

Frequency of Restoration Replacement in Posterior Teeth for U.S. Navy and Marine Corps Personnel

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Clinical Relevance

Both composite resin and dental amalgam are being utilized as direct restorative materials in military dental clinics. When clinicians are choosing one material over another material, it is important to evaluate patient and tooth factors for optimum clinical success.

SUMMARY

Statement of Problem: There are no recent data that describe the replacement rates of resin composite and dental amalgam restorations placed by US Navy dentists. Information is needed to provide the best possible care for our military personnel which would minimize the probability of dental emergencies, especially for those who are deployed.

Purpose: The purpose of this study was to determine if the frequency of posterior resto-

ration replacement in military personnel differed based on the type of restorative material utilized.

Methods and Materials: Data contained in dental records in an observational study (retrospective cohort) were evaluated to identify resin composite and dental amalgam restorations placed by navy dentists in posterior teeth. The status of all erupted, unerupted, missing, and replaced teeth was documented. The type and condition of all existing restorations were recorded for each posterior tooth. Investigators reviewed 2921 dental records, and of those, 247 patients met the criteria for inclusion in the study. A total of 1050 restorations (485 resin composite and 565 amalgam) were evaluated.

Results: A Cox proportional hazards model was adjusted for number of tooth surfaces restored, caries risk, and filled posterior surfaces at initial exam. The overall rate of replacement for all restorations in the sample was 5.7% during the average 2.8-year follow-up. No significant elevation of risk for resto-

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ration replacement existed when comparing resin composite and amalgam. Both the number of restored surfaces and caries risk status were independent risk factors for replacement. When restoring multisurface cavity preparations, providers placed amalgams by an approximate 2:1 ratio over resin composites for this study population.

Conclusion: The results for this study show that no difference existed in the rate of replacement for amalgam vs resin composite. When restorations increased from just a single occlusal surface to additional surfaces, the rate of replacement was elevated and statistically significant for both materials. A higher caries risk status was also significant in elevating replacement rates for both materials.

INTRODUCTION

According to an American Dental Association (ADA) survey conducted in 2005-2006, the number of resin composite restorations on posterior teeth, placed by private practitioners in the United States, surpassed the number of amalgam restorations placed on posterior teeth.¹ Over 76 million resin composite restorations were estimated to have been placed in one year on posterior teeth, accounting for approximately sixty percent of all direct posterior restorations.¹ Many private practices are currently choosing not to utilize amalgam in their offices. Another ADA survey among private practitioners who were currently using amalgam in 2007 showed that over half of the dentists indicated that the number of patients with whom they used amalgam restorations had decreased in the past 12 months.² Record reviews of baseline exams conducted on US Navy and Marine Corps recruits also demonstrated this important trend. Simecek and others³ determined that a cohort of recruits in 1997 had only 10 percent of posterior fillings as composite; however, between five and eight years later, 25 percent of the posterior restorations were resin-based composite.

In an era where dental professionals are promoting minimally invasive management of dental caries, dental schools in both the United States and Canada are currently expanding the time devoted to teaching posterior resin techniques.⁴ In fact, the schools surveyed by Lynch and others⁴ indicated that 49% of posterior intracoronary restorations were resin-based composite, while amalgam placement was at 48%. Clearly, both amalgam and composite resin are considered suitable materials for restoring Class I and Class II cavities, although specific advantages as

well as disadvantages exist for both types of materials. Composites have been documented to have better esthetics, more adhesive properties that result in reduced preparation size, and an ability to reinforce the remaining dental structure, unlike dental amalgam.⁵ Although US dental schools have reported an increased amount of time teaching the placement of resin-based composites on posterior teeth, there are situations where students are advised to use other restorative materials.⁴ The contraindications taught for resin-based composite restorations on posterior teeth include an inability to place rubber dam, parafunctional activity, pathological wear, poor oral hygiene, replacement of large amalgam restorations, and interproximal cavities that would lead to subgingival margins.⁴

Factors such as the patient, the material, the tooth, and even the operator all contribute to the long-term success of dental restorations.⁶ When restorations are evaluated for longevity, mean annual failure rates (AFR) are compared during a period of follow-up. A randomized controlled clinical trial by Bernardo and others⁷ demonstrated mean AFRs for amalgam to be 0.82%, whereas for composites it was higher, at a value of 2.21%. When reviewing multiple recent clinical studies, Demarco and others⁵ determined that when “gold standard” hybrid composites are used to restore posterior teeth, an AFR between 1% and 3% can be expected. Unfortunately, with a greater number of surfaces involved in a restoration, AFRs tend to be higher for both amalgam and resin composites. Bernardo and others⁷ demonstrated this trend with an AFR for a one-surface amalgam to be 0.17% and a two-surface to be 1.41%. Likewise, an increase was also seen for composites, with a one-surface restoration having an AFR of 0.95% and a two-surface restoration having an AFR of 3.03%. This upward trend continued with restorations involving three or more surfaces.

