Two-Year Clinical Evaluation of Repair versus Replacement of Composite Restorations

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ABSTRACT

Purpose: To investigate the effectiveness of alternative treatments to the replacement of resin-based composite (RBC) restorations through a prospective longitudinal cohort clinical study.

Materials and Methods: Forty patients aged 27 to 77 years (mean = 55) with 88 RBC restorations, with one or more features that deviated from ideal, participated in the study. They were assigned to five treatment groups: repair ($N = 25$), sealing of defective margins ($N = 13$), resurfacing ($N = 18$), replacement ($N = 16$), and the no-treatment group ($N = 16$). The replacement and no-treatment groups served as comparison groups and received random assignment. Two clinicians examined the quality of the restorations ($N = 88$) prior to the assigned treatment, and at subsequent recalls (1 and 2 years) using a modified Ryge criteria (Alfa, Bravo, and Charlie, meaning clinically excellent, clinically acceptable with one or more features that deviated from ideal, and clinically unacceptable, respectively) that observed (1) color, (2) marginal adaptation, (3) anatomic form, (4) surface roughness, (5) marginal staining, (6) bulk discoloration, (7) contact, (8) secondary caries, (9) postoperative sensitivity, and (10) luster.

Results: At 1- and 2-year recalls, 66 (75%) and 58 (66%) restorations were examined. Kruskal-Wallis Test showed significant differences for marginal adaptation and marginal staining for both 1- and 2-year recall exams ($p < .05$). The repair, sealant, and replacement groups presented significant improvement when compared with the no-treatment group for marginal adaptation. The repair and replacement groups showed superior results when compared with the no-treatment group for marginal staining.

Conclusion: RBC restorations that present less-than-ideal marginal adaptation and stained margins are better off being repaired.

CLINICAL SIGNIFICANCE

Repair of resin-based composite (RBC) restorations is a conservative option for treatment of RBC restorations with inadequate marginal adaptation and marginal staining.

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INTRODUCTION

Resin-based composite (RBC) materials have relatively short longevity, with an average duration of 7 years.[1–5] RBC restorations fail as a result of recurrent caries, discoloration, and degradation/wear, ie, loss of anatomic form. One comprehensive study emphasized recurrent caries and discoloration as the main reasons for replacement of RBC restorations in general dental practice.[6] "Other reasons" that RBC restorations fail include loose or lost restorations, fracture of the tooth, and pain or discomfort leading to replacement.[6]

Total replacement is the most common treatment for restorations clinically diagnosed as defective or with questionable margins. Most of the time the assessment of the quality of a restoration is done subjectively and often a restoration with minor deviation from ideal, but still clinically acceptable, may still be replaced.

When replacement takes place, a significant amount of tooth structure is lost.[7–9] Recently, three viable treatment options to total replacement that may increase the longevity of the existing restoration and preserve tooth structure have been offered.[10] The alternative treatment options include repairing, sealing, and resurfacing the defective part of the restoration. Repair consists of the removal of part of the restoration and the restoration of the removed site. Sealant includes the application of a resin-based sealant in a small defective site or deficient margin (up to .2 mm). Resurfacing involves the removal of surface staining or excess from RBC restorations with finishing burs. Despite the initial promising clinical results of alternative treatments, the longevity of these nonreplacement strategies has not been established.

The specific aim of this prospective longitudinal cohort study was to assess the longevity of a group of RBC restorations that had been clinically diagnosed with one or more clinical features which deviated from ideal and could require replacement in the near future. Those restorations were treated by repair, sealant, resurfacing, or total replacement. We hypothesized that the alternative treatments would not significantly improve the clinical conditions of the existing restorations.

MATERIALS AND METHODS

Study Design

Forty patients aged 27 to 77 years (mean = 55) with 88 RBC restorations with one or more clinical features which deviated from ideal were assigned to the study. Patients were routinely assigned for treatment at the Operative Dentistry Clinic, College of Dentistry at the University of Florida. The restorations were independently diagnosed during routine treatment planning and then were assigned to five treatment groups: (1) repair (N = 25), (2) sealing of defective margins with sealant (N = 13), (3) resurfacing (N = 18), (4) total replacement (N = 16), and (5) no-treatment group (N = 16). The replacement and no-treatment groups served as comparison groups and received random assignment. The treatment assignment for the experimental groups was done according to the treatment need and it is described in the Study Methods section under Treatment Groups. Although some restorations were placed on posterior teeth (Class V), most of the restorations were placed on anterior teeth and the distribution was as follows: Class III (N = 40), Class IV (N = 19), and Class V (N = 29).

