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A 24-month Evaluation of Amalgam and Resin-Based Composite Restorations: Findings from The National Dental Practice-Based Research Network

Michael S. McCracken, DDS, PhD[1], **Valeria V. Gordan, DDS, MS, MS-CI**[2], **Mark S. Litaker, PhD**[1], **Ellen Funkhouser, PhD**[3], **Jeffrey L. Fellows, PhD**[4], **Douglass G. Shamp, DDS**[5], **Vibeke Qvist, DDS, PhD, DrOdont**[6], **Jeffrey S. Meral, DDS**[7], and **Gregg H. Gilbert, DDS, MBA**[1] **for The National Dental PBRN Collaborative Group**[8]

[1]Department of Clinical and Community Sciences, School of Dentistry, University of Alabama at Birmingham, Birmingham, AL

[2]Department of Restorative Dental Sciences, Division of Operative Dentistry, College of Dentistry, University of Florida Health Science Center, Gainesville, FL

[3]Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, Birmingham, AL

[4]Kaiser Permanente Center for Health Research, Portland, OR

[5]Forestview Family Dentistry, Maple Grove, MN

[6]Department of Cariology and Endodontics, School of Dentistry, University of Copenhagen, Denmark

[7]Coral Springs, FL

Abstract

Background—Knowing which factors influence restoration longevity can help clinicians make sound treatment decisions. The authors analyzed data from the National Dental Practice-Based Research Network to identify predictors of early failures of amalgam and resin-based composite (RBC) restorations.

Methods—This prospective cohort study gathered information from clinicians and offices participating in the network. Clinicians completed a baseline data collection form at the time of restoration placement, and annually thereafter. Data collected included patient factors, practice factors, and dentist factors, and were analyzed using mixed-model logistic regression.

Results—A total of 226 practitioners followed 6,218 direct restorations in 3,855 patients; 386 restorations failed (6.6 percent) during the mean follow-up period of 23.7 (SD 8.8) months. The number of tooth surfaces restored at baseline predicted subsequent restoration failure; large restorations were over 4 times more likely to fail. Material was not significantly associated with longevity; neither was tooth type. Patient age was highly associated with failure ($p<0.0001$). The failure rate for children was 5 percent, compared to 12 percent in persons 65 years old or older. Dentist gender and practice workload were significantly associated with restoration longevity.

To whom correspondence and reprint requests should be addressed: Dr. Valeria V Gordan, Professor, Department of Restorative Dental Sciences, Operative Dentistry Division, College of Dentistry, University of Florida, P.O. Box 100415, Gainesville, Fla. 32610-0415, vgordan@dental.ufl.edu.

[8]The DPBRN Collaborative Group comprises practitioner-investigators, faculty investigators, and staff members who contributed to this DPBRN activity. A list of these persons is at http://www.dpbrn.org/users/publications/Default.aspx

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Conclusions—In this prospective cohort study, these factors significantly predicted an increased failure rate for amalgam and RBC restorations: older patient age and a higher number of surfaces restored at baseline, with other key baseline variables taken into account. Material choice was not significantly predictive in these early results.

Clinical Implications—Understanding risk factors for early restoration failure may lead to more-effective patient care.

Keywords

Direct restorations; decision making; evidence-based dentistry; operative dentistry; amalgam; resin-based composite; dental restorations

INTRODUCTION

When placing a direct restoration, clinicians must consider a variety of factors which may impact restoration longevity. These factors range from those based on scientific evidence to those based on the personal preference of the patient or dentist. Such factors may include esthetic concerns,(1–3) cost,(4, 5) perceived health or environmental risks from mercury,(6–9), and technical expectations of the material.(10–13) Of particular importance to many clinicians is the clinical longevity of the restoration and a predictable treatment outcome.

