utiliza una preparación vertical del diente. Estos potenciales riesgos podrían estar relacionados con un incremento del perfil de emergencia de la corona, lo cual es difícil de controlar por el dentista durante tratamientos prostodónticos y por el paciente en su higiene diaria (Stein y Kuwata 1977). Además hay dificultades relevantes a la hora de manejar una preparación vertical de un diente en relación a la libertad de posición de la terminación de la restauración. Aunque dicha libertad representa una potencial ventaja, es imprescindible una estricta comunicación con el protésico del laboratorio para no interferir negativamente con el nivel del espacio biológico.

Por lo tanto, si no hay necesidad de modificar los tejidos blandos, como en dientes vitales, sin descoloraciones o con márgenes gingivales simétricos o con una sonrisa baja, se tendría que considerar y recomendar un margen yuxtagingival (Figuras 17, 18 y 19).

Relevancia clínica

Los márgenes subgingivales tendrían que ser utilizados solo cuando la situación clínica lo requiere y las preparaciones mas conservadoras como las preparaciones yuxtagingivales, siguen siendo el tratamiento de elección siempre que el caso lo permita. Los riesgos potenciales están relacionados con inflamación gingival, recesión y perdida de inserción. La preparación vertical del diente puede favorecer un mejor festoneado gingival y estabilidad de los tejidos, pero viene con un mayor riesgo de inflamación gingival y sangrado al sondaje. Dicha preparación es muy sensible tanto a las complicaciones biológicas como técnicas y a las variaciones del perfil de emergencia.

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Fig. 1: tratamiento estético de piezas 12, 11 y 21. Para poder obtener la estética requerida en dichas piezas se utilizaron 2 carillas de porcelana en piezas 11 y 21 y una corona en pieza 12.

Fig. 2: Los márgenes han sido posicionados supragingivalmente en pieza 21, yuxtagingivalmente en pieza 11 y subgingivalmente en pieza 12.

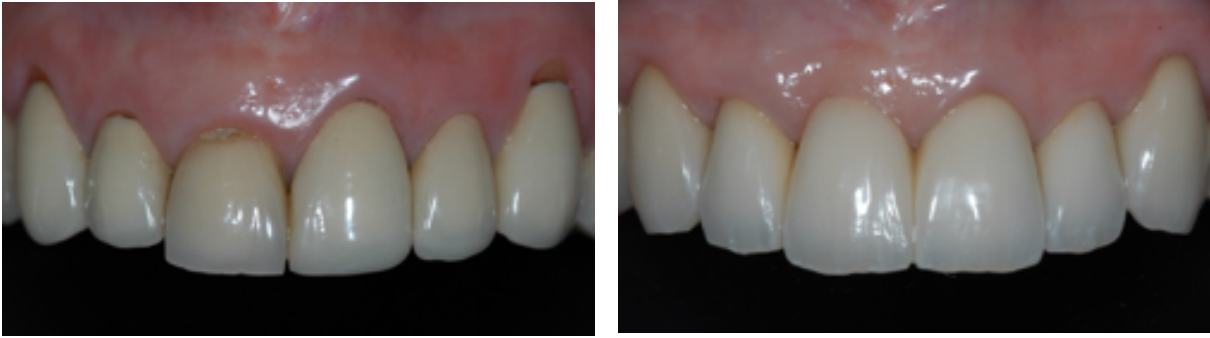Fig. 3: Resultado final con restauraciones definitivas.

Fig. 4-5: Tratamiento estético del sextante anterior. Para poder obtener la estética requerida se reconstruyeron las piezas con 6 coronas con márgenes subgingivales y una modificación del festoneado gingival.

Fig. 6: Corrección del problema estético en pieza 21. Presencia de una descoloración, recesión gingival por vestibular y una restauración de composite defectuosa.

Fig. 7: Restauración provisional tras la preparación vertical de la pieza.

Fig. 8: 1 semana tras la preparación de la pieza y restauración provisional.

Fig. 9: 4 semanas tras la preparación del diente y la restauración provisional.

Fig. 10: Toma de impresión posicionando hilo retractor 000.

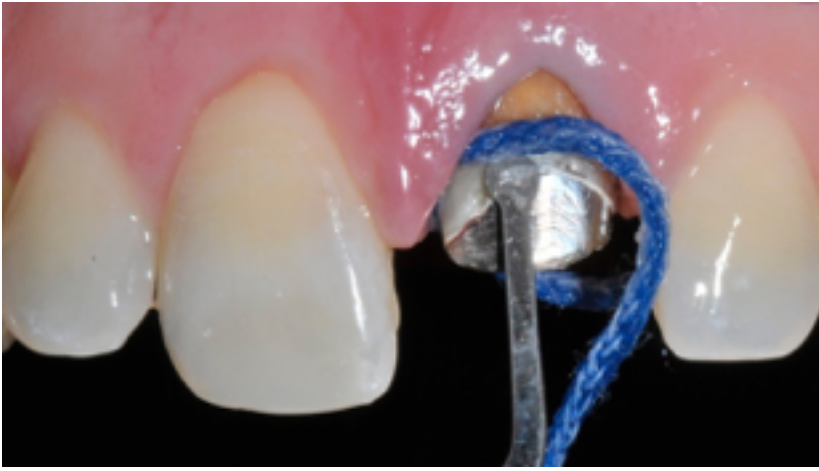Fig. 11: Toma de impresión posicionando hilo retractor 1 encima del hilo retractor 000.

