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Clinical Research

Longevity of Direct Restorations in Stress-Bearing Posterior Cavities: A Retrospective Study

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Clinical Relevance

In posterior stress-bearing occlusal cavities, the longevity of resin composite restorations (RCs) was lower than amalgam restorations, while the clinical performance of the restorations in use was not different. RCs must be observed with periodic follow-ups for early detection and timely repair of failures.

SUMMARY

The aims of this retrospective clinical study were to compare the longevities of direct posterior amalgam restorations (AMs) and resin composite restorations (RCs) that were subjected to occlusal stresses and to investigate variables predictive of their outcome. A total of 269 AMs and RCs filled in Class I and II cavities of posterior teeth were evaluated with Kaplan-Meier survival estimator and multivariate Cox proportional hazard model. Seventy-one retreated restorations were reviewed from dental records. The other 198 restorations still in use were evaluated according to modified US Public Health Service (USPHS) criteria by two investigators. The longevity of RCs was significantly lower than that of AMs (AM = 8.7 years and RC = 5.0 years, $p<0.05$), especially in molars. The prognostic variables, such as age, restorative material, tooth type, operator group, diagnosis, cavity classification, and gender, affected the longevity of the restorations (multivariate Cox regression analysis, $p<0.05$). However, among the restorations working in oral cavities, their clinical performance evaluated with modified USPHS criteria showed no statistical difference between

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both restoratives. In contrast to the short longevity of RCs relative to AMs, the clinical performance of RCs working in oral cavities was observed to be not different from that of AMs. This suggests that once a RC starts to fail, it happens in a rapid progression. As posterior esthetic restorations, RCs must be observed carefully with periodic follow-ups for early detection and timely repair of failures.

INTRODUCTION

Amalgam and composite resin are the most widely used direct filling materials in posterior stress-bearing areas.[1,2] For posterior stress-bearing occlusal surfaces, especially for Class II restorations, amalgam is still the most commonly used material in some countries.[1,3-4] However, the use of amalgam is declining gradually due to patients' esthetic demands and concern over the hazards of mercury.[3-5]

There has been controversy with the longevity of amalgam and composite resin as posterior restorations. Generally, in cross-sectional retrospective studies, amalgam restorations (AMs) exhibited better longevity than composite resin restorations (RCs).[1,6,7] A prospective randomized clinical trial also showed a higher seven-year survival rate in AMs than in RCs.[8] Moreover, even in the reports that showed no significant difference in the longevity of the two restoratives, the replacement rates for RCs were significantly higher than those for AMs.[9,10] However, unlike the results of other retrospective studies, a better 12-year survival rate and a comparable 10-year survival rate of RCs compared to AMs were also reported by a small group of well-motivated practitioners.[11-12] Manhart and others[13] also reported comparable annual failure rates between the two materials from meta-analysis of the survival rates of direct posterior restorations (amalgam 3.0%, composite resin 2.2%).

As reasons for amalgam replacement in the posterior area, poor margins and resulting secondary caries were ascribed to biting force and creep.[14,15] Low-frequency cyclic stresses caused by mastication and thermal changes during ingestion of hot and cold food induce creep.[16] When composite resin is used in a posterior stress-bearing area, it may also be subjected to the same situation. Cyclic loading was found to lead to significant decreases in fracture strength and the fatigue limit of the adhesive itself at the adhesive-dentin interface.[17] Therefore, whenever composite resin is used in a posterior stress-bearing area, the effect of the occlusal stresses being applied to the weakest adhesive-dentin interface should be considered with respect to the aging of the restorations.

Despite the improvement in composite resin materials and bonding techniques, composite resin is still used as a direct posterior filling material without any basis on scientific clinical evidence.[3,18] In fact, the use of composite resin to restore stress-bearing surfaces of molar and premolar teeth may still be controversial due to the individual practitioner's concerns over unpredictability, microleakage, unacceptable wear, postoperative sensitivity, time and technique sensitivity in moisture control and placement, and control of polymerization shrinkage stress.[1,3,19] Comparative data on the longevity of AMs and RCs as direct restorations under similar conditions are needed, especially in posterior stress-bearing areas.

The aims of this retrospective clinical study were to compare the longevities of direct posterior AMs and RCs that were subjected to occlusal stresses in stress-bearing areas and to investigate variables predictive of their outcome. For the purposes, the longevity of AMs and RCs that were placed into Class I and II cavities by multiple operators working in a dental school and their prognostic variables were evaluated retrospectively.