Inclusion Criteria

(1) Patients older than 18 years of age and with no contraindications for dental treatment and (2) patients that had RBC restorations with one or more clinical features which deviated from ideal and could be corrected with repair, sealant, or resurfacing of the margins. At baseline, the restorations needed to score Bravo (United States Public Health System (USPHS), Ryge criteria, Table 1),[11] in at least one of the following clinical criteria: marginal adaptation, anatomic form, surface roughness, marginal staining, and interfacial staining.

TABLE 1. MODIFIED RYGE USPHS CLINICAL CRITERIA.[11]

Clinical Characteristic	Alfa	Bravo	Charlie
Color match	The restoration matches in color and translucency to the adjacent tooth structure	The mismatch in color and translucency is within the acceptable range of tooth color and translucency	The mismatch is outside the acceptable range of color and translucency
Marginal adaptation	Explorer does not catch or has one-way catch when drawn across the restoration/tooth interface	Explorer falls into crevice when drawn across the restoration/tooth interface	Dentin or base is exposed along the margin
Anatomic form	The general contour of the restorations follows the contour of the tooth	The general contour of the restoration does not follow the contour of the tooth	The restoration has an overhang
Surface roughness	The surface of the restoration does not have any surface defects	The surface of the restoration has minimal surface defects	The surface of the restoration has severe surface defects
Marginal staining	There is no discoloration between the restorations and tooth	There is discoloration on less than half of the circumferential margin	There is discoloration on more than half of the circumferential margin
Interfacial staining/Bulk discoloration	There is no stain on the restoration, or the stain is equal on both the tooth and restoration	There is more stain on the restoration than on the surrounding tooth structure	The stain cannot be polished off the restoration (body discoloration)
Contact	Normal	Light	None
Post-operative sensitivity	No sensitivity when an air syringe is activated for 2 seconds at a distance of half an inch from the restoration, with the facial surface of the proximal tooth covered with gauze	Sensitivity is present when an air syringe is activated for 2 seconds at a distance of half an inch from the restoration, with the facial surface of the proximal tooth covered with gauze, and ceases when the stimulus is removed	Sensitivity is present when an air syringe is activated for 2 seconds at a distance of half an inch from the restoration, with the facial surface of the proximal tooth covered with gauze, and does not cease when the stimulus is removed
Secondary caries	There is no clinical diagnosis of caries	NA	There is clinical diagnosis of caries
Luster of restoration	The restoration surface is shiny and has an enamel-like, translucent surface	The restoration surface is dull and somewhat opaque	The restoration surface is distinctly dull and opaque and is esthetically displeasing

Alfa = expected to last for a long time; Bravo = one or more features which deviate from ideal, it may require replacement in the near future; Charlie = future damage to the tooth or surrounding tissues is likely to occur unless the restoration is replaced; NA = not applicable.

Exclusion Criteria
(1) Patients with contraindications for regular dental treatment because of their medical history; (2) patients with xerostomia or (3) those taking medications that are proven to significantly reduce the regular salivary flow; or (4) patients with defective restorations that scored Charlie (unacceptable or failed, USPHS, Ryge criteria).

One-hundred percent of the subjects who met the criteria agreed to participate in the study.

Study Methods
The study was approved by the Institutional Review Board (IRB) at the University of Florida before the study was initiated. Thirty-five third and fourth year dental students performed the treatment of the restorations under faculty supervision. Patients approved and signed the informed consent form previously approved by the IRB.

A modified USPHS/Ryge criteria (Table 1) was used to evaluate the clinical quality of the restorations. Two independent clinical dentists evaluated and recorded the restoration at its initial stage, and at 1- and 2-year recall exams. The importance of calibration among examiners has been emphasized.[11] A calibration exercise revealed that the interexaminer agreement ratio was 92%. If there was disagreement between the evaluators, a third evaluator was called to examine the restoration for a final decision.

