Replacement of resin-based composite: Evaluation of cavity design, cavity depth, and shade matching

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Objective: The aim of this study was to evaluate the effect of different cavity designs, cavity depths, and shade matching on the dimensions of Class I resin-based composite preparations during replacement of the restoration.

Method and materials: Forty Class I cavity preparations were prepared in extracted premolars. The occlusal depths varied from 1.5 to 2.5 mm. In 20 teeth, the buccal and lingual walls were perpendicular to the pulpal floor; in another 20, they were divergent to the pulpal floor. Impressions were made of all preparations. The cavities were restored with resin-based composite. All subgroups were further divided into another two subgroups (n = 5), in which half of the teeth were restored with shade that matched the tooth and the other half were restored with a resin composite that was three shades different from the tooth. After 168 hours in distilled water, the restorations were removed. New impressions were made, and a total of 80 stone casts were fabricated. The perimeter and area of the restorations were recorded with a video-based imaging system. The dimensions of the postoperative cavity preparations were compared to the initial cavity sizes.

Results: The depth of the original cavity preparation had a statistically significant effect on the change in cavity dimension, as measured by area and perimeter. The 2.5-mm-deep cavities showed greater loss of tooth structure. No statistically significant difference was found for different cavity designs or shade matching.

Conclusion: Replacement of Class I resin-based composite restorations results in loss of tooth structure. The deeper the original cavity preparation, the greater the loss of tooth structure at the occlusal cavo-surface margin during replacement. (Quintessence Int 2002:32:273-278)

Key words: cavity depth, cavity design, imaging, replacement restoration, resin composite, shade matching

CLINICAL RELEVANCE: The lifelike appearance of resin-based materials makes it difficult to distinguish between the restoration and sound tooth structure, complicating replacement of restorations. Deeper cavities lose significantly more tooth structure during removal of the restoration.

Despite the advancement of dental adhesive technology, the replacement of resin-based composite (RBC) restorations is a continuing problem in restorative dentistry. Several factors determine the longevity of RBC restorations. Polymerization shrinkage, different coefficients of thermal expansion, and wear resistance of RBC materials still limit these materials from providing lifelong restorations. It is also generally accepted that inadequate operator technique and poor patient compliance are factors that contribute to restoration failure.

In spite of problems that are inherent to the material, the clinical diagnosis of secondary caries is the most common reason for replacement of restorations in general dental practice. This diagnosis is difficult, and it invariably leads to replacement of the entire restoration. Resin composite restorations may also need replacement because of failure resulting from material degradation, marginal or bulk staining, or fracture.

In vitro and clinical studies have shown a significant increase in the size of cavity preparations when RBC restorations are replaced in Class V restorations. However, no studies have demonstrated whether different cavity designs and color mismatching of RBC restorations have any effect on the size of the cavity preparation at the time of replacement.

The main difficulty when RBC restorations are replaced is differentiation between sound tooth structure
and the RBC restorative material. The lifelike appearance of these materials is certainly an appealing characteristic; however, this quality also makes it very challenging to discern the cavity margins at the time of replacement, especially in areas distant from the site of failure. The replacement of RBC restorations consistently results in a loss of tooth structure in intact locations unrelated to the actual failure of the restoration.

The purpose of this in vitro study was to evaluate whether different cavity designs and cavity depths or color mismatching would affect the size of the cavity preparation in the replacement of Class I resin-based composite restorations. The first null hypothesis tested was that deeper cavity preparations would result in no additional loss of tooth structure. The second null hypothesis was that divergent walls would not increase the loss of tooth structure. The third null hypothesis was that color mismatching would not decrease the loss of tooth structure. The size of the cavity preparation was defined, in this study, as the perimeter and the area of the occlusal cavosurface margin.

**METHOD AND MATERIALS**

Forty extracted maxillary first and second premolars were used in the study. Class I cavity preparations were prepared with a No. 330 bur (Brasseler) used in a high-speed handpiece with water spray. Cavity dimensions were approximately 1 mm buccolingually and 3 mm mesiodistally. The occlusal depth varied from 1.5 mm (group 1) to 2.5 mm (group 2). In 20 teeth, the buccal and lingual walls were perpendicular to the pulpal floor (subgroup P); in another 20 teeth, the buccal and lingual walls were made divergent to the pulpal floor (subgroup D) with a No. 168 carbide bur (Brasseler). Impressions were made of all preparations.

The cavities were then restored by one clinician with a resin-based bonding system (Scotchbond MultiPurpose, 3M Dental) and an RBC. All subgroups were further divided into another two subgroups (n = 5). Half of the teeth were restored with a shade that matched the natural tooth color, and the other half were restored with a material that was three shades different from the tooth color. A zirconia and silica-filled RBC (Z100, 3M Dental) was used for shades A1, A2, A3, A3.5, A4, B2, B3, C2, and C4. To color match the teeth, a different brand of RBC (Prodigy, Kerr) was used for shades B1, B4, and C5. All restorations were finished with finishing burs (12-blade, Brasseler) and polished with urethane dimethacrylate points (Enhance, Dentsply/ Caulk).