Two main causes of failure identified by Demarco and others⁵ were fracture (restoration or tooth) and secondary caries. In a previous review of longevity by Downer and others,⁸ the investigators pointed out that having a high caries activity has a negative influence on restoration survival. Demarco and others⁵ pointed out that factors such as patient caries risk, the clinical setting of the study, and characteristics of the socioeconomic status of the population would be more of the determinant for the reasons for failure than the clinical age of the restoration. Secondary caries is related to the individual caries risk, and fracture can be related to the presence of a lining or the strength of the

material used as well as patient factors, such as bruxism.

Every year, the US Navy dental care system sees thousands of new recruits who might be in need of dental care to be classified as mission ready. Based on the 2008 Department of Defense Recruit Oral Health Survey, the mean number of restorations needed for US Navy and US Marine Corps active duty recruits is approximately three.⁹ Restorations may be needed for primary caries or recurrent caries or for those restorations that are deemed non-serviceable. The dentists placing the restorations in these recruits are utilizing both resin composite and amalgam materials for posterior teeth. Being able to look back on the performance of both of these restorative materials that are being placed by many operators with varying degrees of experience can provide valuable information, including an ability to compare the longevity of the two different materials.

With a growing number of posterior resin composite restorations being placed in the mouths of Americans, it becomes necessary to understand the long-term prognoses for resin composites compared to the dental material (amalgam) that previously dominated in terms of direct restorations. Considering recent advancements in composite materials and current techniques, it was hypothesized that replacement rates for both amalgam and composite restorations placed in posterior teeth of sailors and marines during active duty are comparable and fairly low for the duration of their active-duty service.

METHODS AND MATERIALS

In 2011, a retrospective cohort study of resin composite and dental amalgam restorations placed in posterior teeth of US Navy and Marine Corps personnel was initiated. Dental records, maintained at a large Navy Dental Treatment Facility (DTF), were reviewed to obtain data pertaining to restorations placed by navy providers in DTFs. The initial review screened for those dental records that documented the placement of at least one posterior resin composite on a stress-bearing surface (either Class I or Class II restoration) during active duty. From those dental records with a posterior resin composite on either a premolar, a first molar, or a second molar (third molars were not included in the study), only those patients with a documented comprehensive baseline-type exam that included the documentation of existing restorations (forensic exam) were included in the study.

For each patient included in the study, data regarding all direct posterior Class I or Class II restorations placed during active duty were recorded in an Excel spreadsheet with all identifying markers masked. The number of missing and filled teeth, based on the forensic exam, was gathered for all patients. Each posterior tooth identified with either a resin composite or an amalgam restoration was analyzed for the following data: tooth number, number of surfaces, restoration material and type, isolation techniques, existence of previous restoration, placement date, replacement date if applicable, and exam information when need for restoration was diagnosed. Gender and year of birth were also documented for each patient. Caries risk was assessed for each tooth and patient based on information gathered from forensic and annual dental exams in conjunction with the guidelines in Table 1. The study protocol was approved by the Naval Medical Research Unit San Antonio Institutional Review Board in compliance with all applicable federal regulations governing the protection of human subjects.

Statistical Analysis

The numbers and percentages of amalgam and resin composite restorations placed by navy providers in posterior teeth (third molars excluded) of US Navy and Marine Corps personnel were calculated. For all restorations, the date of placement was used as the beginning of follow-up. The date of record review was used as date of censor for restorations that did not fail. For those restorations that did require replacement, the date of the actual replacement was used as the date of failure. The number of resin composite and amalgam restorations that required replacement was calculated on the basis of these parameters. Follow-up was limited to 12 years, and a *t*-test was performed to check for a difference in follow-up time based on material. Preventive resin restorations and any type of crown buildup were excluded from the analysis.