Clinical failure of the restoration or treatment was determined by the criteria outlined on Table 1 under Charlie.

The treatment for each of the five groups is described further.

Treatment Groups
Repair
The RBC at the defective site was removed with a round carbide bur (Brasseler USA, Dental Rotary Instruments, Savannah, GA, USA) to allow a proper diagnosis and extent of the defect. The preparation margins were acid etched with 35% phosphoric acid and bonded with a resin-based bonding system (Single Bond, 3M/ESPE, St. Paul, MN, USA), followed by restoration with a RBC restorative material (Filtek Z250, 3M/ESPE). Rubber dam isolation was used for this procedure.

Sealant
Restorations with a crevice or a "ditch" at the cavosurface margin, received a resin-based sealant (Delton, Denstply/Caulk, Milford, DE, USA) after acid etching with 34% phosphoric acid (Denstply/Caulk) for 15 seconds. The sealant was polymerized with a light-curing unit (Demetron, Division of Kerr Corporation, Danbury, CT, USA). The output of the light unit was measured routinely with a curing radiometer (Demetron, Division of Kerr Corporation) to insure a constant value of at least 470 mW/cm^2.[12] Rubber dam isolation was used for this procedure.

Resurfacing
Stained areas superficial and located at any accessible smooth tooth surface were smoothed with interproximal aluminum oxide finishing strips (Sof-Lex, 3M/ESPE). If the facial, lingual, or buccal area were defective, the surface was first finished with medium series of aluminum oxide disks (3M/ESPE) or carbide finishing burs (12 or 30 blade, Brasseler USA, Dental Rotary Instruments) and then polished with fine series of aluminum oxide disks (Sof-Lex, 3M/ESPE) and rubber diamond acrylic impregnated points (Diacomp, Brasseler USA, Dental Rotary Instruments).

If the stained area was not superficial, repair of the restoration was considered.

Assignment for the No-Treatment and Replacement Groups
Thirty-two of the 88 restorations described previously were randomly assigned to either the no-treatment ($N = 16$) or the replacement ($N = 16$) group.

No-Treatment
The restorations were examined visually and no treatment was done.

Replacement
The restoration was completely removed. After the cavity preparation was completed, the tooth was restored with RBC restorative material (Single Bond and Filtek Z250, 3M/ESPE), under rubber dam isolation.

Outcome Measurements
Rating of the Clinical Condition
Sixteen clinical characteristics using a modified USPHS/Ryge criteria were evaluated: (1) color, (2) occlusal marginal adaptation, (3) proximal marginal adaptation, (4) anatomic form occlusal, (5) anatomic form proximal, (6) surface roughness occlusal, (7) surface roughness proximal, (8) marginal staining occlusal, (9) marginal staining proximal, (10) interfacial staining occlusal, (11) interfacial staining proximal, (12) occlusal contact, (13) proximal contact, (14) secondary caries, (15) postoperative sensitivity, and (16) luster. These characteristics were assigned a score of Alfa, Bravo, or Charlie according to the modified USPHS/Ryge criteria (Table 1).

Timeline
All restorations received a score for each clinical condition at the pre-operative evaluation. The restorations were then assigned to the treatment groups. Each restoration in the pre-operative evaluation had to score a Bravo rating in at least one clinical characteristic. The score of the pre-operative treatment was used as baseline for the analysis of the longitudinal data.

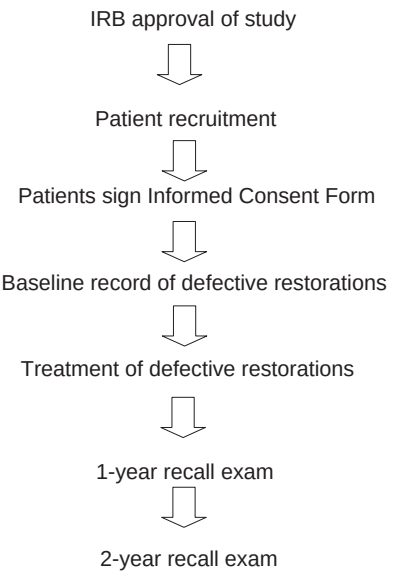

Figure 1. Flow Chart. Diagram demonstrating the entire sequence of the study. IRB = Institutional Review Board.

