Sealing, refurbishment and repair of Class I and Class II defective restorations
A three-year clinical trial

Gustavo Moncada, DDS; Javier Martin, DDS; Eduardo Fernández, DDS; Marie C. Hempel, DDS; Ivar A. Mjör, BDS, MSD, MS, DrOdont; Valeria V. Gordan, DDS, MS, MSci

Approximately 50 percent of resin-based composite (RBC) and 60 percent of amalgam (AM) restorations are replaced after seven (RBC) or 10 years (AM) of service.[1] The main reasons for these replacements are secondary (recurrent) caries, marginal defects, discolorations, degradation/wear and loss of anatomical form.[2,3] For many years, replacement of defective RBC and AM restorations has been the most common treatment in general dental practice,[4] and it represents a major part of oral health care in adults with restored dentitions.[1]

When a restoration is replaced, a significant amount of sound tooth structure is removed and the preparation is enlarged.[5-7] Alternative treatments, such as repair or resurfacing, increase the longevity of restorations at a lower cost than that of replacement, and they are the most conservative option.[8,9] Another procedure that has been performed more commonly is sealing of defective margins. This treatment has significantly improved the longevity of restorations.[10,11] Despite the promising results of these treatments, no longitudinal studies have been published, to our knowledge, that assess these alternative treatments to replacement of restorations.

ABSTRACT

Background. The authors conducted a clinical study to examine the effectiveness of treatments other than replacement for defective Class I and Class II resin-based composite (RBC) and amalgam (AM) restorations.

Methods. The authors recruited 66 patients (age range, 18-80 years) with 271 Classes I and II defective restorations (RBC = 78 and AM = 193). They assigned restorations to one of the following treatment groups on the basis of the type of defect: sealed margins (n = 48), repair (n = 27), refurbishment (n = 73), replacement (n = 42) or untreated (n = 81). They used modified U.S. Public Health Service/Ryge criteria to determine the quality of the restorations. Two examiners assessed the restorations independently at the beginning of the study and three years after treatment (Cohen's κ = 0.74 at baseline and 0.82 at year 3). They used five parameters in assessing the restorations: marginal adaptation, anatomical form, surface roughness, secondary caries and luster.

Results. The authors assessed 237 restorations (RBC = 73, AM = 164) at the three-year recall examination. Restorations that underwent sealing of marginal defects exhibited significant improvements in marginal adaptation ($P \le .001$). Restorations in the refurbishment group exhibited improvements in anatomical form ($P \le .005$) and surface roughness ($P \le .001$). Restorations in the repair group exhibited improvements with regard to anatomical form ($P = .008$). Replaced restorations exhibited improvements in all parameters ($P < .05$), while the untreated group experienced declines in all parameters ($P < .05$).

Conclusions. The results of this study show that defective RBC and AM Class I and Class II restorations undergoing sealing of margins, repair or refurbishment exhibited improvements three years after treatment.

Clinical Implications. Marginal sealing or repair or refurbishment of anatomical form and roughness are conservative and simple procedures that increase the longevity of RBC and AM restorations with minimal intervention.

Key Words. Resin-based composite; amalgam; restorations; longevity; alternative treatment.
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Dr. Moncada is a professor and chairman, Operative Dentistry, Department of Restorative Dentistry, Faculty of Dentistry, University of Chile, Santiago.
Dr. Martin is an associate professor, Operative Dentistry, Department of Restorative Dentistry, Faculty of Dentistry, University of Chile, Santiago.
Dr. Fernández is an associate professor, Operative Dentistry, Department of Restorative Dentistry, Faculty of Dentistry, University of Chile, Santiago.
Dr. Hempel is an associate professor, Operative Dentistry, Department of Restorative Dentistry, Faculty of Dentistry, University of Chile, Santiago.
Dr. Mjör is a professor emeritus, Department of Operative Dentistry, Health Science Center, College of Dentistry, University of Florida, Gainesville.
Dr. Gordan is a professor, Department of Operative Dentistry, Health Science Center, College of Dentistry, University of Florida, Gainesville, Fla. 32610, e-mail "vgordan@dental.ufl.edu". Address reprint requests to Dr. Gordan.

