The purpose of this study was to compare the impact of resin restorations placed supragingivally or impinging periodontal biologic width (PBW). Ten patients (aged 19 to 35 years) with at least two contralateral teeth (premolars and molars) in need of proximal subgingival restorations participated. Test group (TG) (impingement of PBW with transsurgical restorations) and control group (CG) (supragingival restorations after crown lengthening) were randomly assigned. Visible plaque (VP), bleeding on probing (BOP), periodontal probing depth (PPD), and clinical attachment loss (CAL) were evaluated at baseline and at 45, 90, and 180 days, and by transperiodontal probing at baseline and 180 days. Generalized estimating equations, Wald test, and t test were used (P ≤ .05). VP and BOP were reduced and maintained at low levels (less than 10% from day 45 on). PPD initially reduced in the TG. At day 180, no intra- or intergroup differences were observed (P > .05). CAL was higher in the CG after surgery (P < .05) and remained stable for both groups throughout the study. In conclusion, proximal bonded restorations infringing on the PBW may not require clinical crown lengthening.


It is well known that the presence of restorations is associated with an increased prevalence and severity of gingival inflammation as compared to sound tooth surfaces.\textsuperscript{1,2} The location of the cervical margin of restorations is an important factor associated with these observations. Several studies have shown a stronger association between subgingival restorations and gingival inflammation as compared to restorations with the cervical margin located supragingivally.\textsuperscript{3,4} A 26-year follow-up study showed that the presence of restorations with subgingival margins is also associated with greater attachment loss as compared to those with cervical margins located supragingivally.\textsuperscript{5} Some studies have suggested that physical or chemical properties of restorative materials, such as roughness and acidic by-products, may factor into these observations.\textsuperscript{6} The presence of bacteria in association with subgingival restorations has been demonstrated in clinical and morphological studies.\textsuperscript{7,8} It is believed that patients are unable to clean the bacterial deposits in these subgingival areas either because they are located where mechanical cleaning does not reach or because roughness and retentive areas such as the border between restoration and tooth renders bacteria inaccessible.\textsuperscript{9–12}
The actual position of the restorations below the gingival margin has been recognized as a decisive factor in the inflammatory response. The background for these observations is that subgingival restorations often encroach on the periodontal biologic width (PBW). PBW was proposed by Gargiulo et al after histological measurement of the length of the gingival sulcus, junctional epithelium, supracrestal ligament, and bone height in relation to the cementoenamel junction. Since then, different authors have proposed that the integrity of some of these structures should be respected when performing restorative work or should be reestablished by means of crown lengthening prior to placing restorations. It is important to observe that all these recommendations were made in a time when restorative material did not possess adhesive properties, leading to the frequent observation of bacteria in the limits between restoration and tooth.

Experimental studies and some clinical reports have shown that the response of the periodontal structures to new restorative materials may be significantly different from those observed when more traditional materials, such as amalgam or gold, were used. It would be interesting to follow longitudinally restorations placed on the PBW as compared to restorations placed supragingivally. The aim of this clinical study is to compare the periodontal status of patients submitted to restorative procedures employing adhesive resins with or without the impingement of the PBW.

**Materials and methods**

**Experimental design and sample size calculation**

The present study was a randomized split-mouth clinical study. The null hypothesis was that there were no differences between experimental groups for both treatment modalities as far as clinical inflammatory response, periodontal probing depth, and clinical attachment levels are concerned. The protocol of the study was approved by the Ethics and Research Committee of the Federal University of Rio Grande do Sul. The study was conducted according to the Declaration of Helsinki. A sample size of 10 patients was determined using a \(1 \text{ mm} \pm 0.9 \text{ mm}\) difference in clinical attachment loss (CAL) between experimental groups with 80% power, \(.05 \ \alpha\) error, and 20% attrition.

**Study sample**

Patients referred to treatment at the Dental School from the Federal University of Rio Grande do Sul were eligible. According to the following inclusion criteria, 10 subjects were enrolled in the experimental procedures: bilateral carious cavities and/or restorations in need of replacement on proximal surfaces of premolars/molars, and where the cervical margin of the cavity was at a distance less than 3 mm to the bone crest, evaluated by transperiodontal probing (TPP) at baseline and at day 180.

**Randomization and experimental groups constitution**

At baseline, after periodontal examination, teeth were randomly assigned (by a flip of a coin) to a control group (CG) or a test group (TG). The teeth in the CG received, initially, a crown-lengthening surgery.
and, 10 days after, the restoration. The teeth in the TG were restored trans-surgically.

**Surgical and restorative procedures**

The surgical interventions and the proximal restorations were performed in one session. After local anesthesia, the CG teeth were submitted to the crown-lengthening surgery protocol as follows: An apically repositioned flap with osteotomy was performed to establish a distance of 3 mm between the cervical margin of the cavity and the bone crest. Osteoplasty was performed in the adjacent and neighboring tooth surfaces to accomplish a smooth bone contour. The flaps were sutured in their new positions (Fig 1) in the sequence in which the teeth were restored, as described below. In the TG, surgical access was obtained by intrasulcular releasing incisions to gain adequate access to the selected tooth surfaces with no bone excisional intervention. Restorations were performed trans-surgically, and finally the flaps were sutured in their original positions (Fig 2).