Two subsequent evaluations of the clinical characteristics of the restorations were performed at 1- and 2-year recall (Figure 1).

Grading Change of the Clinical Condition Outcome
For each time interval (1-year recall, 2-year recall) each restoration that received a clinical rating of Alfa, Bravo, or Charlie could result in four different outcomes: the final evaluation was either 1 (upgrade from Bravo to Alfa), 0 (no change), –1 (downgrade from Bravo to Charlie), or –2 (downgrade from Alfa to Charlie).

Statistical Analysis
Data management and analysis were done using the Statistical Analysis System (SAS Publishing, Cary, NC, USA). The ordinal dependent variable was "change in level" of the Ryge criteria. Kruskal-Wallis Test was used to assess the change of each clinical criteria (baseline and 1-year, baseline and 2-year recall) across all the treatment groups at $\alpha = .05$. Following significant findings, nonparametric pair-wise comparisons were used to test for specific differences between each treatment and the no-treatment group.

RESULTS

Sixty-six (75%) of the 88 restorations were examined at the 1-year recall exam and 58 (66%) of the 88 restorations were examined at the 2-year recall exam.

Results Comparing the No-Treatment Group with the Alternative Treatments
Significant treatment group differences were found for marginal adaptation and marginal staining (Tables 2 and 3) at 1- and 2-year recall exams. The alternative treatments did not show statistically significant difference from the

TABLE 2. CHANGES IN UPGRADE AND DOWNGRADE OF THE DIFFERENT TREATMENT OPTIONS WHEN COMPARED WITH THE NO-TREATMENT GROUP FOR MARGINAL ADAPTATION PROXIMAL AT EACH RECALL SESSION.

Time (years)	*N*	Treatment	Frequency of upgrade (1)	Frequency of no change (0)	Frequency of downgrade (–1)	*p*-value
0–1	11	**No treatment**	0 (0%)	7 (64%)	4 (36%)	
	24	Repair	7 (29%)	17 (71%)	0 (0%)	.002*
	7	Sealant	5 (72%)	1 (14%)	1 (14%)	.012*
	10	Resurfacing	1 (10%)	6 (60%)	3 (30%)	.563
	14	Replacement	7 (50%)	6 (43%)	1 (7%)	.005*
0–2	11	**No treatment**	0 (0%)	7 (64%)	4 (36%)	
	20	Repair	3 (15%)	17 (85%)	0 (0%)	.004*
	6	Sealant	4 (67%)	1 (16.5%)	1 (16.5%)	.026*
	10	Resurfacing	1 (10%)	6 (60%)	3 (30%)	.563
	11	Replacement	3 (27%)	6 (55%)	2 (18%)	.108

*Statistically significant different at $\alpha = .05$.

no-treatment group for all the other clinical criteria.

Marginal Adaptation

A significant impact on marginal adaptation (Table 2) was found at the first year recall exam for repair, sealant, and replacement groups when compared with the no-treatment group. The repair group showed no deterioration and 29% of improvement of the restorations. The sealant group showed improvement in 72% of the restorations, and replacement group showed improvement in 50% of the restorations. The no-treatment group showed no improvement over the first year period, however it presented 36% of deterioration over the same period of time.

At the second year recall exam, repair and sealant groups produced the least amount of deterioration and the highest improvement when compared with the no-treatment group, about 67% in each group. Surprisingly, this difference was even superior to the replacement group (27%).

Marginal Staining

The main differences of the repair and replacement groups compared with the no-treatment group occurred in the improvement or deterioration of the restorations (Table 3). Over 70% of the restorations in the repair and replacement groups showed significant improvement. Conversely, the no-treatment group showed more degradation than the repair and replacement groups.