MATERIALS AND METHODS

This study is a part of the cross-sectional clinical study that was performed retrospectively in the Department of Conservative Dentistry, Seoul National University Dental Hospital, from July 6, 2009, to August 28, 2009. The project was approved by the Institutional Review Board of the Seoul National University Dental Hospital. In order to compare the longevity of direct AMs and RCs that were filled into the cavities under continuous occlusal forces, data on 269 AMs and RCs placed into Class I and Class II cavities of posterior teeth of 140 patients were selected and evaluated with survival analysis.

Selection criteria included the patients who had appointments during the study period and, among them, who had restorations placed in the department. Prior to a patient's visit, information on the patient and treatment was collected from dental records. Patient information included gender, age, and medical and dental history. From the records, old AMs and RCs that had been directly placed into Class I and Class II cavities of premolars and molars were selected. In order to exclude restorations used for an interim purpose, those restored within one year were not included in this study. Restorative material, cavity classification, tooth type, reason for treatment, and date of treatment were recorded as treatment information.

If there was a record on retreatment or subsequent treatment, such as extraction, endodontic treatment, and prosthodontic treatment that could affect the integrity of the restoration, the date and reason for the subsequent treatment were recorded. The restoration was regarded as an event case, and its longevity was determined as the period from the initial treatment to the subsequent treatment. If there was no record of retreatment and subsequent treatment, the patient was clinically evaluated under informed consent before the appointed treatment of the visit. When a restoration was still in function and its characteristics were consistent with the record, the restoration was evaluated by two investigators according to modified US Public Health Service (USPHS) criteria (Table 1). If there was a disagreement between the investigators, it was resolved by consensus. When the restoration was rated as Alpha or Bravo, the restoration was considered censored. Its censored life span was determined as the period from the initial treatment to the date of examination. Related information was also collected from the records. When the restoration was still in the oral cavity but rated as "clinically unacceptable" Charlie in a single criterion of the modified USPHS criteria, it was recommended for retreatment and regarded as a failure. The longevity of those restorations were also calculated from the initial treatment to the date of examination (Table 2). In cases where it was unclear whether there had been subsequent treatment on the existing restoration or whether the characteristics of the restoration agreed with the record, the cases were excluded from the study.

Statistical analyses were performed with SPSS version 18.0 (SPSS Inc, Chicago, IL, USA). To evaluate the longevity of the AMs and RCs, survival analysis was performed using Kaplan-Meier survival estimates. The effect of the assumed prognostic variables on the survival of the two restorative materials was analyzed using a multivariate Cox proportional hazard model by simultaneously entering all the variables. Reasons for the failures of restorations were compared based on the records and clinical examination results. Finally, using chi-square test/Fisher's exact test between the restorations rated as clinically acceptable (Alpha and Bravo grades) and those rated as unacceptable (Charlie grade) in each USPHS criterion, the clinical performance of both restorations remaining in oral cavities were compared.

RESULTS

Among 374 Class I and Class II posterior AMs and RCs, 105 (28.1%) restorations were excluded from the study due to disagreement between their characteristics and their records. A total of 269 (71.9%) restorations that were placed between 1986 and 2008 in 140 patients were included in this study. Fifty-nine patients were male, and the remaining 81 patients were female. The ages of the patients at treatment were 10-78 years with a mean age (±SD) of 46.9 (±16.0) years and those at evaluation were 15-81 years with a mean age of 53.4 (±16.7) years. There were 131 AMs and 138 RCs (Table 2). Systemic diseases were found in 52 patients (37.1%) with hypertension (24 patients), diabetes (seven patients), and hepatitis (seven patients) being the most prevalent. Patients with disabilities and past dental history related to difficulties in maintaining general oral hygiene, such as multiple caries or xerostomia, were excluded from the study. The number of AMs and RCs delivered in each year and the proportion of each restoration in each year are presented in Figure 1. According to the data, the first direct RC in a stress-bearing cavity of posterior tooth was observed in 1996, and the number and proportion of RCs gradually increased. After 2003, the proportion of RCs exceeded that of AMs.