After 168 hours in distilled water, the restorations were removed. To maintain blind study conditions, the restorations were removed by two other experienced clinicians with carbide burs (No. 330, Brasseler). The clinicians aimed to preserve as much tooth structure as possible during the removal of the restorations. They had no knowledge of the dimensions of the original cavity preparation. Magnifying lenses and explorers were used to ascertain that all RBC was removed.

New impressions were taken with a polyvinyl siloxane material (Extrude, Kerr), and a total of 80 stone casts (Silky-Rock Die Material, Whip Mix) were fabricated from all impressions.

The perimeter and area of the preoperative and postoperative cavity preparations were paired and recorded with a video-based imaging system (725 CCD camera, Dage MTI), equipped with macro lens, at a fixed magnification of ×15. A modified stand allowed final alignment of the preoperative and postoperative images. The essential parts of this device were a microscope table, which allowed controlled x-y translational movement, and a laboratory surveyor, which allowed rotation and tilting (Fig 1).

A manual cursor was used to trace the perimeter of the cavity preparation, allowing the image to be digitized and displayed on a computer monitor. An A15/C computer-based system (Imaging Research) was used to record calibrated morphometric measurements. The computer program then calculated the area (mm²) and the perimeter (mm) of the traced area. On completion of area measurement for the first, or preoperative, specimen, the video input was switched to online and
the second, or postoperative, specimen was brought into view and aligned. The dimensions of the postoperative cavity preparation were compared to initial cavity size. The direction of the buccolingual walls, ie, parallel versus divergent, and the different shades were also compared as independent variables in the increase of the dimensions.

Four tracings, ie, measurement of preoperative and postoperative perimeter and area, were performed for each specimen, and the average values were used for subsequent statistical analysis. The differences were within a 2% range.

The preoperative values were used to examine the effect of design and depth on the loss of tooth structure during cavity preparation. The differences between preoperative and postoperative values were used to examine the effect of design, depth, and color matching on the additional loss of tooth structure during replacement.

Analysis of variance (ANOVA) was used to examine if changes in cavity measurements were statistically significant among groups. The Duncan multiple range test was used to rank the changes in cavity measurement at α = .05.

### RESULTS

Table 1 shows the differences between preoperative and postoperative measurements in area and perimeter. In this experimental design, there were three variables: cavity depth, cavity design, and color matching scheme. Each variable had two levels, leading to eight experimental groups.

A three-way ANOVA was used to investigate the effect of independent variable on the difference in cavity measurements. Cavity design did not have a statistically significant effect on the measurement of the area (P = .7501) and the perimeter (P = .2547).

Two-way ANOVA was then performed on the effect of depth and color matching on the differences in the measurements of each cavity design. In the case of divergent cavity designs, only depth had a statistically significant influence on the area (P = .0006) and the perimeter (P = .0025). The 2.5-mm-deep specimens exhibited greater loss of tooth structure. In the case of parallel design, no statistically significant influences or interactions were found.

Although nonmatching specimens yielded less tooth loss than did color-matched specimens in three of four design and depth groups, no statistical significance could be established (see Table 1).

### DISCUSSION

The first null hypothesis was rejected. The study showed that the deeper the cavity preparation, the greater the loss of tooth structure. Cavity design and color mismatching did not significantly affect the loss of tooth structure during replacement of RBC restorations. Both second and third hypotheses were accepted.

Closer examination of the data revealed that, except for the area measurement of the divergent design with 2.5-mm cavity depth, color-matched groups yielded greater loss of tooth structure than did color-mismatched groups; the color-matched group lost twice as much tooth structure as did the mismatched.
Replacement of RBC restorations resulted in significant loss of tooth structure at the cavosurface margins. Mismatching the shade of the RBC did not improve the differentiation between the restorative material and natural tooth structure. This result is consistent with the findings of other studies. Both a clinical study and an in vitro investigation found a significant loss of tooth structure during the replacement of amalgam restorations. These restorations obviously had a color mismatch. Furthermore, the nature of amalgam restorative material allows it to be removed from the cavity preparation without the fracture of tooth structure, because amalgam is not bonded. However, the clinician may still drill around the cavosurface margins to remove the corrosion or debris that remains at the surface. This procedure could explain why the postoperative cavity became larger in the aforementioned studies, because clinicians apparently have an urge to make cavity walls white, even if amalgam will be the restorative material.

The RBC material, because of the bonding to the enamel, may result in fracture of the enamel at the cavosurface margin, increasing the cavity dimensions. Watson, using a confocal microscope, observed the end of a bur during cutting of enamel. The clinical impression from the use of bladed burs is that there is a tendency to "chatter." Both the bur and the long axes of the enamel prisms were oriented in approximately the same direction. A live confocal microscopy study attributed this phenomenon to structural changes during the cutting process as, one by one, the layers of enamel prisms fail during cutting. The subsurface cracking and fracturing could explain the additional loss of tooth structure during the removal of RBC restorations. This fact would directly affect enamel bonding, because RBC material requires a sound substrate for adhesion.