A wide variety of patient and operator variables influence longevity of direct restorations.(14–16) One example is a patient's caries risk. Patients with a high caries index are likely to have decreased restoration longevity due to recurrent caries.(17–20) Larger restorations, which may be linked to high caries rates, also have shown greater failure rates.(21–24) Tooth position has been shown to impact longevity of restorations, with molars demonstrating lower long-term success than anterior teeth.(23)

Operator variables may also influence restoration longevity. One study found that more-efficient operators had higher restoration survival rates.(25) Clinicians' age and educational background may impact restoration longevity,(26) as well as the type of restorative material selected. One study showed that female dentists were more likely to place amalgam restorations than males.(27) In that study, younger dentists tended to use amalgam more often than older dentists, as did practitioners working in a large group practice setting.(27) One study, based on insurance claims, suggested that patients who change dentists are far more likely to have restorations replaced, which would also impact restoration longevity.(28)

The effect of material type on the longevity of restorations is inconclusive in the literature and may be related to a complex array of patient, tooth, and operator variables.(17) Three recent studies comparing resin-based composites (RBC) and amalgam as restorative materials suggest that amalgam has greater longevity than RBC materials. One study reported the mean survival rate of amalgam to be 14.6 years, compared to 7.8 years for RBC.(29) In a randomized clinical trial of pediatric patients, amalgam outperformed RBC, showing a 94.4 percent survival rate compared to 85.5 percent for RBC at 7 years. The risk of secondary caries was 3.5 times greater for RBC.(30) Findings were similar in another randomized clinical study.(31) However, at least one study shows that RBC materials may have some long-term clinical advantages over other restorative materials, especially in cases where the restoration was large and the patient's caries risk was low.(17) Generally speaking, these clinical data are derived from a small number of clinicians rather than a broad network of operators. Because of this, they may contain operator bias and limited applicability to a larger population.

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This study reports data obtained from participants in The National Dental Practice-Based Research Network, a group of clinicians from a variety of backgrounds and regions. The purpose of this organization is to ask and answer questions that impact the daily practice of dentistry and the delivery of oral health care. At the time of the current study, the network was primarily composed of clinicians from the United States and Scandinavia, principally from five regions: Alabama/Mississippi (AL/MS); Florida/Georgia (FL/GA); dentists in Minnesota, either employed by HealthPartners (Bloomington, Minn.) or in private practice (MN); Permanente Dental Associates, in cooperation with Kaiser Permanente's Center for Health Research in Portland, Oregon (PDA); and dentists from Denmark, Norway and Sweden (SK).

The purpose of this prospective cohort study was to identify factors associated with the clinical longevity of direct restorations, especially when comparing early failures of amalgam and resin-based composite materials. The reasons that these restorations were placed in previously-unrestored teeth are described in detail elsewhere.(32)

PARTICIPANTS, MATERIALS AND METHODS

Dentists were recruited to participate in this study through direct mailings and other advertisements focused on the network regions described above. Participating dentists completed enrollment information and agreed to participate in a cross-sectional study investigating the reasons for placing restorations on previously unrestored permanent teeth. The specifics of recruitment of dentists participating in this study are presented elsewhere.(27) Annual follow-up was conducted to assess the condition of the restorations and record additional repair or replacement, or at the patient's earlier attendance if the clinician noted any change in the restoration before the annual visit. Data from early follow-up visits (up to three years) are reported in this manuscript.

At the baseline appointment, when restorations were placed, clinicians recorded a variety of data, such as patients' characteristics, practice's characteristics, as well as clinical observations. Patients' characteristics included age, gender, race, ethnicity, and insurance status of the patient. Practice variables included practitioner characteristics (years since graduation, gender), practice type/structure, region of practice, and workload of the practice. Large group practice was defined as 4+ practitioners; Solo or Small Group practice as 1–3 practitioners; and Public Health was a practice which receives the majority of its funding from public sources. Clinicians also rated the workload of their practice: "Too busy" was defined as unable to see all patients seeking care in that office; "Overburdened" was defined as a practitioner who feels able to see all patients, but is burdened by this effort; "Balanced" was defined as able to see all patients presenting for care without feeling burdened by the patient load; "Not busy" was defined as needing more patients to fill slots. Full-time was considered more than 32 hours per week in patient care.