For restorations in the sealant and resurfacing groups, most of the restorations remained unchanged over the first year observation period. No statically significant differences were observed for the resurfacing group; however, a trend was observed when reading the *p*-value ($p = .06$) at both 1- and 2-year recall exams. This trend is illustrated by the amount of restorations that remained stable (70%) when compared with the overall results of the no-treatment group.

At the second year recall exam, replacement and repair groups showed some improvement compared with the other groups; however, only the replacement group showed a statistically significant difference when compared with the no-treatment group.

TABLE 3. CHANGES IN UPGRADE AND DOWNGRADE OF THE DIFFERENT TREATMENT OPTIONS WHEN COMPARED WITH THE NO-TREATMENT GROUP FOR MARGINAL STAINING PROXIMAL AT EACH RECALL SESSION.

Time (years)	*N*	Treatment	Frequency of upgrade (1)	Frequency of no change (0)	Frequency of downgrade (–1)	*p*-value
0–1	11	No treatment	1 (9%)	7 (64%)	3 (27%)	
	24	Repair	17 (71%)	6 (25%)	1 (4%)	.02*
	7	Sealant	2 (29%)	5 (71%)	0 (0%)	.743
	10	Resurfacing	0 (0%)	7 (70%)	3 (30%)	.063
	14	Replacement	10 (71%)	4 (29%)	0 (0%)	.015*
0–2	11	No treatment	1 (9%)	7 (64%)	3 (27%)	
	20	Repair	12 (60%)	8 (40%)	0 (0%)	.06
	6	Sealant	2 (33%)	4 (67%)	0 (0%)	.632
	10	Resurfacing	0 (0%)	7 (70%)	3 (30%)	.06
	11	Replacement	9 (82%)	2 (18%)	0 (0%)	.005*

*Statistically significant different at $\alpha = .05$.

Results Comparing the Replacement Group with the Alternative Treatments

When the results of the replacement treatment were compared with the results of the alternative treatments, a statistically significant difference was found only for marginal adaptation at the first year recall exam. The resurfacing group presented significant inferior results when compared with the replacement group.

DISCUSSION

In the current study alternative treatments showed an overall improvement in restorations that presented clinical features that deviated from ideal; however, this improvement had a significant impact mainly on marginal adaptation and marginal staining of the restorations. Because RBC restorations are known to fail primarily at the restoration margins,[1–5,13] alternative treatments mostly affected these two clinical characteristics: marginal adaptation and marginal staining.

Repair Treatment

Even though studies dealing with repair of RBC materials have been widely published,[14–18] this approach is not routinely considered in the treatment plan of restorations that are defective or are not ideal, and as a result, the entire restoration is usually replaced. The practice of repair of RBC restorations is not taught in all dental schools in North America.[19] Yet surprisingly, in the schools that do teach this practice, repairs have been considered a definitive treatment.[19]

Repair had a significant impact on both first and second year recall exams, with significant improvement of the margins of restorations. Furthermore, repair treatment remained stable over a 2-year observation period, which favors this technique for predictability. Additionally, the repair group showed no significant difference when compared with the replacement group. The implication of this finding is a major repercussion in the preservation of tooth structure as only the defective part is removed and restored, leaving the remaining restoration untouched. Therefore, the remaining restoration is preserved from additional healthy tooth removal and, consequently, tooth destruction.

Potential problems, however, may exist with repair of RBC restora-

tions as bonding of resin-based materials to existing RBC restorations may not have the bond strength of the original restoration.[20] Studies have shown that the strength of RBC repair is about half of that in the original restoration.[21–23] Nonetheless, repair is a conservative approach in areas where high bond strength is not critical, as in areas that are surrounded by tooth structure and/or the old restorative material such as on occlusal, buccal, or lingual surfaces. In fact, in the current study, none of the repaired restorations failed and the repair treatment was especially effective regarding improvement of marginal adaptation and marginal staining.

Sealant Treatment

Sealed restorations are superior to unsealed restorations in conserving sound tooth structure.[24] A controversial clinical study showed that sealing caries with resin-based materials arrested the progress of carious lesions up to 9 years.[24–25] Although these studies found that the practice of sealing restorations resulted in a significant improvement at the margins of the intact restorations, they did not evaluate the effect of sealing restoration margins that have some defect. In the current study, sealant significantly improved the marginal adaptation of the majority of the restorations, with minimal deterioration after the 2-year observation period.