Estimated AFRs were calculated for each material utilizing the percentage of total failures divided by the average number of follow-up years. An estimated five-year failure rate was calculated for each material using Kaplan-Meier product-limit estimates. A log-rank test was used to determine a difference in two survival curves, while a chi-square test was utilized to determine differences in proportions. Fisher's exact test was used when the chi-square test was not appropriate. The relative risk for replacement of restorations was described by calcu-

Table 1: U.S. Navy Dental Corps Caries Risk Assessment Criteria ^a	
Caries Risk Status	Criteria
Low	No new incipient or cavitated primary or secondary carious lesions during current exam
	No factors ^b that may increase caries risk
Moderate	One or two new incipient or cavitated primary or secondary carious lesions during current exam OR
	(Presence of at least one factor ^b that may increase caries risk
High	Three or more new incipient or cavitated primary or secondary carious lesions during current exam OR
	Presence of multiple factors ^b that may increase caries risk OR
	Xerostomia
^a Source: Chief, Bureau of Medicine and Surgery, BUMED Instruction 6600.16A 23 August 2010.	
^b Factors may include but are not limited to poor oral hygiene, cariogenic diet, presence of exposed root surfaces, enamel defects or genetic abnormality of teeth, many multisurface restorations, restoration overhangs or open margins, active orthodontic treatment, high titers of cariogenic bacteria, chemotherapy or radiation therapy, eating disorders, physical or mental disability with inability or unavailability of performing proper oral health care, and suboptimal fluoride exposure.	

lating the adjusted hazard ratio (HR), a comparison of the risk of replacement of resin composite to the risk of replacement of amalgam. This calculation takes into consideration the time to replacement to estimate differences in required retreatment while allowing for control of covariates. The sampling methodology ensured the clustering of restorations within patients. In order to arrive at a more accurate estimate of variance in light of the clusters, sandwich variance estimates were calculated in addition to model-based estimates. To identify potential confounders, we calculated HR using Cox's Proportional Hazard Regression to compare the risk of replacement for resin composite and amalgam restorations. A backward stepwise method was used with covariates entered into the model if the *p*-value < 0.25 and retained if the *p*-value < 0.15. Seven potential confounders were included for analysis: 1) number of surfaces in the restoration (one surface vs two or more), 2) caries risk status (low, moderate, high), 3) tooth type (molar, premolar), 4) isolation use (yes, no), 5) number of filled posterior surfaces at initial examination, 6) whether the restoration was the initial restoration, and 7) age of patient at restoration placement. The data were analyzed using statistical software (SAS®, Version 9.2, SAS Institute, Inc, Cary, NC, USA), setting all α levels of error at 0.05 and all confidence limits (CL) at the 95% level.

Table 2: Number of Subjects and Restored Teeth by Caries Risk Status and Number of Filled Posterior Surfaces		
Caries Risk Status	Subjects (%) (n=247)	Teeth (%) (n=1050)
Low	13 (5.3)	17 (1.6)
Moderate	106 (42.9)	311 (29.6)
High	128 (51.8)	722 (68.8)
Number of filled posterior surfaces ^a		
0	71 (28.7)	284 (27.0)
1-9	140 (56.7)	598 (57.0)
>9	36 (14.6)	168 (16.0)
^a At initial examination.		

RESULTS

A total of 2921 dental records of US Navy and Marine Corps personnel were reviewed. Only 247 (8.5%) of the records reviewed had a resin composite posterior restoration placed by a navy provider. Data were available for 1050 restorations (485 resin composite and 565 amalgam). The mean age of the subjects when restorations were placed was 22 years (minimum 18 years, maximum 39 years), and all were male. The average time of follow-up was 2.8 years (SD = 2.2 years; range: 1 day-11.6 years). There was no significant difference (*p*=0.08) in the time of follow-up for amalgam (2.9 years; range: 1 day-11.4 years) and resin composite restorations (2.6 years; range: 24 days-11.6 years).

