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Repair or replacement of restorations: a prospective cohort study by dentists in The National Dental PBRN

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Abstract

OBJECTIVES—(1) quantify 12-month failures of restorations that were repaired or replaced at baseline; (2) test the hypothesis that no significant differences exist in failure percentages between repaired and replaced restorations after 12 months; (3) test the hypothesis that certain dentist's, patient's and restoration's characteristics are significantly associated with the incidence of restoration failure.

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[9]The National Dental PBRN Collaborative Group includes practitioner, faculty, and staff investigators who contributed to this study. A list is at http://www.nationaldentalpbrn.org/collaborative-group.php

METHODS—This prospective cohort study included dentists in the National Dental Practice-Based Research Network. Dentists recorded data for 50 or more consecutive defective restorations. The restorations that were either repaired or replaced were recalled after 12 months and characterized for developing defects.

RESULTS—195 dentists recorded data on 5,889 restorations. 378 restorations required additional treatment (74 repaired, 171 replaced, 84 teeth received endodontic treatment, and 49 were extracted). Multivariable logistic regression analysis indicated that additional treatment was more likely to occur if the original restoration had been repaired (7%) compared to replaced (5%)(OR = 1.6, $p < .001$; 95% CI: 1.2, 2.1), if a molar tooth was restored (7%) compared to pre-molar or anterior teeth (5%, 6% respectively)(OR = 1.4, $p = .010$; 95% CI: 1.1, 1.7), and if the primary reason was a fracture (8%) compared to other reasons (6%)(OR = 1.3, $p = .033$; 95% CI: 1.1, 1.6).

CONCLUSION—An additional treatment was more likely to occur within the first year if the original restoration had been repaired (7%) compared to being replaced (5%). However, repaired restorations were less likely to need an aggressive treatment (replacement, endodontic treatment, or extraction) than replaced restorations.

Keywords

longevity; practice-based research; repair; replacement; decision; defective; restorations; cohort

INTRODUCTION

The longevity of restorations and the cost of replacing restorations are two significant factors determining the long-term cost of restorative therapy. Many factors affect the longevity of restorations, including the restoration quality at the time of insertion, the type and size of the restoration, the restorative material involved, practitioner's knowledge and experience in secondary caries diagnosis, patient factors like oral hygiene, patient's age, dentition, and caries risk, and if the patient maintains regular recall appointments in the same dental practice[1–6]. Most failures occur several years after the restoration was inserted and they are a result of gradual development of secondary caries, some physical defects, such as fracture of restoration or tooth or discoloration of the restoration, or some form of degradation, like marginal breakdown or 'ditching'[7].

Repair of defective restorations rather than replacement of the entire restoration has been a somewhat controversial treatment. The major advantage of repair treatment is that it saves tooth structure[8–12] and patient-chair time. It also places minimal stress on the pulp of the tooth. The approach therefore is consistent with the concept of minimally invasive dentistry. However, because it has not been widely accepted as an alternative treatment, not many clinicians have incorporated this practice into routine care[13]. Therefore, assessing the clinical survival of this treatment, especially in the first twelve months after treatment, is of paramount importance.

Longitudinal studies that assess failure of existing restorations and explore the reasons for failure may provide information to increase the longevity of restorations[7]. Restorations inserted in practice-based studies provide a unique opportunity to follow-up these restorations in a “real-world setting”, *i.e*., the ultimate-test of dental restorations, as the clinical conditions are not controlled[14]. The information gathered from a practice-based setting may improve the longevity of restorations over time, as clinicians can learn the outcome of both types of treatments and hopefully make a decision based on evidence from actually treating existing defective restorations. Therefore, the specific aims of this study were to: (1) quantify the annual failure rate of restorations that were repaired or replaced at baseline; (2) test the hypothesis that there is no significant difference in longevity of restorations that have been either repaired or replaced; and (3) test the hypothesis that some dentist and patient characteristics are significantly associated with the incidence of restoration failure.

METHODS

Selection and recruitment process

This prospective cohort study included 195 dentists of the Dental Practice-Based Research Network (DPBRN) that existed from 2003 to 2012 with a grant from the National Institute of Dental and Craniofacial Research, National Institutes of Health[15]. DPBRN subsequently evolved into The National Dental PBRN, a consortium of dental practices and dental organizations focused on improving the scientific basis for clinical decision making. The data for this study were collected under the auspices of the DPBRN from 2008 to 2009, and the manuscript of this article was prepared under the aegis of The National Dental PBRN.