In total, the median survival times of AMs and RCs in the occlusal stress-bearing cavities of posterior teeth were 8.7 and 5.0 years, respectively, and their survival estimates were significantly different (log rank test, $p<0.05$; Table 3 and Figure 2a). With respect to the classifications, the median survival times of Class I and Class II AMs were 10.0 years and 6.9 years, respectively (log rank test, $p<0.05$; Table 3 and Figure 2b), whereas Class I and Class II RCs were not statistically different (median survival times of 3.3 and 5.4 years, respectively; Table 3 and Figure 2c). With respect to the materials, Class I restorations showed significantly different survival estimates between AMs and RCs (log rank test, $p<0.05$; Table 3 and Figure 2d). However, Class II restorations did not exhibit a difference (Table 3 and Figure 2e). Compared to the AMs that were statistically not different, RCs were significantly different between premolars and molars (Breslow test, $p<0.05$; Table 3). There were no significant differences in the survival estimates of both materials between with and without systemic diseases (Breslow test, $p<0.05$; Table 3). When the patients

Table 1: *The Modified US Public Health Service Criteria Used in the Study*

Category	Rating		Criteria
	Success	Failure	
Retention	Alpha		Present
	Bravo		Partial loss
		Charlie	Absent
Color match	Alpha		No mismatch to the adjacent tooth structure
	Bravo		Slight mismatch but clinically acceptable
		Charlie	Esthetically unacceptable mismatch
Marginal discoloration	Alpha		No discoloration on the margin
	Bravo		Superficial discoloration on the margin
		Charlie	Deep discoloration penetrating in a pulpal direction
Secondary caries	Alpha		No caries present
		Charlie	Caries present
Wear (anatomic form)	Alpha		Anatomy resembles the original restoration
	Bravo		Anatomy exhibits a change in contour but does not require replacement
		Charlie	Excessive wear with dentin exposure requiring replacement
Marginal adaptation	Alpha		Continuity at the margin (no ledge or ditch)
	Bravo		Slight discontinuity detectable with an explorer but does not require replacement
		Charlie	Marginal ledge or crevice requiring replacement
Postoperative sensitivity	Alpha		Absent
		Charlie	Present

had systemic diseases, there was no difference in the survival estimates between both materials. However, among the patients without systemic diseases, AMs exhibited a longer median survival time than RCs (log rank test, $p<0.05$; Table 3). On the other hand, there were significant differences between AMs and RCs with respect to operator, diagnosis, age-groups, gender, and the location in maxilla or mandible (Table 3).

According to the multivariate Cox proportional hazard model and the Wald statistics, the age-group, restorative material, tooth type, operator group, diagnosis, cavity classification, and gender affected the lifetime of the restorations in a descending order ($p<0.05$; Table 4). The location of teeth in the maxilla or mandible and the presence or absence of systemic diseases did not exhibit significant influence on the overall survivals. Among the age-groups, teenagers and those in their 70s had higher risks than the other age-groups, except those in their 40s. With AMs as reference, the relative risk of RCs significantly increased 2.28 times. The relative risk of molars increased 2.45 times compared to premolars. In comparison to Class I restorations, the relative risk of Class II restorations increased 1.63 times. In comparison to males, the relative risk of females was 0.65 times that of males. Among the operator groups, the student group exhibited significantly lower risks than the professor and the resident groups, but the relative risks of the professor group and the resident group were statistically not different. Among the diagnostic categories, the restorations placed due to pulpal problems exhibited the highest risks compared to those restored due to other reasons, but the relative risks of the restorations due to primary reasons and replacements were statistically not different.

Regardless of the longevity of the restorations, from the treatment records of the retreated restorations and the clinical evaluation of the restorations working in oral cavities according to the USPHS criteria, 73 (55.7%) of the 131 AMs were deemed as failures, while 58 (42.1%) of 138 RCs were determined as failures (Table 2). Forty-four AMs and 27

Table 2: *Distribution of Amalgam and Resin Composite Restorations Included in This Retrospective Cross-Sectional Clinical Study for the Survival Analysis of Direct Posterior Class I and II Restorations Subjected to Occlusal Stress*

Restorations	Status	No. (%)			Event
		Amalgam	Composite	Sum	
Replaced		44 (33.6)	27 (19.6)	71 (26.4)	Event
Survived in the mouth	Failure (Charlie)[a]	29 (22.1)	31 (22.5)	60 (22.3)	Event
	Clinically acceptable (Alpha or Bravo)[a]	58 (44.3)	80 (58.0)	138 (51.3)	Censored
Total		131 (100)	138 (100.1)	269 (100)	

[a] *If the restoration was rated a clinically unacceptable grade of Charlie in any one of the seven criteria, the restorations were determined as failures and classified to an event case. The restorations rated as Alpha or Bravo were considered as clinically acceptable and classified to be censored.*