Both groups were prescribed 0.12% chlorhexidine gluconate twice daily for 10 days and 750 mg paracetamol tid for 3 days postoperatively. Sutures were removed after 10 days, and thereafter mechanical plaque control was performed with the aid of extra-soft toothbrushes, fluoridated dentifrice, and dental floss. All subjects were seen weekly in the first month to check and reinforce instructions and motivation for optimal supragingival plaque control. Similar sessions were performed fortnightly in the 2 following months, while in the last 3 months patients were seen once a month.

Restorations with a microhybrid composite (Charisma A 3.5, Heraeus Kulzer) and one-step adhesive system (Clearfil SE Bond, Kuraray) were performed under rubber dam isolation, finished, and polished (#12 surgical blades, extra fine diamond burs [KG Sorensen], and Sof-Lex [3M ESPE] and Enhance [Dentsply] systems).

**Statistical analyses**

Statistical analysis ($P = .05$) was carried out using linear models.
(generalized estimating equations) taking into account the different experimental periods and subject levels. Comparisons between both therapeutic modalities and experimental periods were made using Wald test, taking into consideration the treated sites and contiguous and opposite sites. The analysis was performed using commercially available statistical package STATA 9.0 SE. Mean and standard errors were calculated taking into account patient and tooth as hierarchical levels.

**Results**

At the start of the study, VP varied from 10% of the sound surfaces involved in the surgical crown-lengthening procedure to 20% in the surfaces to be restored associated with crown lengthening. Only 15% of the surfaces involved in the trans-surgical restorative procedure presented VP at the start of the study. VP was reduced to less than 5% for all types of surfaces with no statistically significant differences among them (Fig 3).

BOP varied from 5% of the restored surfaces associated with crown lengthening to 20% of the surfaces restored trans-surgically. The surfaces restored following crown lengthening showed an increase of up to 23% in the BOP from start-up to 45 days of observation and reduced to less than 5% at the end of the study. The surfaces involved in the trans-surgical procedure showed a marked reduction in the first 45 days and remained stable, with less than 5% of the surfaces positive for BOP.

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Fig 2 Images from a site (mandibular molar, patient 1) submitted to a trans-surgical restoration. (a) Preoperative interproximal image. (b) Clinical aspect before flap surgery. (c) Clinical aspect with rubber dam, during the restorative procedures. (d) Clinical aspect of the restoration. (e) Clinical aspect immediately after the trans-surgical restoration and suture.
The sound surfaces involved in the crown lengthening showed a steady decrease as the study progressed. No significant differences were observed between TG and CG (Fig 4).

When the restored sites were considered, mean PPD observed in the CG started at 2.5 mm and remained stable throughout the entire period of observation, finishing with a mean value of 2.4 mm after 180 days. The mean PPD of the TG at baseline was 2.5 mm. It reduced significantly to 1.8 mm after 45 days and gradually increased to 2.4 mm at the end of the study. Differences in mean values at baseline between CG and TG were not statistically significant; however, the differences following the experimental procedures were statistically significant in favor of the TG (Table 1).

A similar pattern was observed for the mean CAL of CG and TG at contiguous and opposite tooth sites (Tables 2 and 3).

Table 1  Mean and standard deviation (mm) of PPD and CAL, considering the treated sites, for the control and test groups during the experimental period

<table>
<thead>
<tr>
<th>Group</th>
<th>Indicator</th>
<th>Baseline</th>
<th>45 d</th>
<th>90 d</th>
<th>180 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG</td>
<td>PPD</td>
<td>2.5 ± 0.3</td>
<td>2.3 ± 0.2</td>
<td>2.3 ± 0.3</td>
<td>2.4 ± 0.4</td>
</tr>
<tr>
<td></td>
<td>CAL</td>
<td>0.6 ± 0.2</td>
<td>2.0 ± 0.2a</td>
<td>2.1 ± 0.2a</td>
<td>2.2 ± 0.4a</td>
</tr>
<tr>
<td>TG</td>
<td>PPD</td>
<td>2.5 ± 0.3</td>
<td>1.8 ± 0.1b</td>
<td>1.9 ± 0.2b</td>
<td>2.4 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>CAL</td>
<td>0.8 ± 0.3</td>
<td>0.7 ± 0.2</td>
<td>0.6 ± 0.2</td>
<td>0.6 ± 0.2</td>
</tr>
</tbody>
</table>

CG = control group; TG = test group; PPD = periodontal probing depth; CAL = clinical attachment loss.

*Significant differences between the experimental groups.

*Significant differences intragroup.

Fig 3  Mean percentage of visible plaque associated with the different types of surfaces involved in either crown lengthening or trans-surgical restoration.