Clinical variables recorded at the time of the baseline restoration included the number of restorations a patient received at that visit (with a maximum of 4 restorations enrolled), the surfaces of the tooth restored, and the post-operative depth of the carious lesion or tooth defect. These were defined on the baseline data form as within the outer one-half of the enamel; within the inner one-half of the enamel; within the outer third of dentin; within the middle third of the dentin; and within the inner third of dentin. These post-operative depth groupings were combined for this report into three categories to facilitate statistical analysis. The categories used in this report are: within the enamel (E); within the outer 2/3 of dentin (D1/D2); or within the inner third of the dentin (D3). Reasons for the placement of the restoration at baseline were noted as either Carious or Non-Carious defects. Finally, the

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restorative material used was described; data from alloys and RBC materials were included in this study. Other restorative materials were not included.

Patient race was categorized as white, black, Asian, other/unknown. Patient age was categorized as <19 years, 19–44 years, 45–64 years, >64 years. Practitioner years since graduation from dental school were categorized as <5 years, 5–15 years, and >15 years.

Dentists in the network were invited to enroll patients in a follow-up cohort study. As patients presented for follow-up appointments, dentists collected data and completed a 2-page data collection form. The target date for observation for the entire study was every 12 months ± 6 months for 5 years; this manuscript reports on early results. By submitting the follow-up evaluation data form, clinicians indicated their desire to participate in the continued cohort longitudinal evaluation.

At follow-up, clinicians were asked to describe the restoration status at follow-up as either "Acceptable" or "Repair or Replace." "Acceptable" was defined as not needing any further clinical action. The category "Repair or Replace" was defined as needing additional clinical action, and the clinician then recorded one or more of these treatment plan options: (1) repair a defective part of the restoration; (2) replace the entire restoration; (3) tooth requires endodontics; (4) tooth will be extracted; (5) other treatment (explain). Restorations classified as "Repair or Replace" by clinicians were deemed failures for this trial. For restorations classified as "Repair or Replace," clinicians were asked to identify the main reason for this. Choices included caries, fractured restoration, fractured tooth, missing restoration, pain or sensitivity, discolored margins, degraded margins, and other. If the restoration was altered prior to the recall appointment, or if the restoration was altered by an endodontic procedure, the restoration was also considered a failure.

Restorations were classified by size and position in the mouth at baseline. Surface category classifications used in this study are:

- Class I: Posterior occlusal restorations which may include a buccal or lingual extension
- Class II: Posterior restorations which include at least one proximal surface
- Anterior Restorations: Class 3 or Class 4 restorations on anterior teeth
- Buccal surface: tooth restorations coded by practitioners as the buccal or facial surface only of the tooth, which is frequently associated with Class V restorations
- Large Restorations: Any tooth or restoration with 4 or more recorded surfaces

Statistical analysis

Restoration-level counts and percentages were tabulated, and were compared between failed and not-failed restorations using mixed-model logistic regression, implemented using generalized estimating equations (GEE) to account for multiple observations within patient and practitioner. Multiple logistic regression models for restoration failure were developed using variable selection in blocks, accounting for correlated observations using GEE. Variable blocks representing patient, practice/practitioner, and tooth/restoration characteristics were defined. The separate block models included variables that were significant at $p < 0.10$ in univariable modeling. Variables showing $p < 0.10$ in the respective block models were included in an overall predictive model. Both restoration surface category and number of surfaces involved were significant in the single-predictor and block models. Number of surfaces remained significant in the initial full model, while surface category became non-significant, with $p = 0.2258$. The strong collinearity between these two

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variables was problematic in this model, resulting in some adjusted odds ratios becoming non-estimable. In order to obtain a more stable model, surface category was removed from the final model. Restoration material, amalgam or resin-based composite, was of primary interest in the study and was included in the block and final models regardless of its statistical significance.

RESULTS

This study reports data derived from 226 practitioners who provided follow-up reports of 6,218 restorations at baseline on 3,855 patients. The mean (SD) follow-up period reported in this study for failed restorations was 17.6 (9.2) months, with n=386. This represents a failure rate of 6.6 percent. The mean (SD) follow-up period for intact restorations was 24.0 (8.7) months, with n=5,832. The mean (SD) follow-up for failed and intact restorations combined was 23.7 (8.8) months. Patients could contribute up to four restorations at the baseline visit; the mean (SD) number of restorations per patient was 1.73 (0.7). A histogram showing the frequency of failures by month is available online at the National PBRN website http://nationaldentalpbrn.org/peer-reviewed-publications.php, where the title of this article is referenced.