Table 2 describes the numbers of teeth and subjects in each of the three caries risk categories as well as the number of filled posterior surfaces for the patients and their teeth included in this sample. Table 3 summarizes the number of amalgam and resin composite restorations placed according to tooth type and surfaces as well as the need for replacement. Less than two percent (1.6%) of the teeth were in low-risk patients, 29.6% were in moderate-risk patients, and over two-thirds (68.8%) were in high-risk patients. The number of filled surfaces at initial examination had a range of 0-44 surfaces. Slightly over one-quarter (27.0%) of the teeth were in patients who had no restorations at initial examination. Over half (57.0%) of the teeth were in patients having one to nine filled surfaces, while the remaining 16.0% of the teeth were in patients with more than nine filled surfaces at initial examination. Slightly over half (52.9%) of the restorations involved only occlusal surfaces. Of the 495 multisurface restorations (two surfaces or more), 337 (68.1%) were amalgam, while only 31.9% were resin composite (see Table 3). For resin composite

Table 3: Number of Restorations Placed and Replaced on Posterior Teeth

Restoration Type (by Surface or by Tooth)	Resin Composite				Amalgam			
	Placed	Replaced		% Requiring Replacement	Placed	Replaced		% Requiring Replacement
		Yes	No			Yes	No	
One surface	327	11	316	3.4%	228	9	219	4.0%
Multisurface	158	10	148	6.3%	337	30	307	8.9%
Premolar	103	5	98	4.9%	130	11	119	8.5%
Molar	382	16	366	4.2%	435	28	407	6.4%
All restorations	485	21	464	4.3%	565	39	526	6.9%

restorations, 382 (78.8%) were in molars, and 103 (21.2%) were in premolars. Likewise, for amalgam restorations, 435 (77.0%) were in molars, and 130 (23.0%) were in premolars.

The overall rate of replacement for all restorations in the sample was 5.7% during the average 2.8-year follow-up (60 of 1050 restorations requiring replacement). Of the 565 amalgam restorations observed, 39 (6.9%) required replacement, while only 21 (4.3%) of the 485 resin composite restorations were cited for replacement. Greater percentages of multisurface restorations required replacement for both materials. Amalgam multisurface restorations had a higher need for replacement (8.9%) compared to 6.3% of resin composite restorations needing replacements. Both composite and amalgam restorations showed an apparent trend in the percentages of replacement as the number of surfaces increased (see Table 4). No significant differences in the proportions existed between resin composite and amalgam restorations when analyzing by the number of surfaces ($p > 0.05$). Although resin composite restorations showed a lower rate of replacement (resin composite: 4.3%; amalgam: 6.9%), there was no statistically significant difference in the risk for resin composite restoration replacement when compared to amalgam replacement as demonstrated by an unadjusted HR of 0.69 (95% CL 0.37-1.27).

The estimated AFR for amalgam was 2.38% per year, and for composite it was 1.65% per year.

Likewise, the five-year failure rate was 12.8% for amalgam restorations, while the five-year failure rate for resin composite restorations was 6.7%. The survival curves for resin composite and amalgam (see Figure 1) demonstrated no statistical difference ($p > 0.05$).

After backward stepwise Cox proportional hazards regression, the final model contained number of surfaces ($p = 0.0056$), caries risk ($p < 0.0123$), filled posterior surfaces ($p = 0.0942$), and material ($p = 0.7337$). The adjusted HR showed no significant difference between the rate of replacement for resin composite and amalgam posterior restorations (HR = 0.89; 95% CL 0.46-1.74). As demonstrated in Table 5, the rate of replacement of multisurface restorations showed a significant elevation when compared to single-surface restorations (HR = 2.24; 95% CL 1.27-3.96). In addition, an increase in caries risk also demonstrated a significant increase in restoration replacement.

DISCUSSION

A multitude of studies have been conducted⁵ demonstrating variability on the longevity of routine direct dental restorations in permanent posterior teeth. Factors influencing variability have been documented to be restoration type, materials, the patient, the operator, the practice environment, and the type of care system.⁸ The contraindications taught at dental schools for resin-based composite

Table 4: Number of Restorations Placed and Replaced Based on Number of Surfaces

No. of Surfaces	Resin Composite (n=485)			Amalgam (n=565)		
	Placed	No. of Replacements	% Replacements	Placed	No. of Replacements	% Replacements
1	327	11	3.4	228	9	4.0
2	138	9	6.5	237	22	9.3
3	16	0	0.0	58	2	3.5
4	2	0	0.0	23	2	8.7
5	2	1	50.0	19	4	21.1

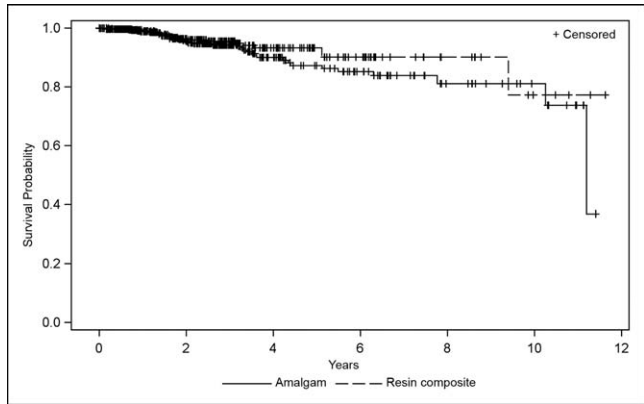


Figure 1. Survival distribution of resin composite and amalgam restorations.

restorations on posterior teeth take these factors into consideration.⁴ These contraindications are taught to increase the success and longevity of the restorative material used.