At the time of this study, the network was composed primarily of clinicians from five regions: Alabama/Mississippi (AL/MS); Florida/Georgia (FL/GA); dentists in Minnesota, either employed by HealthPartners in Bloomington, MN, or in private practice; Permanente Dental Associates (PDA), in cooperation with Kaiser Permanente’s Center for Health Research in Portland, OR; and dentists from Denmark, Norway and Sweden (SK). Each of the 195 participating dentists recorded data for 50 or more consecutive restorations deemed defective during clinical visits. Practice structures differed some by network region. Dentists from the AL/MS and FL/GA regions were primarily from solo or small group practices (SP), Health Partners and PDA are large group practices (LGP), and SK dentists were from solo or small group private practices (SP) or public health care settings (PHS). Results from previous studies confirm that dentists in practice-based research networks have much in common with dentists at large[16–17]. The Institutional Review Boards of each participating region approved the study.

Network dentists were recruited through continuing education courses and/or mass mailings to licensed dentists within the participating regions. As part of the eligibility criteria, all dentists completed (1) an enrollment questionnaire describing their demographic and practice characteristics and certain personal characteristics, (2) an assessment of caries diagnosis and caries treatment questionnaire, (3) training in human subject’s protection, and (4) an in-practice network orientation session with the regional coordinator. Copies of the questionnaires and summary data for dentists’ demographic and practice characteristics are also available at http://www.nationaldentalpbrn.org/study-results.php (*“Longitudinal study of repaired or replaced dental restorations”*).

This study initially used a consecutive patient/restoration recruitment design to gather baseline data. Once the study was started, every patient scheduled to have a repair or replacement of a restoration on a permanent tooth was asked to participate until 50 restorations were enrolled by a single practitioner. Patients who returned for additional appointments while data collection was still ongoing were not eligible for further data collection. In order to increase the number of patients, a maximum of four eligible restorations per patient were enrolled during the first appointment. Restorations discovered after the first appointment were not eligible. A consecutive patient/restoration log form was used to record information on eligible restorations whether or not the patient participated in the study. All the data collection forms used for this study are available at http://www.nationaldentalpbrn.org/study-results.php (under the tabs "Longitudinal study of repaired or replaced dental restorations" and "Reasons for replacement or repair of dental restorations").

The restorations that were repaired or replaced were recalled after 12 months and characterized for quality according to defined criteria. A*cceptable:* The restoration is of satisfactory quality and is expected to protect the tooth and the surrounding structures or has one or more features that deviate from ideal conditions, but it does not need to be replaced or repaired. *Not acceptable*: Additional treatment is necessary because future damage to the tooth and/or surrounding tissues is likely to occur or is occurring,

Reasons for restoration failure

"Secondary/recurrent caries" constituted a lesion detected at the margin of an existing restoration. The lesion had the same characteristics as primary caries lesions.

'*Entire restoration was discolored'* included any mismatch between the color of the body of a tooth-colored restoration and the tooth that led to replacement of the restoration.

'*Restoration margins were discolored'* were found at the tooth/restoration interface and led to repair or replacement.

'*Bulk fracture'* of a restoration included isthmus fracture or any fracture through the body of the restoration or the marginal ridge, but with the restoration still in place.

'*Restoration margins were degraded or ditched', o*nly those restorations with marginal fractures or degraded margins, but without caries were recorded in this category of failure.

'*Restoration was missing'* was recorded when either all of the restoration or a major part was missing due to lack of retention.

"*Tooth was fractured'* was any kind of tooth fracture adjacent to a restoration, for example the fracture of a cusp or of an enamel margin.

'*Pain/sensitivity'* of any kind that required repair or replacement of a restoration, or endodontic treatment or extraction of the tooth.

'*Patient request*' included any reason for replacement of a restoration deemed acceptable by the practitioner.

'*Other reason*" included any other reason for replacement/repair of restorations and endodontic treatment/extraction of teeth than those listed above.

If a serviceable or intact restoration had been replaced because it was incorporated into a larger restoration, it was not recorded as a failure. An example would be the removal of an intact occlusal Class I restoration that became part of a Class II restoration.