RCs had records for replacement. Among them, the reasons for replacement were recorded in 33 AMs and 21 RCs. In cases of replaced restorations, the most common reasons for failures in AMs were loss of the restoration (36.4%), fracture of the restoration (27.3%), and secondary caries (21.2%). In RCs, they were secondary caries (38.1%), loss of retention (23.8%), and fracture of the restoration (14.3%). However, in the failure cases of the 29 AMs and 31 RCs that were retained in oral cavities but determined as failures due to the Charlie grade even in a criterion of the modified USPHS criteria, the most common failure reason was secondary caries for both restorative materials. Ill-fitting margins and a loss of retention followed for both restoratives. Some of them were rated as Charlie in more than one criterion. Among 87 AMs and 111 RCs remaining in oral cavities, the clinical performance of the restorations that were evaluated using USPHS criteria was statistically not different between both restorations in all the criteria (Table 5).

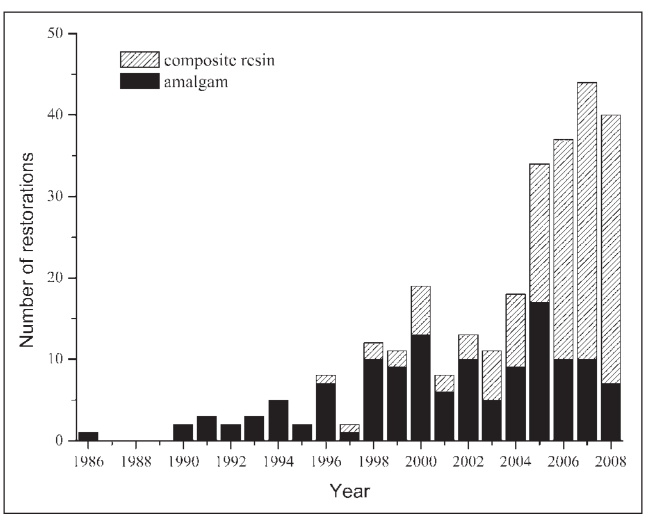

Figure 1. *The number of amalgam and resin composite restorations delivered in each year.*

DISCUSSION

In this study, the longevity of AMs was significantly greater than that of RCs (Table 3). Generally, AMs had better longevity and required less repair or replacement than RCs.[6-8,20,21] Burke and others[6] and Mjör and others[20] reported the median survival times of Class I AMs, Class II AMs, Class I RCs, and Class II RCs as 7.4~10, 6.6~11, 3.3~6, and 4.6~6 years, respectively. Forss and others[7] reported 12 years for AMs and 5 years for RCs. Although this study was performed in a department of a university-based hospital, the longevity data of this study were quite similar to the values reported in those studies based on the general practice settings. The longevity data of this study were also shorter than those obtained from clinical studies practiced by a single dentist or a small group of highly motivated practitioners.[11,21] The reasons for the relatively short longevity of the restorations included in this study may be explained from two aspects. First, most retrospective studies collected data from responses to questionnaires and regarded all the remaining restorations as censored. However, in this study, those restorations rated as Charlie even in one criterion of the USPHS criteria were regarded as failures. The strict criteria to determine the survival may have reduced the longevity values of this study. Second, the fact that a high proportion of molar teeth were included in our study also decreased the longevity of posterior direct restorations (19 premolar and 112 molar in AMs; 49 premolar and 89 molar in RCs). In most other studies, they did not separate the longevity values into premolars and molars.[6,7,20]

Table 3: *Median Survival Times of Amalgam and Resin Composite Restorations According to Prognostic Variables**