TABLE 1

Modified U.S. Public Health Service/Ryge clinical criteria.*

CLINICAL CHARACTERISTIC	ALFA†	BRAVO‡	CHARLIE§
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
Anatomical Form	General contour of the restorations follows the contour of the tooth	General contour of the restoration does not follow the contour of the tooth	Restoration has an overhang
Surface Roughness	Surface of the restoration does not have any surface defects	Surface of the restoration has minimal surface defects	Surface of the restoration has severe surface defects
Secondary Caries	No clinical diagnosis of caries	NA¶	Clinical diagnosis of caries at restoration margin
Luster	Restoration surface is shiny and has an enamellike, translucent surface	Restoration surface is dull and somewhat opaque	Restoration surface is distinctly dull and opaque and is esthetically unpleasing

* Source: Cvar and Ryge.[12]
† Alfa: Restorations in excellent condition, expected to last for a long time.
‡ Bravo: One or more features that deviate from the ideal; restoration may require replacement in the near future.
§ Charlie: Damage to the tooth or surrounding tissue is likely to occur unless the restoration is replaced or repaired.
¶ NA: Not applicable.

The objective of this prospective clinical trial was to evaluate treatments such as sealing of defective margins or refurbishment or repair of localized clinical defects in restorations that traditionally would be treated by replacement.

Our hypothesis was that sealing of margins or refurbishment or repair of Class I or Class II RBC and AM restorations with certain clinical defects would improve their clinical condition across three years.

MATERIALS AND METHODS

We included in this study 66 patients aged 18 to 80 years (mean age, 26.5 years) with 271 Class I or Class II restorations (RBC = 78, AM = 193) that had one or more clinical features that deviated from the ideal. These patients received treatment regularly in the Operative Dentistry Clinic, Faculty of Dentistry, University of Chile, Santiago.

All patients had molar-supported dentition and at least 20 teeth. Restored teeth had to be in functional occlusion with an opposing natural tooth,

and they had to have at least one proximal contact area with a neighboring tooth. All restored teeth were asymptomatic at the baseline examination.

We excluded patients who had contraindications for regular dental treatment according to their medical history, as well as patients with esthetic demands that could not be resolved by the alternative treatments. In addition, we excluded patients who had xerostomia or were receiving treatment with medications that significantly reduced salivary flow. Furthermore, we excluded patients who had psychiatric or physical pathologies that interfered with oral hygiene and patients at an extremely high risk of developing caries.

We obtained written informed consent from all patients, as required by the ethics committee and the research board of the Faculty of Dentistry, University of Chile.

At baseline, two examiners (J.M., E.F.) independently evaluated all restorations clinically by using direct observation only. The parameters examined were marginal adaptation, anatomical form, surface roughness, secondary (recurrent) caries and luster. The examiners classified all restorations as Alfa, Bravo or Charlie, according to modified U.S. Public Health Service/Ryge criteria (Table 1).[12] If the two examiners differed in their evaluation of any parameter, a third examiner was asked to make the final decision. All examiners involved in the study completed calibration exercises.

Two clinicians (G.M., M.C.H.) who did not diagnose the defects completed calibration exercises, assigned teeth to the treatment groups and treated them on the basis of the type of restoration defect present (that is, a total of four operators participated in this study) (interexaminer Cohen's κ = 0.76).

Each patient had experimental and control restorations, and, whenever possible, we used a similar tooth type with comparable cavity size. The

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ABBREVIATION KEY. A: Anatomical form. **AM:** Amalgam. **L:** Luster. **MA:** Marginal adaptation. **R:** Surface roughness. **RBC:** Resin-based composite. **SC:** Secondary caries.

clinician treated all teeth in a patient during the same appointment. Our objective was to include four restorations per patient, but this was not possible for all patients. Nine (14 percent) of the 66 patients received all treatments (including the untreated group), 25 patients (38 percent) received four treatments, 14 patients (21 percent) received three treatments, 11 patients (17 percent) received two treatments and seven patients (11 percent) received one treatment.

After the baseline evaluation, the clinician assigned the restorations to one of the five groups according to the following criteria:

◼ If the restoration had defects in marginal adaptation, the clinician assigned it to the sealed margins or untreated group.

◼ If the restoration was diagnosed with secondary caries, the clinician assigned it to the repair or replacement group.

◼ If defects were noted related to anatomical form (overcontour), roughness or luster, the clinician assigned the restoration to the refurbishment or untreated group.

◼ If the restoration had defects related to contact with neighboring teeth or anatomical form (undercontour), the clinician assigned it to the repair or replacement group.