The sealant treatment is especially effective in treating defects related to marginal adaptation as the resin-based sealant has a viscosity that allows penetration into the spaces at the defective margins. Roughening the surface of the RBC material that will receive the sealant with diamond burs or sandblasting treatment might promote a better retention of the sealant material in to the defective sites,[26] although this practice was not done in the current study.

Resurfacing Treatment

To date no clinical study has been performed to evaluate the effects of resurfacing of defective restorations and only anecdotal knowledge is available. The resurfacing of a defective margin could prevent premature failure of the restoration by removing areas of excess of the RBC material or surface staining. The immediate benefit in removing excess material is a decrease in plaque retention at these sites, which will reflect on the overall health of the tooth and adjacent dental structures. The removal of superficial surface staining may have an immediate improvement in the esthetics of the restoration; however, in the current study, the results of the resurfacing treatment were not maintained after a 2-year observation period for some restorations. Furthermore, no significant difference was observed when compared with the no-treatment group, only a trend of improvement was observed with the numbers presented in the results. This trend could be further considered if a larger sample size was available after the 2-year observation period.

Replacement Treatment

The positive impact of the replacement group was singularly seen for marginal staining after the 2-year observation period when compared with the other alternative treatments. In addition, for the majority of the remaining clinical characteristics, replacement did not have an impact when compared with the no-treatment group. Furthermore, the replacement treatment presented similar outcomes than the repair treatment for marginal adaptation and marginal staining. Marginal staining can be a significant source of concern when esthetics is considered; however, another important consideration should be the significant amount of healthy tooth structure that is lost when the restoration is completely replaced. Furthermore, good marginal adaptation is important to reduce plaque accumulation.

Long-term observation period of the outcomes of the current study might favor the replacement treatment; however, with the current

2-year observation period replacement treatment was not considered justified for the treatment of restorations that were graded as Bravo (USPHS/Ryge criteria).

The current study sends an interesting message that relies mainly on the diagnosis of the restoration with regards to imperfections and on the treatment decision-making process. When the dentist faces a particular restoration which deviated from ideal and doubts the need to replace it, a better alternative might be to monitor the restoration over a period of time. Certainly, caries risk assessment, patient oral hygiene profile, and preventive measures should be taken into consideration when this option is selected. If the questionable area has a particular influence on marginal adaptation and marginal staining, a better and equally predictable option might be to repair the affected area of the restoration. This option will certainly be more conservative in the preservation of healthy tooth structure.

Evaluating Criteria and Limitations of the Study

No statistical significant differences were observed across the treatment groups for any of the modified Ryge criteria following treatment (ie, post-treatment baseline), suggesting that no bias was introduced at the starting point of each restorative treatment. In other words, most of the restorations started with a similar score after the restorative treatment.

One of the limitations of the current study was the use of the USPHS criteria.[11] These criteria may have limited application, as the information provided is too broad and certain characteristics of the restoration may fall between categories. However, this is the most used method for clinical evaluation of restorations worldwide;[13,27–29] therefore, the strength in using these criteria relies on the fact that it can be compared to previous studies. The criteria involve visual inspections, as well as the use of a dental explorer, dental floss, and articulating paper to check the several clinical characteristics in a RBC restoration.

Although the evaluation time required to make a correct assessment of the success of the restoration/treatment has not been clearly established, the current study only observed the restorations for a 2-year period. The long-term longevity of the reported treatments has not been studied and it is necessary that future research focus on this limitation of the current study.

CONCLUSIONS

Within the limitations of the current study it was concluded that restorations that have a Bravo rating for clinical characteristics other than marginal adaptation and marginal staining do not need to be intervened. Monitoring a restoration with a Bravo rating proved to be comparable with the outcomes of replacing a restoration in the 2-year observation period of this study.

If the defective restoration has a Bravo rating for marginal adaptation and marginal staining, the restoration may need to be treated to avoid further deterioration. Repair and replacement would offer the most predictable results, and repair would be the most conservative option of treatment.

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