Prognostic Variables	Amalgam	Composite
Material	8.7 (7.8~9.6)^{A}	5.0 (3.2~6.8)^{B}
Cavity classification		
I	10.0 (7.9~15.5)^{aA}	3.3 (2.5~10.5)^{aB}
II	6.9 (2.9~12.7)^{bA}	5.4 (2.5~10.4)^{aA}
Tooth type		
Premolar	11.2 (10.8~12.7)^{aA}	8.7 (3.3~12.5)^{aA}
Molar	8.3 (3.7~13.7)^{aA}	3.3 (2.2~10.4)^{bB}
Systemic disease		
Absent	8.7 (4.0~13.7)^{aA}	5.2 (2.7~10.4)^{aB}
Present	6.9 (2.8~11.2)^{aA}	3.2 (2.4~11.0)^{aA}
Operator		
Professor	8.1 (3.9~13.7)^{bA}	5.0 (2.5~12.5)^{aA}
Resident	8.3 (3.7~12.7)^{bA}	3.3 (2.3~10.4)^{aB}
Student	13.3 (10.0~15.5)^{aA}	NA^{A}
Diagnosis†		
Primary reason	9.1 (3.9~13.7)^{aA}	5.0 (2.5~10.4)^{aB}
Replacement	8.3 (4.0~8.7)^{aA}	NA^{aA}‡
Pulp pathosis	NA^{bA}	NA^{aA}
Gender		
Male	8.0 (2.8~13.7)^{aA}	3.7 (2.2~10.5)^{aA}
Female	8.9 (4.0~13.3)^{aA}	6.5 (2.5~10.4)^{aB}
Arch		
Upper	8.4 (3.9~13.3)^{aA}	3.6 (2.7~10.4)^{aB}
Lower	10.0 (3.9~13.7)^{aA}	5.4 (2.5~11.0)^{aB}
Age		
10	10.0 (2.9~NA) ^{abA}	1.2 (1.1~1.4)^{bB}
20	10.8 (2.1~12.9) ^{abA}	8.7 (NA~NA)^{aA}
30	12.7 (9.1~14.3)^{aA}	10.4 (3.3~10.5)^{aA}
40	8.0 (5.1~8.7) ^{abA}	2.7 (2.2~3.3)^{aB}
50	7.9 (3.5~17.8) ^{bA}	4.4 (2.8~5.2)^{aA}
60	11.2 (4.0~13.7) ^{abA}	5.4 (2.2~12.5)^{aA}
70	0.4 (NA~NA)^{cA}	3.0 (2.3~NA)^{abB}

** Median survival times are presented in years, and the numbers in the parentheses are the survival times in years at 25% and 75%. Different small superscript letters indicate a significant difference in the longevity within the column, and different capital superscript letters indicate a significant difference in the longevity between the two restoratives within the row.*
† Treatment reasons (diagnoses) were divided into three categories: primary reasons, replacements, and pulpal problems. The primary lesions, such as caries, attrition, abrasion, erosion, tooth fracture, diastema, and esthetic problems, were grouped as primary reasons. Filling body fracture, partial retention loss, and secondary caries were grouped as replacements. Pulpal pathosis and hypersensitivity were included as pulpal problems.
‡ NA means that the value of survival time is not available due to lack of event cases.

However, in our study, a high proportion of molar teeth that had shorter lifetimes than premolars decreased the longevity of AMs and RCs compared to other studies.

Many factors, such as operators with various clinical experience, tooth type, location of the tooth, size of the restoration, and age, may affect the longevity of the restorations.[6,13] Compared to Class II AMs, Class I AMs were reported to have a longer survival time and lower failure rate.[22] Our study also showed that the longevity for Class I AMs was significantly longer than that of Class II AMs. However, there was no significant difference between the longevities of Class I and Class II RCs. This result is contrary to the earlier study, which reported higher failure rates in Class II RCs than in Class I RCs.[23] However, it corresponds to the fact that some studies report shorter longevities for Class I restorations (three to four years) than for Class II restorations (four to seven years).[20,22] Compared to Class I AMs, the relatively short longevity of Class I RCs may result from the drawbacks of adhesion, such as the weakest link of bonding, high configuration factor of the box-shaped cavity, poor resistance to polymerization shrinkage stress, and low-grade continuous occlusal stresses.[17,24,25] The results suggest that the longevity of the posterior direct RCs under occlusal stresses may be determined by the adhesive as the weakest link rather than the restorative material and cavity classification, and the suggestion needs to be further investigated.

In the multivariate analysis, the relative risk of failure for molars was 2.45 times higher than premolars (Table 4). There was no difference in the longevity of AMs in premolars and molars. However, RCs of premolars exhibited significantly higher longevity than those of molars (Breslow test, $p<0.05$; Table 3). Previous studies showed that adhesive restorations were more successful in premolars and in the non-stress-bearing areas than molars and stress-bearing areas.[20,23] Simecek and others[10] also reported a higher incidence of replacement for both AMs and RCs in molars than premolars. In our study, with respect to the materials, there was no significant difference in premolars. However, the RCs in molars exhibited less than half the median survival times of the AMs in molars (AMs 8.7 years, RCs 3.3 years; Table 3). In the multivariate analysis, the restorative material and tooth type contributed the most to longevity, except the age-groups (Wald statistics; Table 4). Contrary to the AMs, the longevity of the RCs in