Group A: sealed margins (n = 48). The clinicians acid-etched the open margins of the RBC and AM restorations that had marginal defects with 35 percent phosphoric acid for 15 seconds. The clinicians used water to rinse off the acid, dried the restoration and applied a resin-based sealant (Clinpro Sealant, 3M ESPE, St. Paul, Minn.) according to the manufacturer's instructions. The dentists light cured the sealant for 20 seconds (Elipar 2500 Curing Light, 3M ESPE). The clinicians checked the output of the curing lamp after every 20 restorations to ensure a regular rate of at least 480 watts/square centimeter. The clinicians performed all procedures using rubber dam isolation.

Group B: refurbishment (n = 73). The dentists finished the occlusal, lingual or facial surfaces of defective RBC restorations with the medium series of aluminum oxide disks (Sof-Lex, 3M ESPE) or carbide burs (12 and 30 blades, Brasseler USA, Dental Instrumentation, Savannah, Ga.) and then polished them with a fine series of aluminum oxide disks (Sof-Lex, 3M

The same blinded examiners re-evaluated the restorations clinically at the recall visits by using the same criteria as those used at the baseline examination.

ESPE) and diamond-impregnated composite polisher (ComposiPro Diacomp, Brasseler). For restorations in which proximal surface areas were affected, the clinicians smoothed them with interproximal aluminum oxide finishing strips (Sof-Lex Finishing Strips, 3M ESPE). For AM restorations, the clinicians used the same type of carbide burs as those above to smooth the defective areas, followed by polishing with silicone impregnated points (Brownie, Greenie and Supergreenie, Shofu Dental, San Marcos, Calif.).

Group C: repair (n = 27). The clinicians explored the defects in both RBC and AM restorations by using carbide burs (no. 330-010, Brasseler USA), starting with the restorative material adjacent to the defect. After removing the restorative material in the area of the defect, the clinicians removed any stained and soft tooth tissues present at the exploratory cavity preparation. The defect rarely involved demineralized or soft dentin.

For RBC restorations, the dentists used a self-priming resin bonding system (Adper Prompt L-Pop Self-Etch Adhesive, 3M ESPE), followed by restoration with RBC (Filtek Supreme Plus Universal Restorative, 3M ESPE). For AM restorations, the dentists used a dispersed-phased AM (Original D, Wykle Research, Carson City, Nev.). The clinicians created mechanical retentions inside the existing restoration. They used rubber dam isolation for the restorative portion of the procedure.

Group D: replacement (n = 42). The clinicians removed defective RBC and AM restorations and restored the teeth with either an RBC (Filtek Supreme Plus Universal Restorative) or AM (Original D) restoration under rubber dam isolation.

Group E: untreated (n = 81). These restorations did not receive treatment and served as a negative control group.

Patients underwent recall examinations at one, two and three years after treatment. The same blinded examiners re-evaluated the restorations clinically by using the same criteria as those used at the baseline examination; calibration exercises preceded each annual evaluation. The calibration exercises revealed an interexaminer Cohen's κ of 0.82.

TABLE 2

Distribution of restorations assessed after three-year observation period.

GROUP	NO. OF RESTORATIONS		TOTAL
	RBC*	AM†	
A: Sealed Margins	17	23	40
B: Refurbishment	7	57	64
C: Repair	7	17	24
D: Replacement	18	19	37
E: Untreated	24	48	72
TOTAL	73	164	237

* RBC: Resin-based composite.
† AM: Amalgam.

TABLE 3

Clinical outcome for restorations in group A (sealed margins).

MODIFIED U.S. PUBLIC HEALTH SERVICE/RYGE CLINICAL CRITERIA*	RESTORATIONS RATED ALFA (%)		P VALUE
	Baseline	Three Years	
Marginal Adaptation	4	60	< .001†
Anatomical Form	73	68	.626
Surface Roughness	88	75	.152
Secondary Caries	100	100	≈ 1
Luster	70	53	.108