Variable selection

Repair treatment was characterized as the removal of part of the existing restoration and any adjacent pathologically altered as well as esthetically unacceptable tooth tissue followed by placement of restorative material in the prepared site. Repair also included light grinding and polishing, removal of overhangs, polishing discolored tooth-colored restorations, or sealing margins. Restoration replacement was characterized as the entire removal of the existing defective/failed restoration and any adjacent pathologically altered and discolored tooth tissue that was esthetically or functionally unacceptable.

Practitioners collected data for each enrolled restoration that needed repair or replacement on permanent tooth surfaces. Data collected included: (1) the main reason for repair or replacement of the restoration [10]; (2) tooth type and tooth surfaces being restored; and (3) the restorative materials used for the old and the new restoration. Dentists diagnosed the need to repair or replace the existing restoration based on the diagnostic methods they typically use in their practice, which consist mainly of visual-tactile in association with radiographic examinations.

Restorative materials were classified as amalgam, direct or indirect resin-based composite (RBC or IRBC), conventional or resin-modified glass-ionomer (GI/RMGI), ceramic or porcelain, cast gold or other metallic-based material, combined metal-ceramic material, and temporary restorative materials. Information about gender, age, race, ethnicity, and insurance coverage of enrolled patients was also recorded in the same recording form.

Statistical analysis

Descriptive statistics were calculated for dentist, patient, and restoration variables. A binary logistic model was used to test the study hypotheses, with Generalized Estimating Equations to adjust for clustering within dentists and restorations within patients. A series of three outcomes was tested using all treated and untreated restorations. First the model was tested in all restorations seen by the one-year follow-up and the dependent variable was coded no treatment = 0 and treatment (repair, replacement, endodontic, and extraction) = 1. The prediction model included treatment for the original defective restoration (repair = 1, replacement = 0); tooth (molar = 1, and premolar or anterior = 0); arch (upper = 1 and lower = 0); original restorative material (amalgam = 1, direct tooth colored/ indirect tooth colored/ gold = 0); repair/replacement restorative material (amalgam = 1, direct tooth colored/ indirect tooth colored/ gold = 0); fractured restoration (fractured restoration = 1 when the primary reason for the defect/failure and coded = 0 when fractured restoration was not the primary reason for the defect/failure); the number of surfaces in the original restoration classified as 1, 2, 3, 4 and 5. Information about patient (gender, age), dentist (gender, years in practice) and practice model were entered in an initial step and included in subsequent testing if they were significant at $p \leq .015$. Two-way interactions involving the "treatment for the original defective restoration" variable with tooth, arch, the restoration material variables, the fracture variable, and the number of surfaces were tested individually. For all significant interactions, models were run separately for (1) replacement of the original defective restoration and (2) repair of the original defective restoration.

The next two models examined only restorations that were treated by the one-year follow-up. The dependent variable for the second model was coded repair = 0 and replacement, endodontic, or extraction = 1. The dependent variable for the third model was coded repair or replacement = 0 and endodontic or extraction = 1. Interactions were not tested for models 2 or 3 because of sample size limitations.

RESULTS

In the original study of defective restorations, data were available for 8,921 restorations with complete data from 6,759 patients. First-year follow-up data were provided from 195 network dentists on 4,648 patients involving 6,059 restorations. Of these, 170 restorations received a temporary restoration and are not included resulting in 5,889 restorations in 4,482 patients in the following analyses. Of these, 378 (6.4%) required additional treatment as follows: 74 (1.3%) were repaired, 171 (2.9%) were replaced, 84 (1.4%) teeth received endodontic treatment, and 49 (0.8%) were extracted.

Dentists were distributed across the network regions as AL/MS=39, FL/GA=43, PDA=40, MN=35, SK=38. Regarding patient characteristics, 58% were female and 42% were males, 25% had dental insurance. Patient race as indicated by the dentist was non-Hispanic White, 82%; Hispanic, 10%; Black or African American, 5%; and Other, 3%. Practice and patient characteristics are presented in Table 1.

