Supragingival Relocation of Subgingivally Located Margins for Adhesive Inlays/Onlays with Different Materials

Dorien Lefever[a] / Ladislav Gregor[b] / Tissiana Bortolotto[c] / Ivo Krejci[d]

Purpose: This study evaluated the marginal adaptation of supragingivally relocated cervical margins. Newly developed and reference materials were compared.

Materials and Methods: Eighty-eight extracted human teeth were divided into 11 groups. A standardized box-shaped cavity (4.0 mm mesiodistal width, 1.5 mm axial depth) was prepared on each tooth with the cervical margin 1.3 mm below the cementoenamel junction. Seven different restorative materials (Filtek Silorane [Sil], Clearfil AP-X [APX], Clearfil Majesty Posterior [CMP], Clearfil Majesty Flow [CMFlow], RelyX Unicem [RelyX], SDR [SDR], Vertise Flow [VertFlow]) were applied in a layer of 1.5 mm, combined with different adhesive systems (Filtek Silorane Primer + Bond [SilPB], Clearfil Profect Bond [ClePB], Filtek Silorane Bond [SilB]). No indirect restorations (ie, inlays/onlays) were placed on these restorations. SEM analysis was performed to evaluate marginal adaptation in enamel and dentin. The results were subjected to statistical analysis by Kruskal Wallis and Duncan post-hoc tests.

Results: In both dentin and enamel, statistically significant differences were present between groups ($p < 0.001$). In enamel, the lowest percentage of continuous margin was observed for SilPB/CMP, SilPB/APX, and ClePB/SDR, while SilPB/Sil exhibited the highest percentage of continuous margin, although this was not statistically different from other groups except for SilPB/CMP, SilPB/APX, and ClePB/SDR. In dentin, a higher percentage of continuous margin was observed for all materials than in enamel ($p < 0.002$). Statistically significant differences were found between ClePB/SilB/Sil, ClePB/SDR, and RelyX, SilPB/APX, ClePB/APX, and ClePB/Sil. ClePB/Sil showed the lowest marginal adaptation. Considering the overall marginal length, the best marginal adaptation was exhibited by ClePB/SilB/Sil, followed by SilPB/Sil, ClePB/SDR, and ClePB/CMP.

Conclusion: Marginal adaptation of supragingivally relocated cervical margins is significantly influenced by the materials used.

Keywords: subgingival, marginal adaptation, silorane, relocation, inlays, onlays, resin composite, resin coating.

J Adhes Dent 2012; 14: 561–567
doi: 10.3290/j.jad.a27795

Submitted for publication: 10.06.11; accepted for publication: 29.09.11

Due to the size and extent of pre-existing amalgam restorations, indirect resin-based composite or ceramic restorations are often indicated for their replacement. In such cases, the cervical margin of the interproximal boxes is often located subgingivally. When an indirect restoration is required, the placement of a retraction cord is deemed mandatory prior to impression taking, in order to clearly expose the cervical margins. Unfortunately, placing a retraction cord causes bleeding in many cases after removal and a higher gingival index. Thus, a composite coating is regularly made in indirect restorations to block out retentive zones of the restorations and to bring the cervical margin to a more supragingival level. Consequently, the impression taking and the luting appointment is easier.[26,27]

This resin coating can be performed with different materials, for example with methacrylate-based resin composites. Either packable or flowable methacrylate-based resin composites may be used. These resin composites have undergone significant improvements, but still have some shortcomings, such as wear resistance, polymerization

[a] *Dentist in Private Practice, Geneva; Research Associate, Division of Cariology and Endodontology, University of Geneva, Switzerland. Idea, performed experiments, wrote manuscript.*

[b] *Dentist in Private Practice, Brno, Czech Republic; PhD Student, Division of Cariology and Endodontology, University of Geneva, Switzerland. Contributed substantially to the discussion.*

[c] *Dentist and Research Associate, Division of Cariology and Endodontology, University of Geneva, Switzerland. Performed statistical evaluation.*

[d] *Chairman and Professor, Division of Cariology and Endodontology, University of Geneva, Switzerland. Idea, experimental design, proofread manuscript.*

Correspondence: *Dr. Dorien Lefever, Division of Cariology and Endodontology, University of Geneva, Rue Barthelemy Menn, 19 Geneva 1205, Switzerland. +41-22-379-4062. e-mail: dorien.lefever@unige.ch*

shrinkage, and color stability. In the long term, these factors may cause problems such as marginal leakage, secondary caries, cuspal deflection, marginal discoloration, and postoperative sensitivity. Many strategies have been developed to reduce the effect of polymerization stresses. Modifications of the placement techniques including the use of incremental curing, altered light activation procedures, and resilient liners[10,22] have been proposed. In addition, changes in the formulation of the composite have been investigated, with recently developed low-shrinkage resin composites, such as those based on silorane.