Fig. 12: Imagen con hilos retractores in situ.
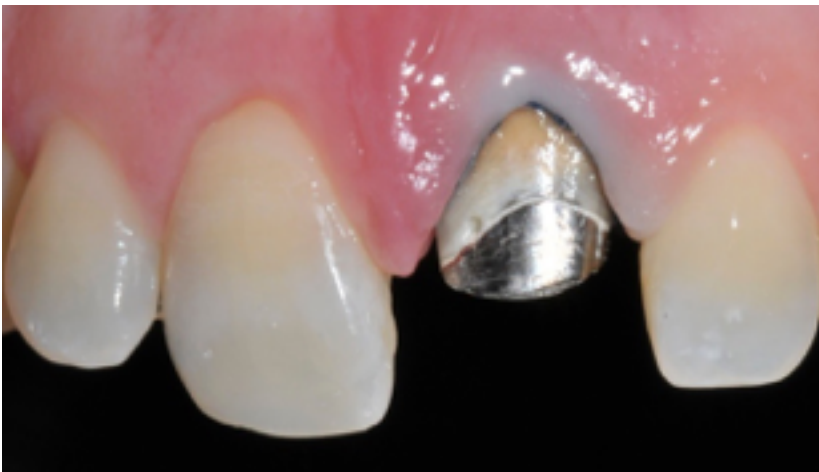

Fig. 13: Restauración final, 1 mes tras el cementado definitivo.
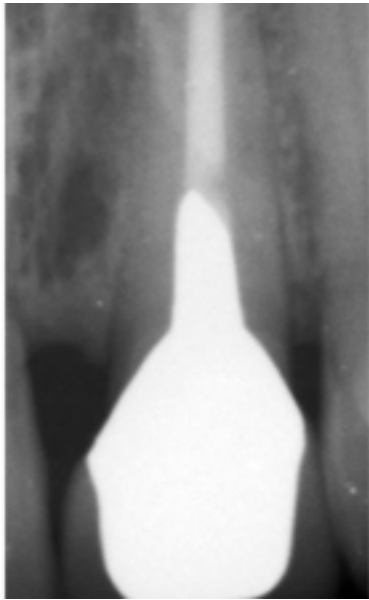
Fig.14: Restauración final, examinación radiológica a los 5 años.

Fig. 15: Restauración final, resultado a los 5 años.

Fig. 16: Restauración final, resultado a los 5 años con sangrado al sondaje.

Fig. 17-19: Tratamiento estético de los incisivos anteriores con márgenes yuxtagingivales.

DISCUSSION

DISCUSSION

Sub-gingival restorative margins are not recommended due to difficulties in managing the prosthetic procedures and especially to the demonstrated negative effects to the periodontium (4-14). The present study confirms these findings with increased bleeding on probing and with increased inter-proximal periodontal probing depth 6 and 12 months after the delivery of restorations with sub-gingival margins, as presented in article one and two.

As described on article 3 it is relevant that sub-gingival margins are necessary in different clinical situations but they should be avoided when not necessary. The present research focused only on sub-gingival margins in the esthetic zone since clinicians are often forced to position the restorative margins sub-gingival in order to improve the treatment outcome and especially to enhance the natural esthetic result and the gingival architecture. (1, 2, 3, 15, 16, 18, 19) Two different restorative margins, deep chamfer and featheredge, were compared, since scientific guidelines have not been described yet. In the recent years improved soft tissue stability, better gingival scalloping and better esthetics, have been presented in a case report with the application of a biologically oriented preparation technique and vertical tooth preparation. (42) Clinical and biological advantages have been described with the application of the so-called BOPT technique, considered easier in regards to tooth preparation, provisional finalization and impression procedures. As described, clinicians can get advantages from the increased freedom in margin positioning and in determining the crown emergence profile. (42) Beside this encouraging

publication, which shows interesting results for this clinical procedure, no scientific data have been described. In our study, plaque and gingival indexes were increased at the 6- and 12- month evaluation, similarly to the previous literature, (62) with no statistically significant differences between the two types of finishing lines. (article 1 and 2) From the comparison of deep chamfer and featheredge with a so-called biologically oriented preparation technique, statistically significant differences were found in regard to bleeding on probing. In accordance to previous literature, a general increased bleeding on probing was noticed around sub-gingival margins. (29, 30, 63) More specifically, even if the gingival tissues appear similar at the 6- and 12-month follow-up (similar gingival index) increased bleeding on probing (BOP) was present with featheredge when compared to chamfer. While at baseline no differences were present between the groups, at 6-month follow-up 48.4% of sites of group 2 had bleeding on probing versus 30.5% of sites of group 1 (p=0.010). (article 1) Similar findings were present at 12-month with results in accordance with the majority of the studies reporting on that subject. (8, 28, 30, 63) A statistically significant higher rate of BOP was associated with the vertical finishing line when compared to the horizontal one. The same clinical procedures were adopted in the fabrication of all the restorations: same clinician, same dental laboratories, same impression materials and retraction cords, same restorative material for provisional and definitive restorations, same type of adhesive cement. The only difference was the tooth preparation technique. (Figure 11 and 12) Hence potential difficulties are probably associated with featheredge. The emergence profile could be determined with more difficulties, both for the provisional and for the definitive restorations. (64, 65) To improve the