Analysis of all restorations

Descriptive statistics for dentist, patient, and restoration variables are listed in Table 2. Table 3 presents regression coefficients for regression models tested. The results of multivariable logistic regression analysis indicated that a treatment at one-year was more likely if the defective restoration had been repaired (7%) compared to replaced (5%; OR = 1.6, $p < .001$; 95% CI: 1.2, 2.1), if a molar tooth was involved in the treatment (7%) compared to pre-molar or anterior teeth (5%, 6% respectively; OR = 1.4, $p = .010$; 95% CI: 1.1, 1.7), and if the primary reason for the defect was a fracture (8%) compared to other reasons (6%; OR = 1.3, $p = .033$; 95% CI: 1.1, 1.6). The number of surfaces involved in the treatment of the defective restoration, whether amalgam material was used in either the original restoration or in treatment of the defective restoration was not associated with needing a treatment by the first year follow-up. The practice model was the only dentist or patient variable that was significant, with treatment more likely to occur for dentists in a large group practice (12%), compared to small group and private practices (5%; OR = 2.2, $p< .001$; 95% CI: 1.7, 2.9).

The interactions between the repair/replace variable and both the number of surfaces in the treated restoration (p = .011) and if amalgam was used in the treatment of the defective restoration (p = .021) were significant. Other interactions were not significant. To interpret the significant interactions, the data were then separated into restorations that were replaced and those that were repaired (Table 4). Multivariable logistic regression analysis indicated when the treatment for the defective restoration was a replacement, a treatment at one-year was more likely if the defective restoration had been replaced with amalgam (9%) compared to all other materials (4%; OR = 2.3, p = .029 95% CI: 1.7, 3.2). There were no differences when the treatment for the defective restoration had been a replacement. In a similar analysis of defective restorations that were repaired, the greater the number of surfaces involved in the repair, the more likely it was to receive additional treatment at one-year (OR = 1.3, 95% CI: 1.1, 1.6, p = .004), however the number of surfaces was not associated with subsequent failure for replacements.

Analysis of the treated restorations only

Table 5 presents regression coefficients for predictors of the treatments received for the 378 restorations that were treated during the year 1 follow-up and Table 6 shows the outcomes stratified by whether the defective restoration was originally repaired or replaced. When the restoration required a treatment during the one-year follow-up, it was less likely to need a replacement, endodontic treatment, or extraction if the defective restoration had been repaired (74%) than had it been replaced (85%; OR = 0.5, 95% CI: 0.3, 0.9, p. = .018).

When the restoration required a treatment during the one-year follow-up, it was less likely to need endodontic treatment or extraction if the defective restoration had been repaired (25%), when compared to restorations that had been replaced (42%; OR = 0.4, 95% CI: 0.3, 0.8, p. = .005). Endodontic treatment or extraction were also less likely for treated restorations if the material used in the repair/replacement was amalgam (23%), compared to other restorative materials (41%; OR = 0.5, 95% CI: 0.3, 0.8, p. = .007). Inspection of Table 5 indicates that the difference between repaired and restored restorations in model 3 results from the greater number of endodontic treatments for the restorations that were originally replaced (29%) compared to those which were repaired (12%) and not from differences in the percentages which were extracted (both 13%).

DISCUSSION

Numerous factors affect the longevity of restorations, and these may be subdivided into operator factors, quality of the restorative material, and patient/restoration factors[3]. The current study showed that restorative material, number of surfaces involved, tooth type, and primary reason for treatment were associated with the short-term longevity of repaired and replaced restorations in permanent teeth.

Repaired restorations were more likely to receive additional treatment 7% of the time compared to 5% for replaced restorations. However, repaired restorations received a more-conservative treatment during follow-up, such as repair (repaired 26% of the time and replaced/endo/extracted 74%) compared to restorations that had been replaced (repaired only 15% of the time and replaced/endo/extracted 85%). Additionally, replaced restorations were more likely to get endodontic treatment (29%) compared to repaired restorations (12%, see table 5). Although repaired restorations may require a treatment more often during the first year after treatment, they require a more-conservative treatment that does not involve the replacement of the entire restoration or even worse, endodontic and extraction treatments. Several studies have shown that restorations that are replaced lose a significant amount of healthy tooth structure[8–9,18], invariably speeding the re-restoration cycle[19–21].

