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Laboratory Research

Proximal Marginal Overhang of Composite Restorations in Relation to Placement Technique of Separation Rings

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Clinical Relevance

A direct contact of the tines of the separation ring with the outer surface of the tooth to be restored will reduce the amount of flash/overhang formation.

SUMMARY

The aim was to investigate *in vitro* the marginal overhang in Class II composite restorations placed with various separation rings and placement techniques. A total of 180 Mesial-Occlusal [MO] preparations in artificial molar teeth were divided into nine groups (n=20). After placement of the sectional matrix, one of three ring systems was applied: Contact Matrix System (Danville Materials), Composi-Tight Gold (Garrison), and V-Ring (Triodent). In each group, rings were placed according to four different techniques (V-Ring placed with technique no. 2 only): 1) occlusally of the wedge, 2) on back end of the wedge, 3) between adjacent tooth and wedge, and 4) between treated tooth and wedge.

After application of the adhesive resin, preparations were restored with composite Clearfil AP-X (Kuraray) and polymerized in increments. After matrix removal, overhang was measured on a standardized digital macroscopic image in millimeters squared. For analysis, analysis of variance and Tukey B were used ($p<0.05$).

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For the Contact Matrix System and Composi-Tight Gold ring, the different placement techniques had a statistically significant effect on the amount of marginal overhang ($p<0.031$). The V-Ring resulted in the least marginal overhang ($p<0.001$).

None of the placement techniques and separation rings could completely prevent marginal overhang, and the placement technique has a significant influence on its occurrence.

INTRODUCTION

A dental restoration should restore form, function, and esthetics of a tooth involved and therefore prevent the occurrence of recurrent caries and periodontal diseases. Studies have shown that bulky and irregular overhanging restorations may promote periodontal diseases due to local accumulation of bacterial plaque rather than mechanical irritation. Epidemiological and clinical experimental studies have demonstrated close associations between such iatrogenic factors and the pathogenesis of local periodontal lesions.[1-7]

Despite all efforts and available techniques, placing a Class II composite restoration will result in various degrees of marginal overhang.[8-11] Circumferential matrix systems resulted in the least marginal overhang compared with sectional matrix systems, and the use of a stiffer matrix band resulted in significantly less marginal overhang compared with dead-soft matrix bands.[11] In addition, plastic matrices, considered necessary in the past, showed significantly more overhang compared with the metal bands.[9]

In order to reconstruct tight proximal contacts with Class II composite restorations, there has been a shift from circumferential to sectional matrices. These newer, precontoured sectional matrices combined with separation rings resulted in a better proximal contour[12] and tighter proximal contacts, compared with circumferential systems, in which flat matrices and no additional separation rings were used.[13]

Among different brands of separation rings, a large variety exists in the configuration of the tines (parallel, divergent, V-shaped), resulting in a different adaptation of the matrix band to the tooth surface. Furthermore, several placement techniques are applicable to keep these rings properly in place. For example, in case the clinical crown height is too short or the box is relatively wide in the buccal-lingual direction, it can be difficult or even impossible to place the ring occlusally from the wedge due to insufficient retention. A technique to provide more retention is placing the ring between the wedge and tooth surface.

As a result, each specific clinical situation offers the clinician several opportunities to place the matrix band and separation ring. However, it is unknown how the different ring configurations and positioning techniques affect the occurrence of marginal overhang. Therefore, the aim of this study was to investigate *in vitro* the marginal overhang in Class II composite restorations placed with different separation rings and ring placement techniques.

MATERIALS AND METHODS

For this study an mesial-occlusal [MO] preparation was made in artificial left first molars in the lower jaw (tooth no. 36), with the following dimensions: 5.0 mm in the bucco-lingual, 6.0 mm in the occlusal-gingival, and 1.3 mm in the mesial-distal direction. The occlusal step was 4.5 mm in buccal-lingual width, 2.5 mm deep, and 6.0 mm in mesial-distal width. The margins of the box were 1 mm supragingivally and finished butt-joint. This model was replicated using a copy-milling machine (Celay, Mikrona Technologie AG, Spreitenbach, Switzerland), resulting in 180 identical preparations. Teeth were placed in a manikin model (KaVo Dental, Biberach, Germany) and apically equipped with a stem-like anchoring system that allowed a standardized mobility of the tooth, simulating the normal physiological tooth mobility. Teeth were divided into nine different groups (n=20), each assigned to a specific ring and placement technique. A flexible sectional matrix band (Contact Matrix, Stiff Flex, Danville Materials, San Ramon, CA, USA) was placed and secured interdentally from the buccal side with a wooden wedge (Slim-Jim, Wizard Wedge, Waterpik Technologies, Ft Collins, CO, USA), after which one of three ring systems was placed. The Contact Matrix System (Danville Materials) and the Composi-Tight Gold ring (Garrison Dental Solutions, Spring Lake, MI, USA) were placed according to one of four placement techniques:

1) *Occlusally of the wedge*. On the buccal and lingual side the ring was placed occlusally of the wedge while both tines were in contact with the treated tooth as well as the adjacent tooth.
2) *On back end of the wedge*. On the buccal side the ring was placed on the back end of the shortened wedge, and both tines were in contact with the treated tooth as well as the adjacent tooth. The tine at the lingual side was placed according to technique no. 1.

Table 1: *Materials Used in the Study*

Materials	Characteristic	Manufacturers	Lot
Contact Matrix (Stiff Flex)	Sectional, flexible, and precontoured (0.05 mm)	Danville Materials, San Ramon, CA, USA	89434
Composi-Tight Gold (AU 400)	—	Garrison Dental Solutions, Spring Lake, MI, USA	18884370032
Contact Matrix ring (outward rings)	—	Danville Materials, San Ramon, CA, USA	89507
V-Ring	—	Triodent LTD, Katikati, New Zealand	3081
Wizard wedges (Slim-Jim)	—	Waterpik Technologies, Ft Collins, CO, USA	1672
PFI 49	—	Hu-Friedy, Chicago, IL, USA	—
Clearfil Photo Bond (Catalyst & Universal)	Catalyst: bisphenol A diglycidyl methacrylate (Bis-GMA), 10-methacryloyloxydecyl dihydrogen phosphate (MDP), 2-hydroxyethyl methacrylate (HEMA), hydrophobic dimethacrylate, dibenzoyl peroxide, dl-camphorquinone. Universal: N, N-di-ethanol-p-toluidine, sodium benzene sulfinate, ethanol	Kuraray Medical, Osaka, Japan	41164
Clearfil AP-X (PLT, color A3)	Barium glass and colloidal silica filler, 85.5 wt%, 70 vol%	Kuraray Medical, Osaka, Japan	0068A

3) *Between adjacent tooth and wedge*. On the buccal side the tine was situated next to the wedge at the side of the adjacent tooth, resulting in contact only with the adjacent tooth surface. The tine at the lingual side was placed according to technique no. 1.
4) *Between treated tooth and wedge*. On the buccal side the tine was placed next to the wedge at the side of the treated tooth, resulting in contact of the tine only with the treated tooth. The tine at the lingual side was placed according to technique no. 1.

Due to its configuration, the V-Ring (Triodent, Katikati, New Zealand) could only be placed according to technique no. 2 (on the back end of the wedge).

Table 1 summarizes the product profiles, lot numbers, and the characteristics of the materials used in the study. In Figure 1 the three ring systems are presented.

In all groups, after placement of the separation ring, the contact area of the matrix band was burnished with a hand instrument (PFI 49, Hu-Friedy, Chicago, IL USA) so contact was present between matrix and adjacent tooth. All cavities were restored with an adhesive and a hybrid composite (Clearfil Photo Bond and Clearfil AP-X, Kuraray Medical, Tokyo, Japan). The dual-cure adhesive system was mixed and applied in the preparation, gently air-dried, and cured for 10 seconds with a halogen polymerization unit (PolyLux II, KaVo; light intensity 600 mW/cm^2). Subsequently, the composite was injected from the preloaded tip into the cavity in three horizontal increments of 2 mm thick and adapted to the cavity walls using a hand instrument (ASH 49). Each increment was cured separately for 20 seconds from the occlusal surface. After removal of the matrix, restorations were postcured for 20 seconds from the buccal and lingual sides. Restorations were not finished or adjusted in order to prevent changes of the proximal surface. All restorations were placed in a random order by one operator, and all measurements were performed blind by an independent observer.