gingival scalloping or to increase the strength of the ceramic at the cervical area, potential over contouring might be expected. (3, 66, 67, 68) Furthermore, the useful freedom in determining margin position during provisional fabrication and definitive restoration finalization might be extremely difficult and time-consuming with possible invasion of the biological width. (6, 20, 21, 22, 23) In this regard, the communication between clinicians and technicians must be really solid to overcome the technician's inability to visualize the exact position of the margin. In addition, Dragoo and Williams have demonstrated that beveled margins are associated with a compromised healing, when compared to shoulder preparations. (64, 65) Although, the finishing line associated with increased BOP in the present study was not a bevel by definition, it can be understood that the feather edge preparation can be considered as a long bevel. Thus, with teeth prepared with feather edge, by establishing a new emergence profile with increased contour, potential problems might be expected. This has been proved to be an important factor for the presence or absence of gingival health, as a study has demonstrated that as the facial and lingual cervical contours of an artificial crown are increased, so does the plaque and sub-gingival microflora. (66, 67, 68)

In general, well-managed restorations with sub-gingival margins have been associated with increased gingival recession, especially with thin gingival biotypes. (5, 6, 10, 29). In a clinical research, sub-gingival margins have been examined for a mean period of 4 to 12 years and gingival recession occurred in 34% of the restorations, much more than around supra-gingival margins, where recession occurred only on 6% of the crowns (5). Similarly, in a longitudinal study by the same authors with a 15-year follow-up, crowns with sub-gingival margins had a 2.65

times greater chance of gingival recession when compared to the contra lateral teeth. (29) Our data confirmed this risk, since 6 months after the delivery of the restorations 4.5% of them had gingival recession with restorative margins exposure, even if minimal with recession limited to 0.5 mm. It is significant to notice that featheredge preparation performed statistically better than chamfer since only 1 crown of group 1 had gingival recession versus 8 of the chamfer group (article 1). This potential benefit might be related to the described increased thickness of the periodontal biotype as a consequence of bopt technique. (42) However, as increased bleeding on probing was noticed, longer-term data will be needed in order to rule out the potential negative effect of gingival inflammation in term of tissue stability. For this reason, the results of the present study might be considered as preliminary, as longer observational periods are probably needed in order to establish better correlations between the examined parameters.

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. (69, 70) The results of our study clearly showed that the interaction between all-ceramic restorations and the gingival tissue is well graded by patients. (article 1) Comparing the two different margin types, as expected and suggested in part of previous researches, significant differences were found between restorations prepared with chamfer and featheredge. (19, 42). Considering both the esthetic and functional perceptions, patient did prefer chamfer preparation (p-value<0,001). These results could be explained with the possibility that chamfer follows more

closely the tooth emergence profile without interfering too much with the periodontium, while featheredge preparations are more related to a newly developed emergence profile. Thus, the described benefits determined by the modification of the emergence profile with improved esthetic results and better soft tissue stability do not seem to be experienced by patients.

CONCLUSION

CONCLUSION

Within the limitations of the present randomized clinical trial the following conclusions can be drawn:

1. There is a statistically significant difference between baseline and the 6-month and 12-month follow up in regard to plaque index, gingival index, and periodontal probing depth but there is no statistically significant difference between chamfer and feather edge finishing lines in regard to these parameters.

   Hence sub-gingival margins should be carefully selected and managed.

2. There is a statistically significant difference between baseline and the 6-month and the 12-month follow up in regard to bleeding on probing. Feather edge preparation presents significantly more bleeding on probing than the chamfer.

   Hence vertical tooth preparations could represent a potential risk for periodontal tissues and need particular care when selected during tooth preparation, provisional restoration fabrication, impression procedures and cementation.

3. A statistically significant difference exists between feather edge and chamfer finishing lines in regard to gingival recession. Increased recession was noticed around chamfer preparation both at 6-month and at 12-month.

Hence vertical tooth preparation might be preferred when soft tissue level has a crucial esthetic impact.

4.   A correlation between gingival biotype, periodontal probing depth, bleeding on probing and the two finishing lines could not be established.

7.   In the esthetic zone, full-coverage restorations with sub-gingival margins, are well accepted by the patients, both considering esthetics and function.

8.   When the restorations are fabricated with horizontal margin design patients reports a higher esthetic and functional satisfaction.

Hence horizontal tooth preparation might be preferred by the patients, even if patients are satisfied by crowns fabricated with both type of margins.

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