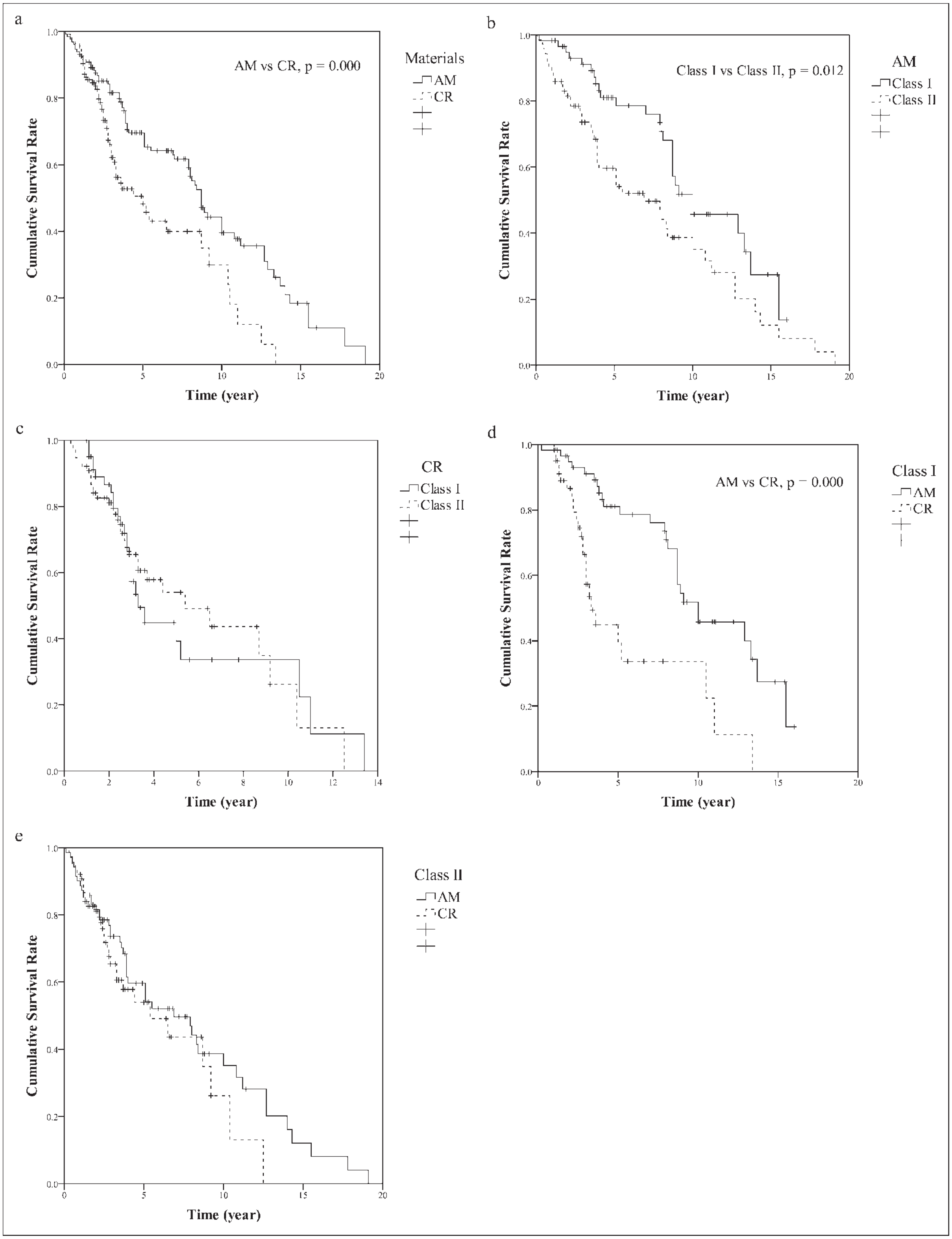

Figure 2. *Cumulative survival estimates of direct posterior Class I and Class II amalgam restorations (AMs) and resin composite restorations (RCs). (a): AMs and RCs. AMs exhibited significantly higher survival estimate than RCs (log rank test,* $p<0.05$*). (b): AMs. There was a significant difference between Class I and Class II restorations (log rank test,* $p<0.05$*). (c): RCs. There was no significant difference between Class I and Class II restorations. (d): Class I restorations. There was a significant difference between AMs and RCs (log rank test,* $p<0.05$*). (e): Class II restorations. There was no significant difference between AMs and RCs.*