Figure 1. *The three ring systems used in this study. The Contact Matrix System (outward ring) of Danville Materials, the Composi-Tight Gold (AU400) of Garrison Dental Solutions, and the V-Ring of Triodent.*

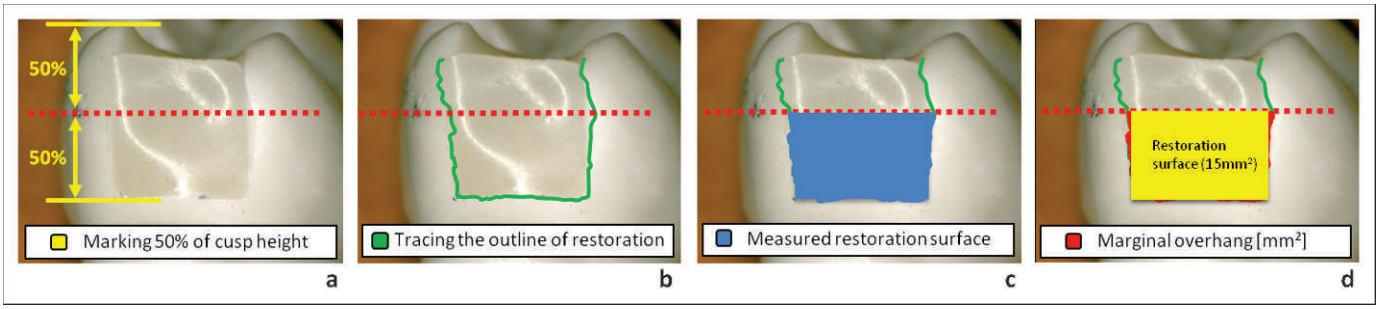

Figure 2. *Procedure for measuring the proximal marginal overhang using a stereomicroscope (7.89×). (a): Only the marginal overhang in the cervical area of the box was measured (50% box height). (b): Digital tracing of the restoration margin. (c): Showing the measured area of the restoration surface. (d): The surface of the preparation (15.0 mm^2) was subtracted from the marked surface, resulting in the marginal overhang.*

Following the restorative procedure each tooth was removed from the manikin model and placed with the box surface horizontal in a mold made of polyvinylsiloxane (Express Putty STD, 3M ESPE, Dental Products, Seefeld, Germany). With a stereomicroscope (Leica MZ 12) standardized digital images were made of the proximal surface with a magnification of 7.89×. Leica Qwin software was used to measure digitally the total proximal restoration surface (millimeters squared) by marking the margin of the restoration on the digital image (Figure 2). Only the cervical area of the box was included (50% box height: 3.0 × 5.0 mm, as previously described by Loomans and others[11]). Because all preparations were identical, it was possible for the software to automatically mark the cutoff point on the 50% box height and to include only the area beneath this cutoff line. Finally, the outer surface of the preparation (15.0 mm^2) was subtracted from the total restoration surface, resulting in the marginal overhang surface area. The marginal overhangs for the buccal and the lingual parts of the box were recorded separately in order to investigate the effect of ring positioning. Data were statistically analyzed using SPSS 14.0 (SPSS Inc, Chicago, IL, USA). To determine differences between the placement techniques for the Contact Matrix System (Danville Materials) and Composi-Tight Gold (Garrison) and to determine differences between the three separation rings at the "on back end" location, one-way analyses of variance (ANOVA) was performed, followed by the post hoc multiple comparison Tukey B ($p<0.05$).

RESULTS

Mean marginal overhang of the restorations is presented in Figure 3. For the total overhang, the values ranged between 0.81 mm^2 and 1.32 mm^2. Data were normally distributed and the measure-