Table 1 describes the characteristics of dentists participating in this study. The majority of clinicians were male, with more than 15 years of practice experience. Most were in solo or small group practices, and were fairly evenly distributed by region.

Patients who participated in the study are characterized in Table 2. Fifty-five percent were female, and 81 percent were white. The vast majority, over 95 percent, was non-hispanic. Forty-four percent were adults under the age of 45; 25 percent were age 45–64, and 22 percent were pediatric patients age 4–18. Only eight percent were 65 years old or older. Over 80 percent of participants had some form of dental insurance.

Reasons for restoration failure are summarized in Table 3. The largest category, “Problem with Restoration,” occurred if the patient had the restoration altered or repaired by another clinician prior to the study recall. For example, a patient might return for an occlusal adjustment or for sensitivity in the tooth. Recurrent decay was cited as a reason for failure 14 percent of the time. Missing restoration was cited 13 percent of the time as a reason for restoration repair or replacement, and a fractured tooth was cited 10 percent of the time. Other cited reasons included pain or sensitivity in the tooth, degraded margins, fractured restorations, and other reasons, such as patient request. Endodontics (that affected the restoration) and extractions were each listed as reasons for failure for 7 and 6 percent of the failed restorations, respectively.

Clinical variables

Several clinical factors were associated with increased restoration failure (Table 4). Based on surface category, most restorations demonstrated a failure rate of around 6 percent. However, Class I restorations failed only 4 percent of the time, while large restorations (4 or more surfaces) demonstrated a failure rate of 17 percent. This was a highly significant predictor for early restoration failure. Large restorations were almost 6 times more likely to fail than single surface occlusal restorations. Restoration failure increased with an increase in the number of surfaces involved in the restoration. When the number of surfaces restored at baseline increased from 1 to 3, the failure rate increased from 5 to 9 percent. However, with 4+ surfaces were restored, the failure rate jumped to 17 percent, with an odds ratio of 4.4 compared to single surface restorations.

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Post-operative depth, as determined at baseline (the time of restoration placement), was also a significant predictor of subsequent restoration failure (Table 4). If the post-operative cavity preparation was contained within the enamel or into the middle dentin areas, failure rate was about 5 percent. When cavities extended into the deepest third of the dentin, however, the failure rate was 9 percent. Odds of failure for deeper restorations were about 60% greater than the more shallow restorations.

When restorations were placed at baseline due to non-carious defects, the failure rate was 8 percent (Table 4). If the reason for the initial restoration was caries, the failure rate was lower, 6 percent. This was also a significant predictor for failure.

Tooth type did not predict restoration failure, and neither did the arch where the tooth was located (Table 4). Material used did not predict restoration failure. The difference in failure rates between amalgam and resin-based composites was not statistically significant.

Dentist variables

When considering dentist and practice characteristics, neither gender, nor years since graduation, nor type of practice were significantly associated with failure rate (Table 4). In univariate analyses, there was a difference noted comparing specialists to general dentists. Pediatric dentists had a significantly lower failure rate compared to general dentists. The failure rate among pediatric dentists was 1.3 percent, while it was 6.3 percent among general dentists. Restorations placed by pediatric dentists were approximately 5 times less likely to fail. However, specialty status was not significant in the multivariable model.

Part-time practitioners had a higher failure rate compared to full-time practitioners, with failure rates of 8 and 6 percent, respectively (Table 4). The results associated with practitioner workload were significant, but mixed. Practitioners who reported being not busy, and those who were overly busy, had the best clinical results, with failure rates about half that of practitioners who had more balanced patient loads.

Patient variables

In univariate analyses, patient age was significantly associated with restoration failure. Percent of restoration failure was higher among older patients; 5 percent of restorations failed in pediatric patients, but 13 percent failed in the senior population. One other factor was included in the multivariate analysis, patient ethnicity, as this factor approached significance in the univariate model. Male and female patients demonstrated a similar failure rate (Table 4). Neither race nor insurance status were significant predictors of failure.