Type of tooth was a significant variable. Molar teeth (7%) received additional treatment more often than any other teeth (pre-molar 5% and anterior 6%). A possible explanation may be that molar teeth receive most of the biting forces[22]. Also related to the same line of thought, restorations involving a higher number of surfaces were repaired and more likely to require additional treatment[23–25]. A practice-based research study involving thousands of restorations showed that the number of tooth surfaces restored at baseline helped predict subsequent restoration failure; restorations with four or more restored surfaces were four times more likely to fail[26]. Interestingly, the number of surfaces did not predict a subsequent failure for restorations that were replaced. In repaired restorations, the interface between the old and new material maybe the weakest link and possibly affect its outcome[27–28].

A potential weakness in the current study design is the lack of assessment of patient’s caries risk. Both a literature review and a meta-analysis concluded that longevity of restorations were affected by secondary caries (related to the individual caries risk) and fracture of restoration (related to the strength of the material used), as well as patient factors such as bruxism [5–6].

In the current study, when a fracture was the primary reason for the defect, the restoration was more likely to be re-treated within the first year when compared to other reasons (8% - 6%). Previous studies showed that restorations that were repaired due to fracture had a lower survival rate than restorations that were repaired due to other reasons[7, 29–30]. Fracture as a reason for failure and amalgam as a restorative material may jointly exert negative influences on the survival of restorations[30]. If the original restoration was treated due to a restoration fracture or a tooth fracture it may be more likely to fail, especially if the restoration is subjected to the same forces that caused the original failure, leading to subsequent or repeated fracture more often.

With regard to the material used for treatment, if the restoration was replaced, amalgam failed more often (9%) compared to all other materials (4%), more than twice the rate, especially if the tooth was a molar (6%) compared to pre-molar (4%) or anterior (5%). And that makes sense, as molar teeth are often more likely to receive amalgam restorations than any other tooth. When the restoration was repaired though, the subsequent use of amalgam was not associated with one-year failures. In the majority of the restorations that were repaired a resin-based composite material was used as the restorative material. RBC materials are known to bond to the existing tooth surfaces potentially reinforcing the existing tooth structure particularly in large restorations of molar teeth[31–32]. Furthermore, amalgam restorations are also most likely to be replaced due to patient requests for a more-esthetic material[33]. It is possible that patients’ expectations for a more-esthetic appearance than that of the existing amalgam material may have influenced the clinician’s decision to replace the existing restoration with a tooth-colored material. However, in the present study very few restorations were originally repaired or replaced because of patient request (2%). Studies have confirmed the decline of amalgam as a restorative material in recent years[34–36]. While the reasons for replacement of amalgam restorations have remained fairly constant, the reasons for failure of resin-based composite restorations and their longevity have changed markedly during recent years. When resin-based Class II composite restoration came into common use about 15–20 years ago, the difference in longevity between amalgam and composite restorations was quite marked[37]. However, more recent long-term data indicate that the longevity of composite restorations has increased[3]. Indeed, in the current study six percent (Table 2) of direct tooth-colored restorations failed within a year. The reason for this change is manifold, including improved material quality and clinical experience of clinicians in handling the materials. Long survival rates for posterior composite restorations can be expected provided that patient, operator and materials factors are taken into account when the restorations are performed[5–6]. Additionally, other unobserved variables such as practitioners' preferences and skills may also have played a role in the results.

The longevity of restorations is closely linked to their replacement rate. The diversity of opinions among clinicians about what constitutes a failed restoration is a major problem when reporting on the longevity of restorations. No generally accepted, objective criteria have been established for what degree of failure constitutes a condition that will cause future damage to the tooth or to the patient. In the current study, practice model was the only dentist variable that was significant, with treatment more likely to occur (OR 1.4) for dentists in a large group practice (12%) compared to small group and private practices (5%). In the large group practice, it is possible that patients are seen by different dentists within the same practice. As previously demonstrated, subjective decision-making still prevails[38–39] and marked variations between clinicians in diagnosing failures have been demonstrated[1–2, 4, 40–42]. Studies have shown that dentists are more likely to intervene in a restoration that they had not placed[11, 43–45]. Another study[46], based on insurance claims, suggests that patients who change dentists are far more likely to have restorations replaced. Conclusions about longevity of restorations might also be strongly influenced by clinicians' thresholds for replacing restorations that they consider “defective”. If dentists have a low threshold for replacing a restoration, then naturally the age of restorations will be shorter.