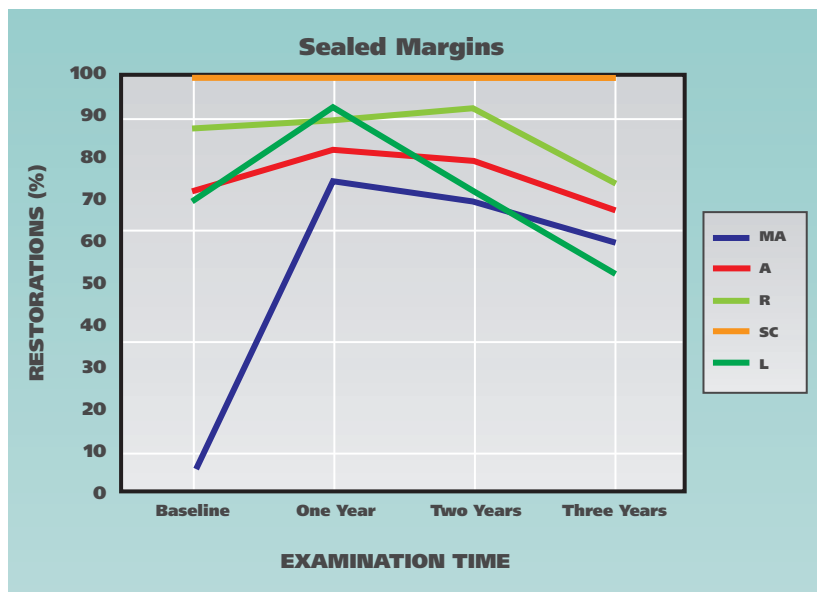* Source: Cvar and Ryge.[12]
† Statistically significant.

Figure 1. Alfa ratings for restorations in group A (sealed margins) at baseline and at one, two and three years after treatment. MA: Marginal adaptation. A: Anatomical form. R: Surface roughness. SC: Secondary caries. L: Luster.

We removed from the study any restorations that had failed after three years and treated the teeth according to their diagnosed needs.

Statistical analysis. We analyzed the results by using nonparametric pairwise comparisons to contrast the preoperative and postoperative condition, at α = .05 (SPSS 15.0.1 for Windows, SPSS, Chicago).

RESULTS

Of the 271 restorations evaluated at baseline, 262 (97 percent) were examined after one year, 256 (94 percent) after two years and 237 (87 percent) after three years. Seventy-three (31 percent) of the 237 restorations were RBC and 164 (69 percent) were AM. At the third-year recall examination, 34 restorations had been lost from the study. Twenty-eight were lost because the patients had dropped out, four were lost owing to orthodontic reasons (metallic bands covered the restorations), one was lost owing to endodontic re-treatment and one was lost as a result of a car accident. Table 2 shows the distribution of restorations assessed after three years.

Sealed margins. Table 3 presents the results for restorations in group A (sealed margins), which exhibited a significant improvement in marginal adaptation ($P < .001$). The restorations received Bravo ratings for anatomical form, surface roughness and luster, with no significant differences observed between the recall periods. We did not note any changes with regard to secondary caries (Figure 1).

Refurbishment. Restorations in group B (refurbishment) experienced a significant improvement in anatomical form ($P < .001$) (Table 4). Surface roughness also improved significantly (Figure 2). Marginal adaptation and luster returned to baseline levels three years after treatment.

Repair. In group C (repair), the only clinical parameter that improved significantly was anatomical form ($P = .008$) (Table 5). Secondary caries also experi-

enced an improvement, but the result was not statistically significant. Marginal adaptation, surface roughness and luster returned to baseline values after three years.

Replacement. As Table 6 shows, restorations in group D (replacement) experienced significant improvement from baseline to three years in marginal adaptation, anatomical form, secondary caries and luster.

Untreated. Restorations in group E (untreated) deteriorated significantly with regard to marginal adaptation ($P < .001$), surface roughness ($P = .012$) and luster ($P = .024$) (Table 7). Results for the other parameters did not change significantly from baseline to three years.

DISCUSSION

Our proposed hypothesis was confirmed; Class I and Class II RBC and AM restorations with certain clinical defects that underwent refurbishment or repair exhibited significant improvement across three years.

Sealed margins. Results from the one- and two-year recall examinations show that sealing of margins and refurbishment or repair of localized defects in RBC and AM restorations are successful treatments, requiring minimal removal of tooth structure.[9,11] For restorations in group A (sealed margins), sealing the marginal discrepancies resulted in an increase in Alfa ratings during the three-year observation period. These alternative treatments to replacement of restorations also reduced the risk of needing more complex restorative therapy, as well as stress on the dental pulp.[13,14] In addition, the examiners did not observe any tooth fractures or pulpal injuries during the three-year observation period. The examiners recorded secondary caries in only two refurbished restorations. None of the restorations that were repaired or sealed failed during the three-year observation period.