Silorane-based resin composites consist of a matrix which is formed by the cationic ring-opening polymerization of the silorane monomers. The silorane molecule represents a hybrid that is made of both siloxane and oxirane structural moieties.[32] Studies have shown that siloranes exhibit several advantageous properties compared to methacrylate-based resin composites, eg, low polymerization shrinkage (0.94 vol%[32]), low microleakage,[1] good color stability,[12] and low water sorption and solubility.[21]

Even though many aspects of siloranes have been recently studied, for instance, material characterizations[16,20] and physical properties,[14,17] micro- and nanoleakage,[1,7] color stability and gloss retention,[12] compatibility with methacrylate-based resin composites,[29] cuspal strain,[2] and the influence of the placement technique,[30] no studies to date have examined the marginal adaptation of these materials applied as a resin coating, with their proper adhesive system, or combined with a classic self-etching adhesive system.

On the other hand, many efforts have been made to simplify the application procedure of restorative materials, in order to reduce technique sensitivity. Therefore, materials such as self-adhesive resin composites or cements which are used without the application of any adhesive system have been recently introduced onto the market. Currently, no studies on the marginal adaptation of these newly introduced materials compared to other restorative materials – eg, siloranes and methacrylate-based resin composites – are available.

Therefore, the aim of this study was to evaluate which material would be the most appropiate for the relocation of the interproximal cervical margin by combining it, if necessary, with different adhesive systems. The null hypotheses tested were therefore that (1) the marginal quality was not influenced by the type of restorative material or the adhesive system, and (2) no difference in marginal adaptation was observed between enamel and dentin.

MATERIALS AND METHODS

Eighty-eight sound, freshly extracted human molars with completed root formation were stored in 0.1% thymol solution. The teeth were retrieved from the solution, abundantly rinsed, and finally stored in water at 37°C during the last 24 h before use in this in vitro test.

After scaling and pumicing, a standardized proximal box cavity of 1.5 mm in the mesiodistal and 4.0 mm in the buccolingual dimension was prepared on the mesial surface of each sample. The cervical margin of the cavity was located 1.3 mm below the cementoenamel junction. Cylindrical 80 µm and 40 µm diamond burs were used to prepare the cavity (Intensiv; Lugano, Switzerland). The preparation was finished with fine diamond burs of 25-µm particle size. The preparations were checked for imperfections under a microscope at 12X magnification.

Teeth were divided into 11 experimental groups (n = 8), each of which was assigned to a specific adhesive system and restorative material, as shown in Table 1. Table 2 contains the product profiles, expiration dates, and lot numbers.

In groups 1 to 3, the self-etching primer of the Silorane Adhesive System (3M ESPE; Seefeld, Germany) was applied onto the surface and left in place for 20 s. Subsequently, excesses were removed using a microbrush and the material was slightly blown out with compressed air. Polymerization was performed for 20 s at 1100 mW/cm^2 (DEMI, Kerr; Orange, CA, USA). Silorane Bond (3M ESPE) was then applied, excesses were removed, and polymerization was performed for 20 s (DEMI). The restorative material (group 1 SilPB/Sil: Silorane; group 2 SilPB/APX: Clearfil AP-X; group 3 SilPB/CMP: Clearfil Majesty Posterior) was then used after preheating at 54°C (Calset, Addent; Danbury, CT, USA) for relocation of the subgingival cervical marginal. One layer of 1.5 mm was applied into the cavity surrounded by a metallic matrix, and the material was left to cool down to room temperature before polymerizing for 40 s.

In group 4 (ClePB/SilB/Sil), the self-etching primer (Clearfil Protect Bond, Kuraray; Tokyo, Japan) was applied onto the surface. After conditioning the tooth surface for 20 s, the product was left unmoved for 20 s, and finally the volatile ingredients were evaporated with a mild oil-free air stream. The adhesive (Clearfil Protect Bond) was then applied, excesses were removed, and polymerization was performed for 20 s at 1100 mW/cm^2 (DEMI). Silorane bond was then applied, excesses were removed, and polymerization was performed for 40 s (DEMI). The restorative material (Silorane) was placed into the cavity as one increment of 1.5 mm after preheating at 54°C (Calset), left to cool down to room temperature and polymerized for 40 s.