Table 4: *Relative Risk of Failure in Posterior Direct Amalgam and Resin Composite Restorations According to Prognostic Variables*[a]

Variables	*p*-Value	Relative Risk	95% CI Lower	95% CI Upper	Wald Statistics
Age	0.000				25.153
10		1.00			
20	0.014	0.33	0.14	0.80	
30	0.000	0.14	0.06	0.34	
40	0.106	0.53	0.25	1.14	
50	0.010	0.37	0.17	0.79	
60	0.002	0.26	0.11	0.62	
70	0.225	0.46	0.13	1.61	
Material	0.000				13.696
Amalgam		1.00			
Composite		2.28	1.47	3.53	
Tooth type	0.001				11.885
Premolar		1.00			
Molar		2.45	1.47	3.53	
Operator	0.005				10.704
Professor		1.00			
Resident	0.140	1.39	0.90	2.14	
Student	0.014	0.36	0.16	0.81	
Diagnosis	0.010				9.284
Primary reason		1.00			
Replacement	0.416	0.75	0.37	1.51	
Pulp problem	0.005	8.69	1.91	39.51	
Cavity classification	0.023				5.149
I		1.00			
II		1.63	1.07	2.49	
Gender	0.030				4.681
Male		1.00			
Female		0.65	0.44	0.96	
Arch	0.140				2.180
Maxilla		1.00			
Mandible		0.75	0.52	1.10	
Systemic disease	0.764				0.090
Absent		1.00			
Present		1.07	0.70	1.63	

Abbreviation: CI, confidence interval.
[a] *The data in this table were obtained through the multivariate Cox proportional hazard model. According to the Wald statistics, the variables affecting the lifetime of the restorations were presented in a descending order. The arch and the systemic diseases did not exhibit significant influence on the survivals ($p>0.05$). In each variable, the relative risk of each group showed the ratio of the risk compared to the first group with a relative risk of 1.00.*

molar teeth was significantly lower than in premolar teeth. Due to advances in composite materials, bonding techniques, and operator experience, there is now a decreasing trend in the failure rate of RCs.[3,4,18] However, as seen from the result of this study, the longevity of RCs was significantly lower than that of AMs, especially in molars. The longevity of the restoration might have been affected by the tooth type due to reasons such as the inherent difficulties of accessing molar teeth during treatment, the large size of the restorations, and the heavy occlusal forces. In spite of the significantly shorter longevity of RCs than AMs, the observation that the clinical performance of the restorations working in oral cavities showed no statistical difference between both restorative materials (Table 5) suggested the rapid progressing nature of the failure of RCs. Therefore, as posterior esthetic restorations, RCs must be observed carefully with periodic follow-ups for early detection of failures and for a timely repair procedure.

Among the systemic diseases, hypertension, diabetes, and hepatitis were the most prevalent ones. Systemic diseases were too diverse with small sample sizes to be evaluated for each disease. Therefore, systemic diseases were evaluated only for their presence or absence in this study. The presence of systemic diseases had no significant effect on the longevity of both the AMs and RCs (Tables 3 and 4). Only in the healthy patient group without systemic diseases did RCs have shorter median survival time than AMs (Table 3). The patient factors that raise the caries risk with respect to the longevity of restorations may be xerostomia, dietary habits, oral hygiene, oral flora, and root exposure through the effect of salivary secretion.[26] In this study, because patients with systemic diseases who may have issues with salivary secretion were excluded, the relative risk of the group was not different from the group without systemic diseases. Further studies are needed on the effect of the presence of systemic diseases on the longevities of restorations and the relationship between individual systemic disease and the longevity of restorations. By the same token, treatment reasons (diagnoses) as a prognostic variable were divided into three categories: primary reasons, replacements, and pulpal problems. The primary lesions, such as caries, attrition, abrasion, erosion, tooth fracture, diastema, and esthetic problems, were grouped as primary reasons. Restoration body fracture, partial retention loss, and secondary caries were grouped as replacements. Pulpal pathosis and hypersensitivity were included as pulpal problems. Although there was no

Table 5: *Comparison of the Clinical Performance Between the Restorations Filled With Amalgam and Composite Resin Evaluated on the Basis of the Ratings of the Modified US Public Health Service Criteria*