Sealed marginal gaps can deteriorate

TABLE 4

Clinical outcome for restorations in group B (refurbishment).

MODIFIED U.S. PUBLIC HEALTH SERVICE/RYGE CLINICAL CRITERIA*	RESTORATIONS RATED ALFA (%)		*P* VALUE
	Baseline	**Three Years**	
Marginal Adaptation	38	39	.856
Anatomical Form	45	84	< .001[†]
Surface Roughness	47	70	.007[†]
Secondary Caries	100	97	≈ 1
Luster	38	45	.37

* Source: Cvar and Ryge.[12]
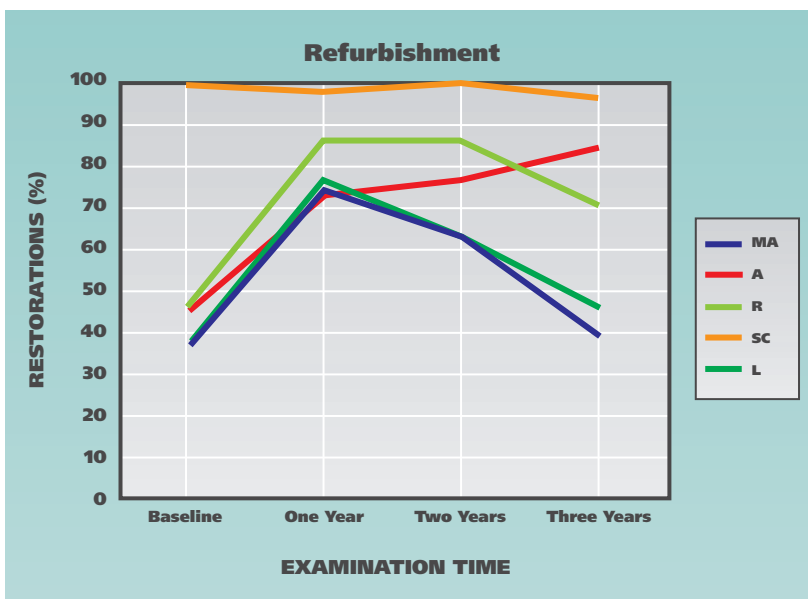† Statistically significant.

Figure 2. Alfa ratings for restorations in group B (refurbishment) at baseline and at one, two and three years after treatment. MA: Marginal adaptation. A: Anatomical form. R: Surface roughness. SC: Secondary caries. L: Luster.

TABLE 5

Clinical outcome for restorations in group C (repair).

MODIFIED U.S. PUBLIC HEALTH SERVICE/RYGE CLINICAL CRITERIA*	RESTORATIONS RATED ALFA (%)		*P* VALUE
	Baseline	**Three Years**	
Marginal Adaptation	21	17	.712
Anatomical Form	21	58	.008[†]
Surface Roughness	50	58	.562
Secondary Caries	88	100	.074
Luster	38	46	.558

* Source: Cvar and Ryge.[12]
† Statistically significant.

TABLE 6

Clinical outcome for restorations in group D (replacement).

MODIFIED U.S. PUBLIC HEALTH SERVICE/RYGE CLINICAL CRITERIA*	RESTORATIONS RATED ALFA (%)		P VALUE
	Baseline	Three Years	
Marginal Adaptation	22	60	.001†
Anatomical Form	22	60	.001†
Surface Roughness	49	62	.242
Secondary Caries	57	100	< .001†
Luster	43	73	.01†

* Source: Cvar and Ryge.[12]
† Statistically significant.

TABLE 7

Clinical outcome for restorations in group E (untreated).

MODIFIED U.S. PUBLIC HEALTH SERVICE/RYGE CLINICAL CRITERIA*	RESTORATIONS RATED ALFA (%)		P VALUE
	Baseline	Three Years	
Marginal Adaptation	81	51	< .001†
Anatomical Form	78	68	.189
Surface Roughness	92	76	.012†
Secondary Caries	100	100	≈ 1
Luster	74	56	.024†

* Source: Cvar and Ryge.[12]
† Statistically significant.