In groups 5, 6, 7, 9, and 11 the self-etching primer (Clearfil Protect Bond) was applied onto the surface. After conditioning the tooth surface for 20 s, the product was left unmoved for 20 s, and finally the volatile ingredients were evaporated with a mild oil-free air stream. Adhesive (Clearfil Protect Bond) was then applied, excesses were removed, and polymerization was performed for 20 s (DEMI). The restorative material (group 5 ClePB/Sil: Silorane; Group 6 CLePB/APX: Clearfil AP-X; Group 7 ClePB/CMP: Clearfil Majesty Posterior; Group 9 ClePB/CMFlow: Clearfil Majesty Flow; Group 11 ClePB/SDR: SDR) was then placed into the cavity, surrounded by a metallic matrix, as one 1.5-mm increment after preheating at 54°C (Calset), left to cool down to room temperature, and polymerized for 40 s at 1100 mW/cm^2 (DEMI).

In group 8 (VertFlow), the flowable self-adhesive composite (Vertise Flow, Kerr) was directly applied onto the cavity surface as a thin layer (< 0.5 mm) according to the

Table 1 Description of the experimental groups

Group	Abbreviation	Adhesive system	Manufacturer	Restorative material	Manufacturer
1	SilPB/Sil	Filtek Silorane Primer + Bond	3M ESPE; Seefeld, Germany	Filtek Silorane	3M ESPE
2	SilPB/APX	Filtek Silorane Primer + Bond	3M ESPE	AP-X	Kuraray
3	SilPB/CMP	Filtek Silorane Primer + Bond	3M ESPE	Clearfil Majesty Posterior	Kuraray
4	ClePB/SilB/Sil	Clearfil Protect Bond + Filtek Silorane Bond	Kuraray; Tokyo, Japan + 3M ESPE	Filtek Silorane	3M ESPE
5	ClePB/Sil	Clearfil Protect Bond	Kuraray	Filtek Silorane	3M ESPE
6	ClePB/APX	Clearfil Protect Bond	Kuraray	AP-X	Kuraray
7	ClePB/CMP	Clearfil Protect Bond	Kuraray	Clearfil Majesty Posterior	Kuraray
8	VertFlow			Vertise Flow	Kerr; Orange, CA, USA
9	ClePB/CMFlow	Clearfil Protect Bond	Kuraray	Clearfil Majesty Flow	Kuraray
10	RelyX			RelyX Unicem	3M ESPE
11	ClePB/SDR	Clearfil Protect Bond	Kuraray	SDR	Denstply; Milford, DE, USA

manufacturer's instructions and polymerized for 40 s at 1100 mW/cm^2. A second layer was then applied in order to obtain a layer of 1.5 mm thickness.

In group 10 (RelyX), the restorative material (RelyX Unicem, 3M ESPE) was activated and mixed for 10 s in a RotoMix Capsule Mixing unit (3M ESPE), then directly applied into the cavity, surrounded by a metallic matrix, as an increment of 1.5 mm thickness. No indirect restorations were placed on these cavities with relocated margins.

Finishing and polishing were performed in all groups immediately after restoration with 40-µm diamond burs (Intensiv) and flexible disks of decreasing grit size (Sof-Lex Pop-On, 3M ESPE). A polyvinylsiloxane impression material (Président Light Body, Coltène Whaledent; Altstätten, Switzerland) was then used to make an impression of the surface of each restoration. Subsequently, epoxy replicas (Epofix, Struers; Rodovre, Denmark) were prepared for observation in a scanning electron microscope (XL20, Philips, NL-5600; Eindhoven, Netherlands). A quantitative evaluation of the marginal adaptation was performed at 200X magnification. Two margin segments that constituted the total margin length were analyzed: approximal enamel, and cervical and approximal dentin. Because the distribution was not normal (Kolmogorov-Smirnov, Shapiro-Wilk), a nonparametric (Kruskal Wallis) and Duncan's post-hoc test at a 0.05 level of significance were performed.