In multivariable regression analysis (Table 5), patient age, patient ethnicity, number of surfaces restored, dentist gender, and dentist practice workload were significant predictors of early restoration failure, while all other variables -- including the restorative material used and dentist specialty -- were insignificant.

DISCUSSION

Understanding the factors associated with early restoration failure should help the clinician provide better patient treatment for restorations in permanent teeth. Judging from the results in the current study, the size of the restoration, for example, has a significant impact on longevity, as reflected in the univariate and multivariate analyses. As the number of surfaces reached 4 or more, failure rates were 4–5 times greater than the failure rate in single surfaces occlusal restorations. With increasing restoration size, there is more surface area for recurrent caries, fracture, and restoration failure.(15, 21, 22) Buccal surface restorations, Class II, and anterior restorations had 50–70% higher odds of failure compared to Class I

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restorations. This could be related to size of the restoration, as in the case of the typical Class II filling, or with greater technical complexity relative to the Class I restoration. Additionally, in the case of Class I restorations, the walls adjacent to the cavity preparation may provide additional resistance to restoration fracture.

Neither arch (maxilla vs. mandible) nor tooth type (anterior vs. posterior) were predictive of failure rates.(33) This is in contrast to at least one study, which found an increased long-term failure rate in premolars.(29) In our study, restorations placed to treat caries survived longer than those placed to treat non-carious defects. As described in a previous study,(32) most non-carious restorations were Class V abrasion/abfraction lesions or for restoring fractured teeth. Our results also suggest that these types of restorations are more likely to fail. This can be due to a relative lack of mechanical retention features compared to other restorations.

In this study, the choice of using amalgam or resin-based composite had no meaningful impact on restoration longevity. It should be noted that the choice of material was not randomized, so other factors could confound the data. For example, perhaps clinicians are more likely to use RBC in a younger patient. In this study, both the amalgam and RBC groups showed about a 6 percent failure rate during follow-up. While most literature tends to report longer-term data, a 4–6 percent annual failure rate seems roughly consistent with other reports.(30, 34)

A large number of clinician variables were significantly associated with restoration longevity. Practice workload was a significant predictor, but the reason for this finding is unclear. One could suppose that a dentist with an abundance of time might take longer with a procedure and offer more attention to detail. Indeed, we see with dentists who report needing more patients, the success rate is about twice that of the balanced or slightly busy clinicians. Clinicians who describe their practice as overly busy, though, also enjoy a high success rate. It could be that these clinicians are more efficient.(25) The very busy and the not busy practices had restorations with higher survival rates. The explanation may be related to a complex conundrum of practice style, work environment, and clinical approach.

In the multivariable regression, a difference in restoration longevity was noted with clinician gender. Restorations placed at baseline by male clinicians in this study were less likely to fail than those placed by female clinicans. This may be related to another finding in this study -- clinicians practicing part-time had greater failure rates than full-time clinicians. Practice patterns among men and women differ, with women providing more of the part-time work force than men.(35–38) Also, women may practice differently than men, choosing a more-conservative restorative approach for some lesions.(39) It is possible that the differences found in multivariable analysis are due to differences in diagnosis patterns; for example if women are more likely to report a restoration as a failure, while men may not report it as such.

Pediatric dentists enjoyed a higher success rate than general dentists, by a factor of 5, as shown in the univariate model. This observation may be confounded by patient age and size of restoration, even though all of the teeth restored in this study were permanent teeth. Obviously, the pediatric dentist will see younger patients. In our data, patient age was significantly associated with restoration longevity in univariate analysis, so the pediatric dentist may have a biased, younger population when reporting. Alternatively, the pediatric dentist may simply benefit from additional formal training in operative dentistry procedures. This observation was not significant in the multivariable model, suggesting that confounding was indeed occurring.