Fig 4  Mean percentage of bleeding on probing associated with the different types of surfaces involved in either crown lengthening or trans-surgical restoration.
Discussion

The results of the present study have shown that the periodontal conditions following surgical and restorative procedures were stable. Besides the loss of attachment associated with surgical crown lengthening, no further significant differences could be observed in the inflammatory or periodontal destructive response to the restorative procedures. While this could be anticipated at the sites where restorations were placed following the surgical crown lengthening, a similar response to restorations kept subgingivally in clear transgression of the PBW conflicts with the observations that restorative procedures may be a risk factor for inflammation and loss of attachment.3,21,22 Observational studies have analyzed the periodontal status of restored sites and have consistently reported more inflammation, deeper periodontal pockets, and larger loss of attachment as compared to sound surfaces or even surfaces with restorations placed supragingivally.1,5 Several factors may have contributed to these observations, such as different study design, oral hygiene habits, presence of systemic or behavioral risk factors, and susceptibility to periodontal disease. In the present study, patients were adults (aged 26 ± 5 years) with no history of destructive periodontal disease and no systemic condition that could interfere with the periodontal response.

The presence of plaque was reduced and kept below 10% in the areas where subgingival restorations were performed. As a consequence, BOP was also kept under 10% at these sites. With small and insignificant differences, this behavior was also present at the sites where surgical crown lengthening was performed. The surgical and restorative procedures apparently did not affect plaque removal.

These procedures also did not influence the inflammatory response, although it has been shown that supragingival plaque control can significantly reduce the local inflammatory response.23 In general,
levels of plaque lower than 10% are associated with negligent local inflammation. As a consequence, PPD and CAL were kept stable following the experimental procedures. More recently, absence of bleeding on probing associated with subgingival GIC restorations was described as impinging the PBW.

As expected, CAL values increased from baseline in the areas where osteotomy was performed (CG). It is interesting to observe that the distance between the cervical margin of the restorations and the bone crest at the control sites showed a small decrease from the 3.0 mm surgically established to 2.2 mm. In a recent systematic review, the authors concluded that transperiodontal probing is a reliable method to clinically measure the biologic width. In the same study it was shown that in individuals and teeth with no history of destructive periodontal disease, the biologic width ranged from 1.5 mm to 2.7 mm. It is possible that the reductions in distance observed in the present study reflect an accommodation of the periodontal structures over an 18-month period following surgical intervention. There is evidence that a 6-month period is needed for periodontal tissue remodeling after crown-lengthening surgery.

Three areas were considered in this analysis: the area treated, the adjacent surfaces of the same tooth (facial and lingual/palatal), and the neighboring surface of the adjacent tooth. The latter two areas were involved in the surgical crown lengthening resulting in loss of attachment. They could also be affected by the presence of the restorations, especially those placed subgingivally. Lanning et al considered these different sites while investigating the position of the gingival margin after crown lengthening. The results for these surfaces are comparable to those observed for the restored ones, showing that they responded in a similar fashion to the restorative procedures and to the plaque control measures applied. Thus, subgingival restorations, as performed in the present study, did not represent a potential risk of residual inflammation for neighboring teeth.

The results of the present study should be interpreted in relation to two premises. The first is that adhesive restorations have a completely different interface with dental structures. As such, the presence of bacteria, commonly reported at the interface of full crowns or amalgam fillings, may be minimized by the adhesive nature of the restorations used. The traumatism inflicted on the periodontal structures by restorations that encroach on the periodontal biologic width may not lead to permanent injuries of the periodontium. Experimental and clinical reports support this contention. Glass-ionomer restorations placed subgingivally in dogs with and without a history of periodontitis resulted in less inflammation and no continuing bone resorption or loss of attachment as compared to amalgam fillings. This was especially the case when a strict plaque control regimen was established. Clinically, using a similar model as reported earlier, Santamaria et al observed an absence of subgingival bleeding in sites provided with restorations at the bone crest in animals undergoing supragingival plaque control and absence of difference in PPD comparing restored (GIC) and unrestored sites. Some authors observed that following experimental cavities prepared at the bone level in dogs, even without restorations, led to bone loss up to the formation of a junctional epithelium apical to the cervical margin. No further loss was observed over 12 months of observation. Similarly, some authors reported on the use of resin and glass-ionomer cement restorations in cases of root resorption in humans. They observed an absence of progressive clinical attachment loss, and negligible inflammation associated with this extreme procedure. The second premise is the strict plaque control regimen established throughout the study. Several studies have shown the importance of the presence of plaque for the inflammatory response in areas with subgingival restorations. The restorative characteristics of adhesive restorations allied to instructions and motivations toward excellent performance in daily oral hygiene by the participants contributed to a minimal presence of plaque. As a consequence, the inflammatory response was kept low and the conditions for an inflammatory destruction of the periodontal structures were not established. This observation was recently described to some degree, confirming a previous finding that subgingival GIC restorations do not imply more CAL as compared to sites without restorations.
Considering that in several clinical situations, crown lengthening, even motivated by restorative/prosthetic or orthodontic needs, is not possible for esthetic and functional reasons, the present results may be taken into consideration when selecting the most appropriate approach to the problem.

Conclusions

The results have shown that, within the limits of the study, proximal bonded restorations infringing on the periodontal biologic width may not require clinical crown lengthening.

Acknowledgments

The authors reported no conflicts of interest related to this study.

References