RESULTS

Significantly lower marginal adaptation was observed in enamel, which represented about 6% of the total marginal length, than in dentin ($p < 0.002$) (Fig 3). Perfect margins in dentin ranged from 71.7% (ClePB/Sil) to 100% (ClePB/SDR, ClePB/SilB/Sil), with a median of 94%. For margins located in enamel, a slightly less favorable situation was observed, with percentages of continuous margins ranging from 56% (SilPB/CMP) to 98.5% (SilPB/Sil), with a median of 81.3%. The results are graphically represented as boxplots in Figs 1 to 3. Medians with 25th and 75th percentiles and groups of significance are presented in Tables 3 and 4.

Regarding marginal adaptation in dentin, statistically significant differences were observed between groups ($p < 0.001$). ClePB/Sil had the significantly lowest marginal adaptation when compared with all other materials, which performed relatively well. Furthermore, statistically significant differences were found between ClePB/APX, SilPB/APX and RelyX, as well as between CLePB/SilB/Sil and ClePB/SDR. Significantly lower percentages of perfect margins were also observed for ClePB/APX than for SilPB/CMP and SilPB/Sil. The highest percentage of continuous

Table 2 Details of the materials used in this study

Material	Expiration date	Lot No.
Filtek Silorane Adhesive System	2012-02	N141785
Filtek Silorane	2011-07	N136714
Clearfil Protect Bond	2011-10	41192
Clearfil AP-X	2012-08	1041AA
Clearfil Majesty Posterior	2013-01	0021BA
Clearfil Majesty Flow	2011-11	213BA
Vertise Flow	2011-09	3434294
RelyX Unicem	2011-03	380261
SDR	2012-07	1003000491

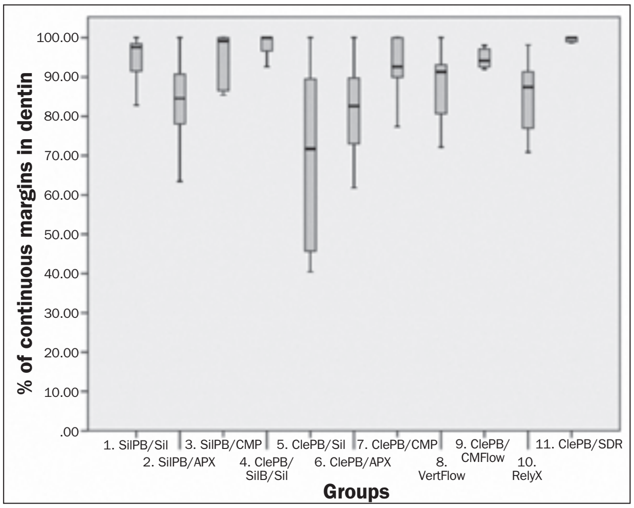

Fig 1 Boxplot of percentages of continuous margins in dentin.

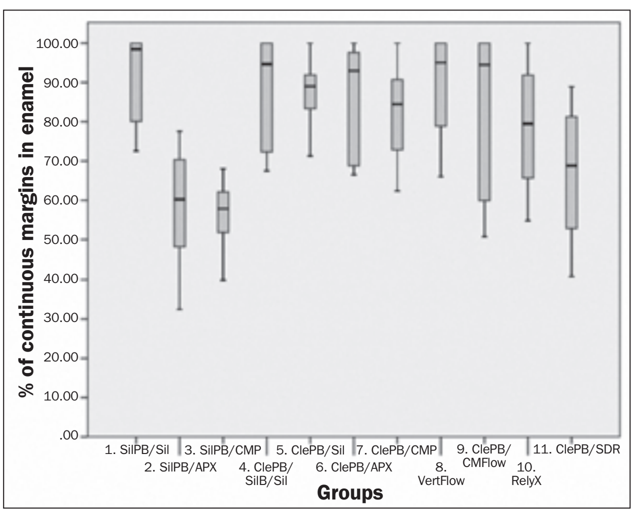

Fig 2 Boxplot of percentages of continuous margins in enamel.