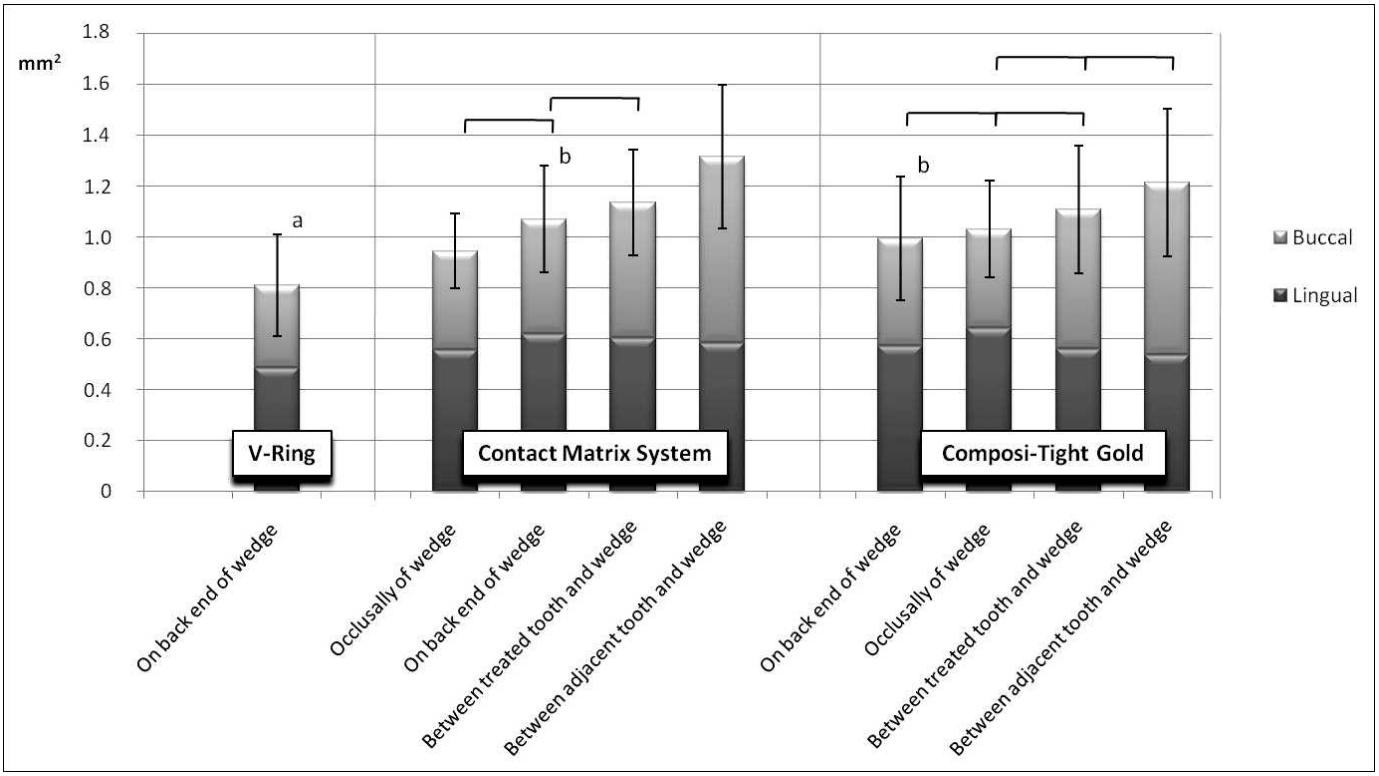

Figure 3. *Recorded proximal marginal overhang (divided by buccal and lingual) of composite (mm^2) together with the standard deviation (SD) of the total overhang, combined with an indication of statistical differences between groups (ANOVA:* $p<0.05$*). Different letters indicate statistically significant differences: only comparing the technique "on back end of wedge" (ANOVA:* $p<0.05$*).*

ment error was established by remeasuring five random specimens eight times, for an average measurement error of 0.0014 mm^2, varying between 0.0007 and 0.0024 mm^2. This resulted in a measurement error of less than 1% of the total restoration surface.

Statistically significant differences were found in the total amount of proximal overhang between the placement techniques for the Contact Matrix System (ANOVA: $p<0.001$) and Composi-Tight Gold (ANOVA: $p=0.031$). Post hoc tests demonstrated that the largest total amount of marginal overhang in the Contact Matrix group was found in the ring placed "between adjacent tooth and wedge" (1.32 ± 0.28 mm^2), which was statistically significantly larger than those placed according to the "between treated tooth and wedge" (1.14 ± 0.21 mm^2), "on back end" (1.07 ± 0.21 mm^2), and "occlusally" (0.95 ± 0.15 mm^2) techniques. No statistically significant difference was found between the "occlusally" and "on back end" techniques, nor between the "on back end" and "between treated tooth and wedge" techniques.

The post hoc tests for the Composi-Tight Gold system revealed that the largest total amount of marginal overhang was recorded for "between adjacent tooth and wedge" (1.22 ± 0.29 mm^2), which was statistically significantly different only from the "on back end" (1.00 ± 0.24 mm^2) technique. No statistically significant difference was found between the "occlusally" (1.03 ± 0.19 mm^2) and "between treated tooth and wedge" (1.11 ± 0.25 mm^2) placement techniques.

The lingual overhang formation was similar for all placement techniques regarding the Contact Matrix System (ANOVA: $p=0.365$) and Composi-Tight Gold ring (ANOVA: $p=0.083$). At the buccal side, statistically significant differences were found for both ring systems (ANOVA: $p<0.001$). Post hoc tests showed that the largest overhang formation was found with the "between adjacent tooth and wedge" placement technique for both the Contact Matrix System (0.73 ± 0.22 mm^2) and Composi-Tight Gold ring (0.70 ± 0.25 mm^2), which was statistically significantly larger than the other placement techniques.