Criteria	Chi-Square Test/Fisher's Exact Test[a]			
	Total		Odds Ratio	
	χ^2	*p*	AM/RC	95% CI
Retention	0.160	0.824	0.837	0.350~2.001
Color match[b]	—	—	—	—
Marginal discoloration[b]	—	—	—	—
Secondary caries	2.007	0.180	0.623	0.323~1.202
Wear (anatomic form)	NA[c]	1.000[a]	0.804	0.158~4.089
Marginal adaptation	1.064	0.396	0.647	0.282~10485
Postoperative sensitivity	NA	1.000[a]	0.778	0.153~3.952

Abbreviations: AMs, amalgam restorations; CI, confidence interval; NA, not available; RCs, resin composite restorations.
[a] When the expected incidence in more than one cell was less than 5, the result of Fisher's exact test was selected.
[b] The statistical results for the criteria "color match" and "marginal discoloration" were not available because the data on the two criteria were obtainable for RCs but not for AMs.
[c] The χ^2 value and odds ratio were not calculated, as there was more than one cell showing no incidence in the 2 × 2 tables.

significant difference between the relative risks of the restorations due to primary reasons and replacements, the relative risk of the restorations delivered due to pulpal problems was significantly higher than the other reasons (Tables 3 and 4).

The reason for failure of the restorations were evaluated in two ways, that is, from the treatment records and from the clinical evaluations according to the modified USPHS criteria for retreated cases and restorations working in oral cavities. For the retreatment cases, the loss of retention, fracture of the restoration, and secondary caries were the reasons for replacement in AMs. Secondary caries was the most frequent reason for replacement of RCs, followed by the loss of retention and fracture of the restorations. For the restorations working in oral cavities, because the restoration was classified as failure when it was rated as Charlie in any one of the seven modified USPHS criteria, the failure reasons for each restoration could be numerous. The most frequent reason for a clinically unacceptable Charlie grade was secondary caries in both types of materials, followed by marginal adaptation and loss of retention. This was consistent with other studies, in which secondary caries and fracture of the restorations were the main reasons for the failure irrespective of the restorative materials.[6,20] In AMs, the restorations with poor marginal adaptation were more numerous than those with retention loss. However, in RCs, the restorations with poor marginal adaptation were less frequent than AMs. This result met well with the low marginal strength of dental amalgam. Occurrence of marginal discoloration as well as poor marginal adaptation in RCs can be attributed to the polymerization shrinkage of the resin composite itself, long-term degradation of adhesion, and accumulation of fatigue from continuous occlusive forces.[17,25] Although AMs exhibited poor marginal adaptation, they might have better longevity than RCs due to the increased marginal seal by corrosion products and creep mechanisms.[27,28]

This study had several limitations. This study was performed retrospectively on a limited number of patients who visited our department during a period of eight weeks. The sample size was relatively small compared to other studies in which several thousands of restorations were collected using questionnaires by mail.[6,7,20] Moreover, the treatment records did not contain all the necessary data, such as missing data on the reason for replacement and on the techniques and materials, such as adhesives and restoratives. This made a large portion of valuable information unavailable. These were definite shortcomings of this study compared to a prospective controlled study. On the contrary, this study, performed in a department of a university hospital, had several advantages. First, the restorations were delivered by operators with various experience, including students, residents, and professors. Having various operators performing the restorations may have a definite advantage over a single dexterous operator or a small group of well-motivated practitioners in preventing biases.[11,12,21] Second, because the data were collected from patient records at a university hospital, treatment protocols were relatively standardized, and the longevity calculated from the record was accurate and reliable. Third, compared to the general practitioner–based retrospective study, nearly three-fourths of the restorations were evaluated clinically by two trained examiners according to the widely used criteria. The evaluation of the clinical status of the restorations must have been more consistent and reliable than other studies. Finally, in this study, because the restorations rated as clinically unacceptable Charlie even in one criterion were ethically recommended to be replaced, they were classified as event cases. As a result, the longevity of the restorations in this study was relatively short due to the strict criteria on the event case compared to the studies based on the responses of general practitioners to the requested questionnaires.

CONCLUSIONS

This study evaluated the effect of the variables that might be related especially to the occlusal stresses, such as material, cavity classification, tooth type, gender, arch, and age. The longevity of RCs was significantly lower than that of AMs, especially in molars. In spite of short longevity of RCs, the clinical performance of RCs working in oral cavities was not different from that of AMs. This suggests that once a RC starts to fail, it happens in a rapid progression. As posterior esthetic restorations, RCs must be carefully observed with periodic follow-ups for early detection and timely repair of failures.

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Conflict of Interest

The authors 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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