A retrospective clinical study on longevity of posterior composite and amalgam restorations by Opdam and others¹⁰ demonstrated that resin composite and amalgam were comparable in their failure rates. The study focused on restorations placed by operators who were trained not only in the use of amalgam but also in the use of resin composite. With the growing confidence in the quality and advantages of posterior composites as well as an increase in the skills of trained dentists, Opdam and others¹⁰ were optimistic toward the longevity of posterior composite restorations. The AFRs calculated in our study for both materials are low and demonstrate an acceptable survival rate in a clinical environment where multiple operators deliver treatment. Based on the HR in this study, amalgam and resin composite had no significant differences in the rate of replacement, thus demonstrating the same clinical success. Although the randomized controlled clinical trial conducted by Bernardo and others⁷ demonstrated that AFRs were over three times greater for composites than amalgams, their study also showed that large restorations and those with three or more surfaces (with composite being lower than amalgam) had the lowest survival rates. This paralleled our study. Although multisurface restorations had less clinical success, the performance of both materials was similar, thus indicating that each material is being utilized in a manner that will optimize the success of the restoration.

The caries risk of patients was determined to have an effect on the replacement rate of restorations in this study. This is similar to several reviews and

Table 5: Comparison of Adjusted Hazard Ratios for Replacement Rates of Resin Composite and Amalgam Restorations During Follow-Up

Variables	Adjusted Hazard Ratio for Replacement ^a (95% Confidence Limits)
Material (resin composite vs amalgam)	0.89 ^b (0.46-1.74)
Number of surfaces of restoration	2.24 ^c (1.27-3.96)
Caries risk	2.20 ^d (1.19-4.09)
Filled posterior surfaces	0.95 ^b (0.90-1.01)

^a Full model: material, restoration surfaces, caries risk, and filled posterior surfaces.
^b Not significant; $p > 0.05$.
^c $p < 0.01$.
^d $p < 0.05$.

studies that determined that the caries risk of patients plays a significant role in the long-term survival of restorations.^{5,8,11} Navy dentists assess a patient's caries risk and provide dental care that is appropriate for the determined risk status. In essence, providing certain types of restorations will be based on the caries risk status of the individual. As indicated in Table 1, many of the factors that are considered to determine a person's caries risk status are also those factors that are taught as contraindications to placing direct composite restorations. The criteria and protocols in place to assist navy dentists in selecting teeth appropriate for composite restorations assist in controlling for caries risk.

Study Limitations

Reasons for restoration failure were not documented in this study. The failure of some restorations may have been due to fracture of material or recurrent caries around the actual restoration. Other restorations may have been replaced because an adjacent surface had primary caries and there was a need to remove a sound restoration to include an additional surface. This would not necessarily constitute failure of the material or the restoration.

A limited number of women access the DTF where the records were reviewed to be included in the study. Out of the 2921 records reviewed, no women met the inclusion criteria for this study. Gender itself is not necessarily a risk factor for caries, but there are gender differences in treatment-seeking behaviors and adherence to treatment and preventive instructions that could potentially affect outcome.¹²

The length of follow-up time for all restorations was limited. Another study by Opdam and others¹¹

found that amalgam and composite showed a comparable performance at five years, but differences were seen at 12 years. Thus, restorations with less than a three-year life span might not demonstrate differences in replacement rates due to the limitation of follow-up time.

CONCLUSIONS

The results for this study show that no difference existed in the rate of replacement for amalgam versus resin composite in navy DTFs. When restorations increased from just a single occlusal surface to additional surfaces, the rate of replacement was elevated and statistically significant for both materials. Additionally, a higher caries risk status also significantly elevated the risk for restoration replacement. There will always be a risk of fracture and failure of restorations that can occur among sailors and marines, but selectively choosing appropriate dental materials based on the patient appears to minimize this risk of failure and fracture.

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Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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