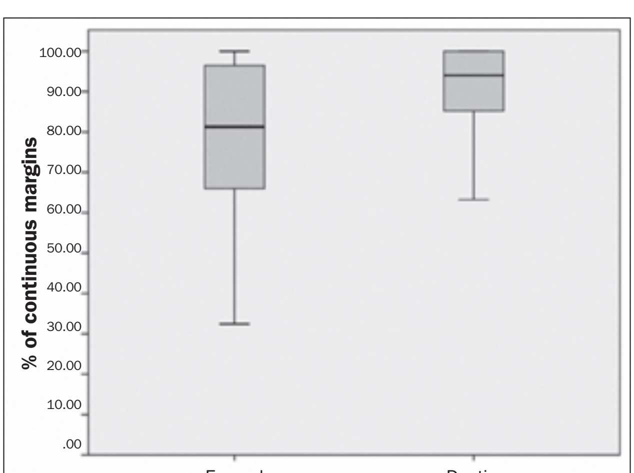

Fig 3 Boxplot of percentages of continuous margins in enamel and dentin.

margins was observed for ClePB/SDR and ClePB/SilB/Sil, but this was not statistically significantly different from SilPB/CMP, SilPB/Sil, ClePB/CMFlow, ClePB/CMP, and VertFlow. No other significant differences were observed between the remaining groups.

In enamel, statistically significant differences were observed between groups ($p < 0.001$). SilPB/CMP and SilPB/APX showed the significantly lowest marginal adaptation compared to all other groups except for ClePB/SDR. ClePB/SDR also exhibited significantly lower marginal adaptation than ClePB/APX, ClePB/Sil, ClePB/SilB/Sil, VertFlow, and SilPB/Sil. No other significant differences were observed between the remaining groups.

When the total marginal length was considered, ClePB/SilB/Sil presented the best marginal quality, followed by SilPB/Sil, ClePB/SDR, and ClePB/CMP (Table 3). The worst marginal adaptation was observed for ClePB/Sil.

DISCUSSION

Relocation of subgingivally located margins was proposed by Dietschi et al[5,6] to facilitate the clinical procedure of impression taking, rubber-dam placement, and luting of adhesive inlays and onlays.[26,27] Up to now, little information on the best choice of material with respect to marginal seal for this indication has been available. Dietschi et al[5] found that there were no statistically significant differences between different materials used for the relocation of subgingival margins in indirect restorations. In the present study, the restorative materials shown in Table 1 were chosen, as each of them represented a specific advantageous characteristic. One of the tested materials was a silorane-based resin composite, in which cationic ring-opening polymerization of the silorane monomers leads to reduced polymerization shrinkage.[32] Furthermore, siloranes are hydrophobic, which seems to be an advantage regarding plaque accumulation and marginal discoloration.[24] Vertise Flow and RelyXUnicem were applied without the use of any adhesive system, representing reduced technique sensitivity and rapidity. SDR is a recently introduced restorative material, which is claimed to possess low viscosity together with low polymerization shrinkage due to the presence of special monomers. On the other hand, flowable composites such as Clearfil Majesty Flow exhibit a lower viscosity but higher shrinkage than conventional resin-based composite materials (manufacturer's unpublished data), such as Clearfil AP-X. Finally, Clearfil Majesty Posterior was included in the present study because it is an extremely highly filled methacrylate-based composite which, according to manufacturer's unpublished data, exhibits reduced shrinkage when compared to Clearfil AP-X. Clearfil AP-X, a standard hybride composite, served as a control.

As cervical margins were located subgingivally in dentin, a self-etching adhesive system was selected to establish adhesion. As there is no water-spray rinsing, it is easier to apply than an etch-and-rinse material. Furthermore, Clearfil Protect Bond was chosen because it performs as well as the well-investigated Clearfil SE Bond (Kuraray).

Table 3 Percentages of continuous margins (medians with 25th and 75th percentiles) in dentin and enamel

Abbreviation	Dentin				Enamel			
	25th percentile	Median	75th percentile	Significance	25th percentile	Median	75th percentile	Significance
ClePB/Sil	44.4	71.7	92.1	D	80.3	89.0	94	A'
ClePB/APX	69.7	82.6	91.6	C	68.2	93.0	98.8	A'
SilPB/APX	71.8	84.6	96.2	BC	43.0	60.2	73.0	C'
RelyX	75.8	87.4	94.9	BC	61.5	79.5	100.0	A'B'
VertFlow	76.3	91.3	94.7	ABC	67.4	95.1	100.0	A'
ClePB/CMP	89.6	92.7	100.0	ABC	66.0	84.5	93.4	A'B'
ClePB/CMFlow	92.4	94.2	97.4	ABC	57.0	98.0	100.0	A'B'
SilPB/Sil	89.1	97.6	98.6	AB	77.4	98.5	100.0	A'
SilPB/CMP	86.3	99.2	100.0	AB	47.1	56.0	65.2	C'
ClePB/SilB/Sil	95.8	100	100.0	A	72.3	94.7	100.0	A'
ClePB/SDR	98.9	100	100.0	A	46.8	60.5	79.2	B'C'

Different letters indicate significant differences between the groups of materials and same letters indicate same statistical group.