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Limitations of study

Most restorative evaluations are long-term reports. Because these data reflect a maximum 36-month observation, the results may not be applicable to long-term expectations. Insufficient information is available on short-term direct restorations, though, so this report fills a need in the literature. The data in this study are based on a relatively small number of 386 failures. These numbers are expected to increase over time and become more robust in subsequent follow-up reports. Statistically, these data tend to cluster. Some clinicians placed a large number of restorations, and some patients received more than one restoration, leading to a second level of clustering in the data. While this clustering effect may be managed statistically, it is not desirable. This study was conducted by volunteer clinicians in a "real-world" context. No effort was made to influence treatment decisions, but rather to simply record treatment outcomes. Numbers of racial and ethnic minorities were relatively low.

Not all clinicians who participated in the baseline cross sectional analysis elected to participate in the longitudinal evaluation. This makes it difficult to determine loss to follow-up. If a follow-up data evaluation sheet was submitted, this was considered participation. Subsequent reports will undoubtedly demonstrate less retention as patients and clinicians withdraw from the trial for various reasons.

Additional limitations of this study include patient factors that were not reflected in the statistical analysis or data collection, such as socioeconomic factors, oral hygiene status, and other confounders, such as patient education. These confounders may somewhat limit the application of these data to any given dental population. Finally, multivariable factors were accounted for statistically, but inferential power would be greater if a randomized clinical trial study design could be used to test the effects of these factors separately.

Strengths of study

These data represent restorations placed by a wide variety of practitioners with various backgrounds and regional diversity. A variety in practice type also exists, with dentists working in solo, large group practice, and public health as well as clinicians from different countries. They represent different treatment styles and philosophies. Also, they serve a diverse patient population and the overall number of restorations and patients in this study was large.

CONCLUSIONS

The early failure rate of direct restorations in this study was 6.6% after an average follow-up of 24 months. There was no evident difference between amalgam and resin-based composite materials. Additionally, when considering dentist and practice characteristics, neither years since graduation nor type of practice were significantly associated with failure rate. Failure rates increased as the number of surfaces in the restoration increased; failure rates were lowest for Class I restorations. Patient age was strongly associated with restoration failure, with children age 4–18 having the lowest failure rates. Practice workload may impact restoration longevity. The results of this study, derived from a wide variety of clinicians and practices, contribute to the evidence base for clinical decisions.

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consent of all human subjects who participated in this investigation was obtained after the nature of the procedures had been explained fully.

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Table 1

Characteristics of dentists and dental practices who participated in this study.

Characteristic	Number of dentists (n=226)	Percent
Gender		
Male	170	75
Female	56	25
Years Since Graduation		
<5	23	10
5–15	44	20
>15	159	70
Type of Practice		
Large Group	79	35
Solo/Small Group	128	57
Public Health	19	8
Network Region		
AL/MS	62	27
FL/GA	36	16
MN	31	14
PDA	51	23
SK	46	20
Work Load		
Too busy	23	10
Burdened	38	17
Balanced	107	47
Not busy	25	11
Missing	33	15
Time		
Full time	164	73
Part time	34	15
Missing	28	12

Definitions. **Type of Practice:** Large group is 4+ practitioners; Solo or Small Group practice: 1–3 practitioners; Public Health is a practice which receives the majority of its funding from public sources. **Network Region** Alabama/Mississippi (AL/MS); Florida/Georgia (FL/GA); dentists in Minnesota, either employed by HealthPartners (Bloomington, Minn.) or in private practice (MN); Permanente Dental Associates, (PDA); Denmark, Norway and Sweden (SK). **Work load:** Too busy is defined as unable to see all patients seeking care in that office; Overburdened is a practitioner who feels able to see all patients, but is burdened by this effort; Balanced is defined as able to see all patients presenting for care without feeling burdened by the patient load; Not busy was defined as needing more patients to fill slots. **Time:** Full time was considered more than 32 hours per week in patient care.

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Table 2

Characteristics of patients who participated in the study.

Patient Characteristic	Number n=3,855	Percent
Gender		
Male	1,710	44
Female	2,136	55
Missing	9	less than 1
Patient Age (yr)		
4–18	868	22
19–44	1,688	44
45–64	981	25
≥65	300	8
Missing	18	less than 1
Race		
White	3,144	81
African-Amer	292	8
Asian	113	3
Other/Missing	306	8
Hispanic/Latino Ethnicity		
Yes	175	5
No/Unknown	3,680	95
Insurance		
Yes	3,118	81
No	725	19
Missing	12	less than 1

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Table 3

Reasons for failure of restorations cited by clinicians (n=386).