CONCLUSION

Six percent of restorations received additional treatment such as repair or replacement after one-year of treatment. An additional treatment was more likely to occur if the defective restoration had been repaired (7%) compared to replaced (5%), if a molar tooth was involved in the treatment, if a greater number of surfaces were involved in the original treatment, and if the primary reason for the defect was a fracture. However, when the restoration required a treatment at the one-year follow-up, it was less likely to need an aggressive treatment (replacement, endodontic treatment, or extraction) if the defective restoration had been repaired than if it had been replaced.

The practice model was the only dentist or patient variable that was significant; treatment was more likely to occur for dentists in a large group practice compared to small group private practices.

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Table 1

Practice and patient variables

VARIABLE	MEAN (SD) OR % (N)
Dentists' characteristics (n=195)	
Gender (male)	70% (136)
Years since dental school graduation	23 (SD=10.3)
Average number of patients seen in a week (missing=9)	47 (SD=16.5)
Practice type	
- Solo or small group private practice	57% (112)
- Large group practice	37% (72)
- Public health care setting	6% (11)
Race/ethnicity	
- Hispanic White	5% (10)
- Non-Hispanic-White	84% (164)
- Non-Hispanic Black	3% (5)
- Other	8% (16)
Placed the original restoration (missing=9)	75% (4391)
Patients' characteristics (n=4,482)	
Patient gender (male) missing=8	42% (1878)
Patient age	53 (SD=15.3)
Race – ethnicity (missing=60)	
- Non-Hispanic White	83% (3744)
- Hispanic	8% (356)
- Black	5% (214)
- Other	3% (114)
Dental insurance or any third party coverage	25% (1136)

Table 2

Restoration failure and their relationship with dentists' and tooth's characteristics

VARIABLE	Restorations in study % (n) n=5,889	Restorations that failed % (n) n = 378
Practice Model		
SP	74% (4,358)	5% (213)
LGP	22% (1,283)	12% (148)
PHS	4% (248)	7% (17)
Decade of dental school graduation		
- 1979	29% (1,680)	6% (76)
- 1980–1989	45% (2,630)	6% (156)
- 1990–1999	13% (761)	7% (53)
- 2000–2008	14% (818)	8% (68)
Treatment		
Repaired	25% (1,498)	7% (144)
Replaced	75% (4,391)	5% (234)
Tooth		
Molar	54% (3,148)	7% (228)
Upper	25% (1,483)	8% (118)
Lower	28% (1,665)	7% (110)
Pre Molar	26% (1,515)	5% (81)
Upper	14% (816)	5% (37)
Lower	12% (699)	6% (44)
Anterior	21% (1,226)	6% (69)
Upper	16% (938)	5% (42)
Lower	5% (288)	9% (27)
Number of surfaces in repair/replacement		
One	27% (1,589)	6% (87)
Two	32% (1,869)	7% (114)
Three	22% (1,294)	7% (81)
Four	9% (512)	9% (48)
Five	11% (625)	6% (48)
Material of the original restoration		
Amalgam	53% (3,054)	6% (194)
Direct tooth-colored	37% (2,154)	6% (135)
Indirect tooth-colored	11% (606)	7% (43)
Missing information (n=81)		
Repair/replacement material		
Amalgam	21% (1,215)	10% (117)
Direct tooth-colored	58% (3,338)	6% (182)
Indirect tooth-colored	22% (1,252)	6% (71)

VARIABLE	Restorations in study % (n) n=5,889	Restorations that failed % (n) n = 378
Missing information (n=92)		
Reason for repair or replacement		
Secondary/recurrent caries	43% (2,514)	7% (167)
Fracture/bulk fracture/missing	36% (2,095)	8% (157)
Degraded/ditched	8% (461)	4% (16)
Other	7% (399)	4% (16)
Margins or restoration discolored	3% (196)	3% (6)
Patient request	2% (127)	5% (6)
Pain sensitivity	1% (65)	9% (6)
Missing information (n=36)		

SP = solo or small group practices

LGP = large group practices

PHS = public health care settings

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Table 3

Baseline characteristics associated with whether or not the restoration received treatment of any type during follow-up