Due to its high hydrophobicity, the manufacturer of Clearfil Protect Bond claims that it exhibits an antibacterial effect. This might decrease plaque accumulation, which in turn might be important in the context of a subgingivally located margin.

Filtek Silorane comes with a two-step adhesive system with the trade name "Silorane System Adhesive" (SSA). First, a self-etching hydrophilic primer (SSA-Primer) is applied and light cured separately prior to the application of a hydrophobic adhesive resin (SSA-Bond). SSA-Bond is a methacrylate-based material containing a hydrophobic bifunctional monomer to match the hydrophobic silorane resin. The primer of SSA can be considered an ultra-mild one-step self-etching adhesive,[28] as the actual bond to the tooth surface is realized by the SSA-Primer only. According to various studies, the short-term bonding effectiveness of one-step self-etching adhesives is disappointing.[4,7,15,18,23] Bonds obtained by "mild" two-step self-etching adhesives on the other hand, seem quite durable.[3] Therefore, the present authors tried to combine a two-step self-etching adhesive system (Clearfil Protect Bond) with a phosphorylated methacrylate (SSA-Bond) as an intermediate coating resin before applying the silorane-based resin composite.

Except for the flowable restorative materials and RelyX Unicem, all materials were preheated at 54°C (Calset). According to previous studies,[8,13] this results in a better flow and adaptation of the material. Once the material was placed into the cavity, it was left to cool down to room temperature before polymerization, in order to avoid increased shrinkage.

Finishing and polishing of the Class II restorations was performed in this study with burs and flexible disks of decreasing grit, as this was necessary for adequate evaluation of the marginal adaptation. However, this procedure is likely to be much more aggressive than the real clinical finishing and polishing.

Table 4 Percentages of continuous margins (medians with 25th and 75th percentiles) of total marginal length

Group	Total marginal length			
	25th percentile	Median	75th percentile	Significance
ClePB/Sil	52.8	76.8	92	D"
ClePB/APX	61	81.4	91.1	C"D"
SilPB/APX	74.4	83.6	87.5	B"C"D"
RelyX	77.9	84.1	93.4	A"B"C"D"
VertFlow	76.3	85.4	94.2	B"C"D"
ClePB/CMP	80.9	88	95.2	A"B"C"
ClePB/CMFlow	81.4	91.2	94.1	A"B"C"
SilPB/Sil	85	93.2	96.8	A"B"
SilPB/CMP	87.9	93.2	95.5	A"B"
ClePB/SilB/Sil	89.8	94.8	98.3	A"B"
ClePB/SDR	91	96.8	100	A"

Different letters indicate significant differences between the groups of materials and same letters indicate same statistical group.

Regarding dentin, all groups exhibited acceptable marginal adaptation, except for ClePB/Sil. This might be due to the incompatibility of the methacrylate-based adhesive and the oxirane-based silorane.

SilPB/APX and SilPB/CMP resulted in low marginal adaptation in dentin. In contrast, SilPB/Sil resulted in higher marginal adaptation. This might be due to the lower contraction exhibited by Filtek Silorane. However, these differences in marginal adaptation between SilPB/Sil and SilPB/APX and SilPB/CMP were not significant. It might be speculated that in a cavity with a higher C-factor[9] than the one present in this study, this tendency could become significant; in general, marginal adaptation is influenced by the interaction of various factors such as force of adhesion, shrinkage stress, and hydrophilic and hydrophobic properties of the material in question.

With the exception of ClePB/APX, percentages of continuous margins were found to be lower in enamel than in dentin when a one-step or two-step self-etching adhesive system was applied (Fig 3). This is in line with previous studies.[11] Furthermore, the pH, and therefore the etching ability, of SSA-primer is higher than the pH of Clearfil Protect Bond, explaining the higher marginal adaptation in enamel of ClePB/APX than SilPB/APX. As confirmed by various studies,[13,19,25] RelyXUnicem performs comparably to other multistep systems on coronal dentin, while the bond strengths in enamel are also significantly lower. However, only 6% of the total margin was located in enamel. Therefore, marginal adaptation between enamel and dentin is difficult to compare, although it represents the clinical situation.