Figure 3. Alfa ratings for restorations in group C (repair) at baseline and at one, two and three years after treatment. MA: Marginal adaptation. A: Anatomical form. R: Surface roughness. SC: Secondary caries. L: Luster.

over time, as shown by the downward trend in our study results (Figure 1). Therefore, clinicians should check sealants regularly. The deterioration in margin quality probably is due to the tendency of restorations to wear. In addition, the reasons for marginal deterioration were not identified, and we did not evaluate the variables related to the characteristics of individual restorations, including differences in cusp flexion of teeth; bonding of the sealant; and problems related to cavity design, occlusion and bruxism. These factors need to be explored to find a complete answer regarding the deterioration of the sealant.

Refurbishment. Resurfacing the restorations resulted in a significant increase in Alfa ratings for roughness and anatomical form after three years (Figure 2). This improvement was stable during the observation period. Marginal adaptation and luster parameters, as expressed in Alfa ratings, returned to baseline levels after three years. Gordan and colleagues[9] described refurbishment as encompassing smoothing of restoration surfaces, removing excess restorative material and resurfacing restorations to improve their anatomical form, which will result in less retention of dental plaque and less ditching of the restoration margins. Replacement of defective restorations has been the traditional response of clinicians, but the results of this study show that the alternative treatments achieved similar results during the three-year observation period.

Repair. Repair consists of removing a part of the restoration at the defective site[9] to remove a localized restoration defect or to remove accessible secondary carious lesions. In this study, all teeth treated via repair remained free of carious lesions after three years. Repaired restorations showed significant improvement in anatomical form after the first year, and this result was maintained during the next two years. The quality of the restorations was better after three years than at baseline, as
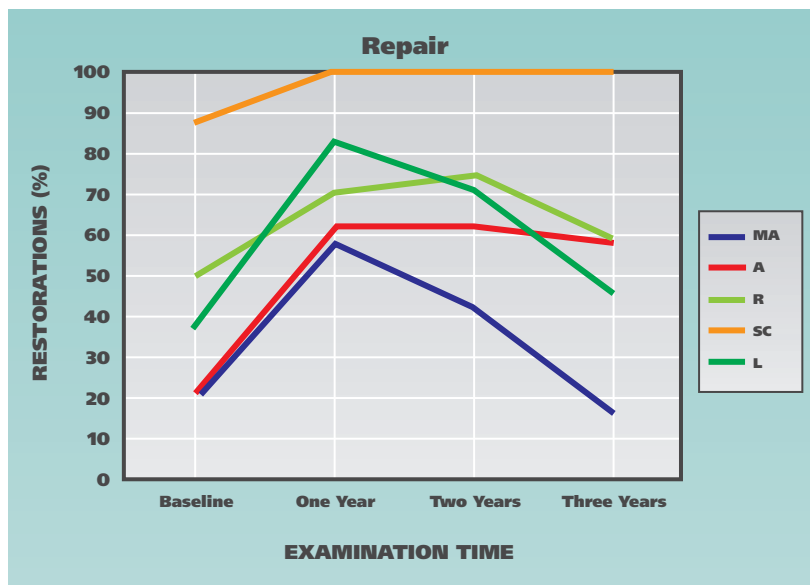
demonstrated by an increase in Alfa ratings (Figure 3). Repair is a relatively simple and conservative treatment that could increase the longevity of restorations at a low cost, by requiring the removal and replacement of only the defective section, leaving the remaining part of the restoration untouched.[6-9,15-17] For the Class I and Class II repaired restorations in our study, marginal adaptation, surface roughness and luster returned to baseline levels at three years, as expressed in Alfa ratings. This observation was consistent in all five groups.

Replacement. The results of this study show that replaced restorations deteriorated over time (Figure 4), as did restorations in the other groups. Thus, traditional replacement may not be the treatment of choice for defective restorations. Longer observation periods may substantiate the findings of this study and support our proposed conservative treatment techniques.

Untreated. With the exception of secondary caries, restorations in the control group experienced frank degradation for all parameters after three years in comparison with baseline values (Figure 5).

To our knowledge, this clinical trial is the first three-year follow-up of sealed, refurbished and repaired Class I and Class II RBC and AM restorations. The results provide clinicians with options for treating defective restorations with minimally invasive procedures, especially when faced with localized defects.