Reason for Failure	Number	Percent
Problem with Restoration *	67	17
Recurrent Decay	53	14
Restoration Missing	50	13
Tooth Fractured	40	10
Endodontics **	28	7
Extraction	23	6
Pain/Sensitivity	23	6
Restoration Fractured	16	4
Margins Degraded	13	3
Other	73	20

* Problem with Restoration: patient had the restoration altered/replaced prior to the recall visit, typically by another dentist.

** Endodontics was counted as a failure if the root canal therapy altered the restoration under investigation.

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Table 4

Univariate analysis for factors that were associated with restoration failure rate.

PREDICTOR VARIABLE	RESTORATION FAILURE N (%)		*P* VALUE	OR (95% CI)
	NO (n=5,832)	YES (n=386)		
Tooth Type				
Anterior	1,208 (92)	100 (8)	.323	1.27 (.95, 1.71)
Premolar	1,535 (94)	101 (6)		1.06 (.82, 1.37)
Molar	3,089 (94)	185 (6)		1.00
Tooth Arch				
Maxillary	3,299 (93)	240 (7)	.073	1.22 (.98, 1.52)
Mandibular	2,533 (95)	146 (5)		1.00
Surface Category				
Buccal Surface	991 (93)	74 (7)		1.70 (1.22, 2.39)
Anterior	878 (93)	68 (7)		1.70 (1.17, 2.46)
Class I	1,716 (96)	69 (4)	**.0002** *	1.00
Class II	1,960 (94)	133 (6)		1.55 (1.15, 2.08)
Large	114 (83)	24 (17)		5.56 (2.84, 10.88)
Other	173 (91)	18 (9)		2.45 (1.43, 4.20)
Number of Surfaces				
1	4,043 (95)	227 (5)		1.00
2	1,364 (93)	104 (7)	**.002** *	1.35 (1.03, 1.75)
3	311 (91)	31 (9)		1.79 (1.20, 2.68)
4+	114 (83)	24 (17)		4.36 (2.31, 8.24)
Post-operative Depth				
E1/E2	495 (94)	29 (6)		1.01 (.57, 1.80)
D1/D2	3,769 (95)	211 (5)	**.011** *	1.00
D3	639 (91)	60 (9)		1.66 (1.19, 2.32)
Uncertain/missing	929 (91)	86 (9)		1.61 (1.2, 2.16)
Reason for Restoration				
Caries	4,868 (94)	298 (6)	**.017** *	1.00
Non-carious defect	964 (92)	88 (8)		1.45 (1.10, 1.92)
Material Used				
Amalgam	1,940 (94)	123 (6)	.502	1.00
Direct resin	3,892 (94)	263 (6)		1.08 (.86, 1.35)
DENTIST CHARACTERISTICS				
Gender				
Male	4417 (94)	274 (6)	.095	.78 (.59, 1.03)
Female	1415 (93)	112 (7)		1.00