When comparing the three ring systems for the total amount of marginal overhang using the "on back end" technique, the V-Ring (0.81 ± 0.20 mm^2)

produced the least total overhang compared with the Composi-Tight Gold ring (1.00 ± 0.24 mm^2) and Contact Matrix System (1.07 ± 0.21 mm^2) ($p<0.001$). At the buccal side also, the V-Ring (0.32 ± 0.13 mm^2) produced the least total overhang compared with the Composi-Tight Gold ring (0.43 ± 0.13 mm^2) and Contact Matrix System (0.45 ± 0.15 mm^2) ($p<0.02$). At the lingual side, a statistically significant difference was found only between V-Ring (0.49 ± 0.13 mm^2) and Contact Matrix System (0.62 ± 0.13 mm^2) ($p=0.011$).

DISCUSSION

In this study, the influence of several placement techniques of three different separation rings on the occurrence of proximal marginal overhang in Class II composite restorations was investigated. It was found that both the placement technique and type of ring had a statistically significant effect on the amount of marginal overhang.

The methodology for the present study has already been described in a previous study,[11] and as in that study, the measurement of the overhang was restricted to the cervical area, 50% of total box height of the restoration, because the overhang in this region is very difficult or even impossible to remove. The advantage of this *in vitro* model is that it gives controlled experimental conditions; however, it fails to account for the complexities of factors that are found under *in vivo* conditions.

Regarding the total amount of proximal overhang, the use of the V-Ring resulted in the least overhang compared with the Composi-Tight Gold and Contact Matrix System. This may be explained by the V-configuration of the tines in the buccal-lingual direction, leading to a better adaptation of the matrix to the tooth compared with the other systems. The advantage of this system is that the ring is placed in one very stable position; at the same time this is a disadvantage, because ring position cannot be adjusted. In a majority of clinical situations this V-Ring may be used; however, it may fail in cusp replacement situations or when clinical crown height is low, because remaining cusps of sufficient height are needed for retention. The more "basic" rings, such as BiTine ring (Dentsply Caulk, Milford, DE, USA), Composi-Tight Gold, and Contact Matrix System, offer the clinician more freedom in placement technique.

The marginal overhang was analyzed separately for buccal and lingual surfaces. Lingual overhang was comparable for all placement techniques for each ring system, which could be expected because the tines at the lingual side were always placed identically. At the buccal side, tines were placed in four different ways, resulting in statistically significant differences in marginal overhang. Tines placed "occlusally" and "on back end" resulted in the least buccal overhang, whereas tines placed "between adjacent tooth and wedge" resulted in a statistically significant larger overhang. In the situation of rings placed "occlusally" and "on back end," tines are in contact with the treated as well as the adjacent tooth. These techniques seemed to provide the best adaptation of the matrix to the tooth, thus preventing marginal overhang. Tines placed "between treated tooth and wedge" contacted only the treated tooth, resulting in pressure of the ring against the wedge away from the treated tooth, which led to a gap at the cervical area. Tines placed "between adjacent tooth and wedge" caused pressure against the wedge toward the treated tooth resulting in a good cervical adaptation. In this last situation, adaptation of the matrix to the tooth is compromised toward the occlusal side, resulting locally in a gross overhang. However, in this area excess material can be removed easily using finishing discs.

All techniques in this study resulted in some marginal overhang, and this finding is in accordance with previous studies.[8-11] It may be concluded that a complete prevention of proximal overhang is hardly achievable. Therefore, a major issue remains about how to deal with marginal overhang in composite restorations. An overhang at the buccal or lingual margin is relatively easily removed with the use of polishing discs (eg, Sof-Lex, 3M ESPE) or a special oscillating diamond finishing tip (Profin, Dentatus, or EVA, KaVo).[14] However, overhang at the cervical proximal margin is difficult to remove without damaging the tooth and/or adjacent tooth surface.

Most studies about marginal overhang are related to amalgam restorations, and the conclusions from these studies may not be generally applicable for composite restorations.[1-7] The clinical relevance of a marginal overhang might depend on the size, shape, and clinical appearance (smooth or rough and bulky) of the restoration. Rough and bulky outlines or the presence of gross overhang might result in accumulation of plaque and irritation of the epithelial attachment and might require replacement or repair of the restoration. For marginal overhang that is adhesively attached, due to the spread of bonding, and is smooth and continuous (a "flash"), no direct clinical need of removal might exist; this flash might be regarded as an extended bevel. However, the true

clinical relevance and effect of such a proximal overhang on periodontal condition is unknown.

CONCLUSIONS

- None of the placement techniques and separation rings could completely prevent marginal overhang.
- The placement technique of the separation ring has a statistically significant influence on the occurrence of marginal overhang.

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