The application of a hydrophobic resin coating (SSA-Bond) on top of Clearfil Protect Bond before application of Silorane significantly increased the marginal quality in dentin when compared to ClePB/Sil applied alone. As shown by Duarte et al[7] and Tezvergil-Mutluay et al,[29] when a phosporylated methacrylate is used as intermediate resin coating, the phosphate group of this coating resin can bind to the oxiranes of the silorane-based composite, while the acrylate group binds to the dimethacrylate-based resin. On the other hand, this adhesive layer creates an impermeable layer on the humid dentin, which improves the adhesion to the hydrophobic silorane. However, according to Duarte et al,[7] the adhesive layer might show signs of nanoleakage after aging in comparison to uptake after 24 h. Therefore, more studies are necessary to clarify the bond between methacrylate-based and silorane-based composites.

Significantly lower marginal quality was observed when Filtek Silorane was applied directly over dentin surfaces treated with Clearfil Protect Bond. Another study observed a similar effect for microtensile bond strengths of Filtek Silorane applied over dentin treated with Single Bond plus.[7] As the percentage of continuous margins in enamel was higher, this effect might be explained by the difference in hydrophilicity/hydrophobicity of the substrate.

In this study, no indirect (ie, inlays/onlays) or direct restorations were placed into the cavities with relocated margins. In a subsequent study on this best group of materials, these cavities with relocated margins will be treated with direct and indirect restorative techniques, mechanical loading, and simultaneous thermocycling in order to increase the discriminative power of the testing procedure by evaluating the influence of artificial aging.

The first null hypothesis had to be rejected, as statistically significant differences were observed in marginal quality between different restorative materials and adhesive systems. Furthermore, due to the fact that different marginal qualites were observed in enamel and in dentin, the second null hypothesis was rejected as well.

CONCLUSION

Under the conditions of the present study, the marginal adaptation of supraginigvally relocated cervical margins with different materials was significantly different and there were differences in quality of marginal adapation in enamel and in dentin. Interestingly enough, a whole group of materials gave the best results, without detecting significant differences among them. In a subsequent study on this best group of materials, cavities with relocated margins will be treated with direct and indirect restorative techniques, mechanical loading, and simultaneous thermocycling in order to increase the discriminative power of the testing procedure by evaluating the influence of artificial aging.

REFERENCES

1. Bagis YH, Baltacioglu IH, Kahyaogullari S. Comparing microleakage and the layering methods of silorane-based resin composite in wide Class II MOD cavities. Oper Dent 2009;34:578-585.
2. Bouillaguet S, Gamba J, Forchelet J, Krejci I, Wataha JC. Dynamics of composite polymerization mediates the development of cuspal strain. Dent Mater 2006;22:896-902.
3. De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, Van Meerbeek B. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res 2005;84:118-132.
4. De Munck J, Van Meerbeek B, Satoshi I, Vargas M, Yoshida Y, Armstrong S, Lambrechts P, Vanherle G. Microtensile bond strengths of one- and two-step self-etch adhesives to bur-cut enamel and dentin. Am J Dent 2003;16:414-420.
5. Dietschi D, Olsburgh S, Krejci I, Davidson C. In vitro evaluation of marginal and internal adaptation after occlusal stressing of indirect class II composite restorations with different resinous bases. Eur J Oral Sci 2003;111:73-80.
6. Dietschi D, Spreafico R. Current clinical concepts for adhesive cementation of tooth-colored posterior restorations. Pract Periodontics Aesthet Dent 1998;10:47-54; quiz 56.
7. Duarte S, Jr., Phark JH, Varjao FM, Sadan A. Nanoleakage, ultramorphological characteristics, and microtensile bond strengths of a new low-shrinkage composite to dentin after artificial aging. Dent Mater 2009;25:589-600.
8. El-Korashy DI. Post-gel shrinkage strain and degree of conversion of preheated resin composite cured using different regimens. Oper Dent 2010;35:172-179.
9. Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. J Dent Res 1987;66:1636-1639.
10. Ferracane JL. Buonocore Lecture. Placing dental composites – a stressful experience. Oper Dent 2008;33:247-257.
11. Frankenberger R, Tay FR. Self-etch vs etch-and-rinse adhesives: effect of thermo-mechanical fatigue loading on marginal quality of bonded resin composite restorations. Dent Mater 2005;21:397-412.
12 Furuse AY, Gordon K, Rodrigues FP, Silikas N, Watts DC. Colour-stability and gloss-retention of silorane and dimethacrylate composites with accelerated aging. J Dent 2008;36:945-952.