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PREDICTOR VARIABLE	RESTORATION FAILURE N (%)		*P* VALUE	OR (95% CI)
	NO (n=5,832)	YES (n=386)		
Years Since Graduation				
<5	572 (93)	42 (7)	.678	1.14 (.78, 1.67)
5–15	1180 (93)	85 (7)		1.11 (.84, 1.47)
>15	4080 (94)	259 (6)		1.00
Type of Practice				
Large Group	2173 (94)	144 (6)	.957	.97 (.74, 1.26)
Private	3287 (94)	216 (6)		1.00
Public Health	372 (94)	26 (6)		1.03 (.54, 1.81)
Network Region				
AL/MS	1701 (95)	89 (5)		1.00
FL/GA	925 (93)	70 (7)	.466	1.34 (.85, 2.11)
MN	874 (93)	65 (7)		1.32 (.88, 1.97)
PDA	1414 (94)	90 (6)		1.13 (.74, 1.73)
SK	918 (93)	72 (7)		1.42 (.91, 2.22)
Work Load				
Too busy	581 (96)	24 (4)		.57 (.36, .90)
Burdened	949 (92)	85 (8)	**.002** *	1.21 (.86, 1.69)
Balanced	2863 (93)	215 (7)		1.00
Not busy	651 (96)	25 (4)		.53 (.33, .86)
Time				
Full time	4423 (94)	281(6)	**.054** *	1.00
Part time	755 (92)	70 (8)		1.44 (1.04, 2.00)
Specialty				
General	5591 (94)	380 (6)	**.012** *	1.00
Pediatric	224 (99)	3 (1)		.17 (.005, .58)
Other	17 (85)	3 (15)		2.55 (2.24, 2.91)
PATIENT CHARACTERISTICS				
Gender				
Male	2,572 (93)	185 (7)	.168	1.17 (.94, 1.46)
Female	3,246 (94)	200 (6)		1.00
Age				
4–18	1,450 (96)	54 (4)		1.00
19–44	2,616 (94)	165 (6)	**<.0001** *	1.55 (1.09, 2.20)
45–64	1,337 (92)	122 (8)		2.23 (1.53, 3.25)
>65	403 (90)	44 (10)		2.78 (1.73, 4.47)
Race			.424	

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PREDICTOR VARIABLE	RESTORATION FAILURE N (%)		*P* VALUE	OR (95% CI)
	NO (n=5,832)	YES (n=386)		
White	4,689 (94)	371 (6)		1.00
African-Amer	508 (95)	27 (5)		.86 (.55, 1.35)
Asian	174 (91)	17 (9)		1.42 (.82, 2.46)
Other/Unkn	461 (95)	25 (5)		.79 (.52, 1.22)
Ethnicity				
Hispanic/Latino	312 (96)	12 (4)	**.010** *	.56 (.34, .94)
Not Hispanic/Unknown	5,520 (94)	372 (6)		1.00
Insurance Status				
Yes	4,783 (94)	313 (6)	.767	1.00
No	1,027 (93)	72 (7)		1.05 (.77, 1.43)

* denotes significant predictor or p<.05

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Table 5

Multivariable mixed-model generalized estimating equations analysis of restoration failure.

PREDICTOR VARIABLE	OR (95% CI)*	*P* VALUE
Number of Surfaces		
1	1.0	
2	1.6 (1.2, 2.3)	**.0025** *
3	1.9 (1.2, 3.1)	
4+	4.7 (2.4, 9.2)	
Material Used		
Amalgam	1.00	.662
Direct resin	1.1 (.8, 1.4)	
Patient Ethnicity		
Hispanic/Latino	.6 (.30, 1.1)	**.053** *
Not Hispanic/Unknown	1.00	
Patient Age		
4–18	.8 (.5, 1.1)	
19–44	1.00	**.0006** *
45–64	1.5 (1.1, 2.0)	
>65	2.0 (1.4, 2.9)	
Dentist Gender		
Male	1.00	**.0089** *
Female	1.5 (1.1, 1.9)	
Dentist Work Load		
Too busy	.6 (0.9 1.8)	
Burdened	1.3 (0.9, 1.8)	**.001** *
Balanced	1.00	
Not busy	.5 (0.3, 0.8)	
Specialty		
General	1.00	.110
Pediatric	.3 (0.1, 1.0)	
Other	4.6 (3.0, 6.9)	

N = 5371 restorations, 348 restorations failures, 226 practitioners.

The outcome variable was coded as 1= restoration failed at any point after its placement at baseline; 0 = not.

*95% confidence interval. Variable selection procedure: Separate analyses were conducted using each of the variable blocks “patient characteristics”, “tooth/restoration characteristics” and “dentist/practice characteristics”. Variables showing $p < 0.10$ in the respective block models were included in an overall predictive model. Restoration material, amalgam or resin-based composite, was of primary interest in the study and was included in the block and final despite lack of statistical significance.

*Variables with $p < 0.05$ were considered significant in the final model, but no variables that were significant in the block models were removed from the final model.