It seems that color mismatch defines the area to be cut, but the cutting process does not necessarily follow the enamel-resin composite interface. Because of the bonding between the two substrates, some cutting will definitely occur in the enamel. For color-matched restorations, clinicians must rely on their own tactile feeling as the bur cuts into different substrates. In this study, color mismatch provided the clinician a slight edge in removing less tooth structure, but the difference was not statistically significant.

Fracture of RBC has been observed clinically after aging. A degradation of RBC has also been reported in the absence of loading or abrasive forces. The mechanism of wear has been associated with solvent degradation of surface and subsurface, in conjunction with fracture of the resin matrix or the filler or the filler-matrix interface.

An important point in this context is that the restorations in this study were not aged to the extent that most RBC restorations are under oral working conditions. Because of the inherent limited clinical properties of the RBC materials, eg, wear resistance, fracture resistance, and especially marginal degradation arising from polymerization shrinkage and difference in the coefficient of thermal expansion, aging may allow better differentiation of the RBC at the enamel cavosurface margins.

The fact that parallel cavity design often resulted in greater loss of tooth structure, although the difference was not statistically significant in this study, may be explained by the orientation of the enamel rods at the cavosurface margin. The composite was evidently bonded to the margins. In an occlusal surface, the enamel rods are positioned roughly perpendicular to the outside of the enamel surface. In a conservative Class I cavity preparation, the buccal and lingual walls would have different degrees of inclination to the enamel rods for both divergent and parallel cavity designs. Divergent cavity design results in an obtuse angle between the buccal and lingual walls and the position of the enamel rods, compared to parallel cavity design. This difference in the angle could be responsible for greater bond forces between the enamel structure and the restorative material. These results resemble the findings from another in vitro study, in which butt-joint finishing at the occlusal cavosurface margin in Class V cavity preparations resulted in a greater increase in both perimeter and area of the new cavity preparations at the time of the replacement than did bevel-type finishing.

The measurements of the various cavity preparations were two dimensional; that is, the depth of the cavity preparation was not taken into consideration during the measurement. This study did not measure the actual volume of tooth structure loss. However, depth was indeed a variable. The study showed that the deeper the cavity preparation, the greater the loss of tooth structure at the cavosurface margin.

A possible explanation for the greater loss of tooth structure could be that the bur stayed in contact with the tooth for a longer period in deeper (2.5-mm-deep) cavity preparations. Clinicians reported that when the composite was removed from a 1.5-mm-deep cavity preparation both outline and depth were reached at the same time. However, in a 2.5-mm-deep cavity, a clean cavosurface margin was usually reached first and then the resin composite was removed from the pulpal floor. In this process of drilling, the clinicians could have inadvertently touched the enamel cavosurface margins.
Another consideration regarding diverging the cavosurface margins relates to wear. Clinical studies have shown RBC materials placed in preparations with beveled margins to have greater wear than those placed in preparations with butt-joint cavosurface margins.19,20

A major concern with RBC materials is that the restorations may need replacement due to staining, fracture defects, or secondary caries.21,22 Although studies have shown that Streptococcus mutans accumulates more on RBC material surfaces,23 fractures and secondary caries may not necessarily be related to the material itself. Qvist24 showed that secondary caries is not always originated from marginal gaps or fractures along the peripheral portion of resin restorations. Nonetheless, the results of the current study confirmed that repeated replacement results in gradually larger restorations.25,26

Resin-based composite materials are becoming the routine posterior restorative material, even in stress-bearing areas.2 The use of amalgam restorations has decreased in relative and absolute numbers in Nordic countries.27-30 Resin composite restorations in posterior teeth have clinically shown the need for replacement after 4 to 8 years of service.22,31,32 However, not all failed restorations require total replacement. More dental schools worldwide teach the use of posterior resin composites today32-36 than 12 to 14 years ago.53,58 To date, no report has been published regarding the teaching of repair or refurbishing of restorations in dental schools. Major focus has been placed on preservation of tooth structure through the implementation of minimally invasive restorations.39 Until a directly placed esthetic restorative material that will provide good long-term results is available, the most conservative option would be to refurbish or to repair defective margins of RBC restorations without the removal of the entire restoration when the remaining restoration is intact, ie, when the restoration does not need replacement.6

CONCLUSION

Replacement of a Class I resin-based composite restoration resulted in an increase in the perimeter and area of the new cavity preparation. The cavity design of the original preparation had no significant impact on the amount of healthy tooth structure lost during removal of the restoration. Although color mismatch between the tooth and the restoration resulted in less tooth loss during removal of the restoration, the results were not statistically significant. Depth, however, did significantly affect loss of tooth structure during removal of the Class I resin-based composite restoration. The deeper the cavity preparation, the greater the loss of tooth structure at the occlusal cavosurface margin.

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REFERENCES