13. Hikita K, Van Meerbeek B, De Munck J, Ikeda T, Van Landuyt K, Maida T, Lambrechts P, Peumans M. Bonding effectiveness of adhesive luting agents to enamel and dentin. Dent Mater 2007;23:71-80.
14. Ilie N, Hickel R. Macro-, micro- and nano-mechanical investigations on silorane and methacrylate-based composites. Dent Mater 2009;25:810-819.
15. Inoue S, Vargas MA, Abe Y, Yoshida Y, Lambrechts P, Vanherle G, Sano H, Van Meerbeek B. Microtensile bond strength of eleven contemporary adhesives to dentin. J Adhes Dent 2001;3:237-245.
16. Leprince J, Palin WM, Mullier T, Devaux J, Vreven J, Leloup G. Investigating filler morphology and mechanical properties of new low-shrinkage resin composite types. J Oral Rehabil 2010;37:364-376.
17. Lien W, Vandewalle KS. Physical properties of a new silorane-based restorative system. Dent Mater;26:337-344.
18. Loguercio AD, Manica D, Ferneda F, Zander-Grande C, Amaral R, Stanislawczuk R, de Carvalho RM, Manso A, Reis A. A randomized clinical evaluation of a one- and two-step self-etch adhesive over 24 months. Oper Dent 2010;35:265-272.
19. Luhrs AK, Guhr S, Gunay H, Geurtsen W. Shear bond strength of self-adhesive resins compared to resin cements with etch and rinse adhesives to enamel and dentin in vitro. Clin Oral Investig 2010;14:193-199.
20. Mine A, De Munck J, Van Ende A, Cardoso MV, Kuboki T, Yoshida Y, Van Meerbeek B. TEM characterization of a silorane composite bonded to enamel/dentin. Dent Mater 2010;26:524-532.
21. Palin WM, Fleming GJ, Burke FJ, Marquis PM, Randall RC. The influence of short and medium-term water immersion on the hydrolytic stability of novel low-shrink dental composites. Dent Mater 2005;21:852-863.
22. Park J, Chang J, Ferracane J, Lee IB. How should composite be layered to reduce shrinkage stress: incremental or bulk filling? Dent Mater 2008;24:1501-1505.
23. Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater 2005;21:864-881.
24. Poggio C, Arciola CR, Rosti F, Scribante A, Saino E, Visai L. Adhesion of Streptococcus mutans to different restorative materials. Int J Artif Organs 2009;32:671-677.
25. Radovic I, Monticelli F, Goracci C, Vulicevic ZR, Ferrari M. Self-adhesive resin cements: a literature review. J Adhes Dent 2008;10:251-258.
26. Rocca GT, Krejci I. Bonded indirect restorations for posterior teeth: from cavity preparation to provisionalization. Quintessence Int 2007;38:371-379.
27. Rocca GT, Krejci I. Bonded indirect restorations for posterior teeth: the luting appointment. Quintessence Int 2007;38:543-553.
28. Santini A, Miletic V. Comparison of the hybrid layer formed by Silorane adhesive, one-step self-etch and etch and rinse systems using confocal micro-Raman spectroscopy and SEM. J Dent 2008;36:683-691.
29. Tezvergil-Mutluay A, Lassila LV, Vallittu PK. Incremental layers bonding of silorane composite: the initial bonding properties. J Dent 2008;36:560-563.
30. Van Ende A, De Munck J, Mine A, Lambrechts P, Van Meerbeek B. Does a low-shrinking composite induce less stress at the adhesive interface? Dent Mater;26:215-222.
31. Walter R, Swift EJ, Jr., Sheikh H, Ferracane JL. Effects of temperature on composite resin shrinkage. Quintessence Int 2009;40:843-847.
32. Weinmann W, Thalacker C, Guggenberger R. Siloranes in dental composites. Dent Mater 2005;21:68-74.

Clinical relevance: This paper points out that supragingival relocation of subgingivally located margins can be successfully performed with a whole group of materials, although further research is necessary to determine the influence of aging and overlying indirect/direct restorations.