VARIABLE	B (SE)	p value	OR (95% CI)
Model 1: All restorations (n=5,687)[a]			
Treatment (repair)	.470 (.141)	< .001	1.6 (1.2, 2.1)
Original material (amalgam)	−.163 (.132)	.217	0.8 (0.7, 1.1)
Replacement material (amalgam)	.222 (.179)	.215	1.2 (0.9, 1.6)
Tooth site (Molar)	.310 (.133)	.010	1.4 (1.1, 1.7)
Reason for failure (fracture)	.260 (.122)	.033	1.3 (1.1, 1.6)
Surfaces	−.046 (.051)	.374	0.9 (0.9, 1.1)

Model for all restorations included 5,687 restorations because of 202 missing values among the predictor variables. The interactions between the repair/replace variable and both the number of surfaces in the treated restoration ($p = .011$) and if amalgam was used in the treatment of the defective restoration ($p = .021$) were significant.

Table 4

Baseline characteristics associated with whether or not the restoration received treatment of any type during follow-up, tested separately for restorations that were replaced and restorations that were repaired.

VARIABLE	B (SE)	p value	OR (95% CI)
Model 2: Replaced restorations (n=4,226) [a]			
Original material (amalgam)	−.263 (.143)	.095	0.8 (0.6, 1.0)
Replacement material (amalgam)	.846 (.170)	<.001	2.3 (1.7, 3.2)
Tooth site (Molar)	.205 (.097)	.014	1.4 (1.1, 1.9)
Reason for failure (fracture)	.138 (.162)	.395	1.1 (0.8, 1.5)
Surfaces	.034 (.051)	.504	1.0 (0.9, 1.1)
Model 3: Repaired restorations (n=1,461) [b]			
Original material (amalgam)	−.039 (.211)	.848	1.0 (0.7, 1.4)
Replacement material (amalgam)	.223 (.225)	.320	1.3 (0.9, 1.9)
Tooth site (Molar)	.366 (.228)	.109	1.2 (0.9, 2.0)
Reason for failure (fracture)	−.051 (.119)	.669	1.0 (0.8, 1.2)
Surfaces	.295 (.103)	.004	1.3 (1.1, 1.6)

[a]Model for replaced restorations included 4,226 restorations because of 165 missing values among the predictor variables.

[b]Model for repaired restorations included 1,467 restorations because of 37 missing values among the predictor variables

Table 5

Predicting type or treatment received among restorations that were treated by the one year follow-up.

	B (SE)	p. value	OR (95% CI)
Treatment was replacement, endo, extraction [a]			
Treatment (repair)	−.839 (.299)	.005	0.4 (0.2, 0.8)
Original material (amalgam)	−.382 (.316)	.227	0.7 (0.4, 1.3)
Replacement material (amalgam)	−.317 (.313)	.311	0.7 (0.4, 1.3)
Tooth site (Molar)	.306 (.122)	.012	1.4 (1.1, 1.7)
Reason for failure (fracture)	−.043 (.288)	.958	1.0 (0.5, 1.7)
Surfaces	−.180 (.117)	.124	0.8 (0.7, 1.1)
Treatment was endo or extraction [b]			
Treatment (repair)	−.706 (.261)	.007	0.5 (0.3, 0.8)
Original material (amalgam)	−.183 (.263)	.487	0.8 (0.5, 1.4)
Replacement material (amalgam)	.711 (.287)	.013	0.5 (0.3, 0.9)
Tooth site (Molar)	.346 (.244)	.157	1.4 (0.9, 2.3)
Reason for failure (fracture)	.292 (.230)	.204	1.3 (0.9, 2.1)
Surfaces	.069 (.093)	.457	1.1 (0.9, 1.3)

[a]The dependent variable was coded as repair = 0 and replacement, endodontic, or extraction = 1.

[b]The dependent variable was coded repair or replacement = 0 and endodontic or extraction = 1.

These models examined only the 378 restorations that were treated by the one-year follow-up. Interactions were not tested because of sample size limitations.

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Table 6

Outcomes for restorations treated after 1 year

	RESTORATION OUTCOME AT ONE YEAR				
TREATMENT AT BASELINE	**Repair**	**Replace**	**Endodontic**	**Extraction**	**Total**
Repaired restoration	26% (38)	49% (70)	12% (17)	13% (19)	144
Replaced restoration	15% (36)	43% (101)	29% (67)	13% (30)	234
Total	20% (74)	45% (171)	22% (84)	13% (49)	378