In general, the restoration intervention techniques tested in this study proved to be a reasonable alternative to total restoration replacement during the three-year observation period. The examiners did not record any failures after repair or refurbishment of defective restorations, and these simple procedures reduce the negative effects of replacement such as stress on the pulp and further weakening of the teeth.

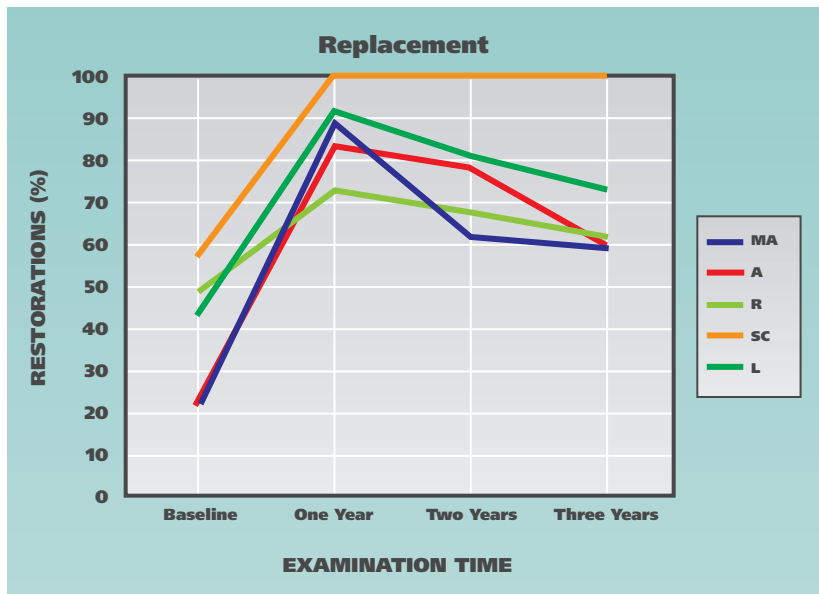Understanding marginal sealing, repair and refurbishment techniques and their appropriate

Figure 4. Alfa ratings for restorations in group D (replacement) at baseline and at one, two and three years after treatment. MA: Marginal adaptation. A: Anatomical form. R: Surface roughness. SC: Secondary caries. L: Luster.
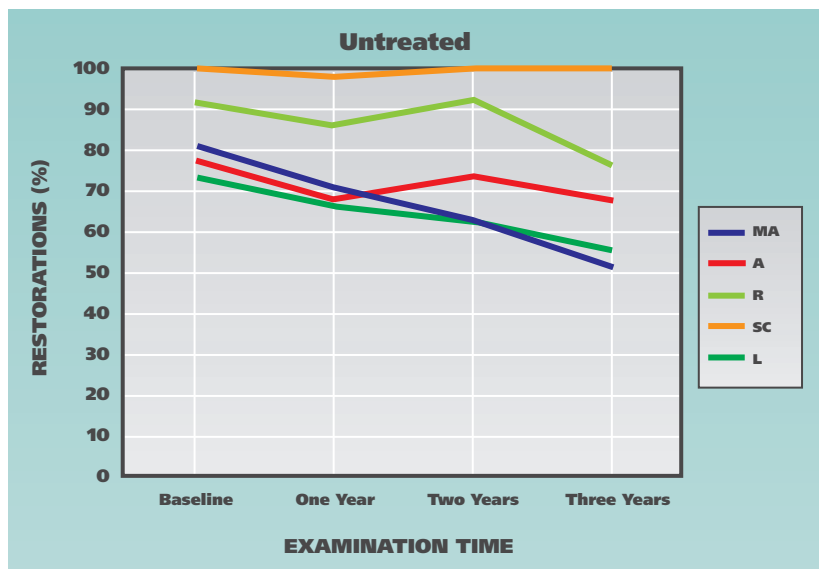

Figure 5. Alfa ratings for restorations in group E (untreated) at baseline and at one, two and three years after treatment. MA: Marginal adaptation. A: Anatomical form. R: Surface roughness. SC: Secondary caries. L: Luster.

indications in operative dentistry can lead to improved restoration quality and enhance the longevity of restorations.

CONCLUSION

The results of this study show that Class I and Class II RBC and AM restorations that traditionally would be replaced are candidates for treatment via sealing of margins, refurbishment or

repair of localized defects. Most of the restorations in our study treated with one of these procedures retained their clinical characteristics during the three-year observation period. ∎

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