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A Retrospective Clinical Study of Cervical Restorations: Longevity and Failure-Prognostic Variables

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Clinical Relevance

The longevities of resin composite (RC) and glass ionomer (GI) used for cervical restorations were statistically not different, but the clinical performance of the RC was superior to GI in retention, marginal adaptation, and marginal discoloration.

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SUMMARY

The aim of this retrospective clinical study was to compare the longevity of cervical restorations between resin composite (RC) and glass ionomer (GI) and to investigate variables predictive of their outcome. The clinical performance of the two restorative materials in function was compared using the ratings of the modified United States Public Health Service (USPHS) criteria. A total of 479 cervical restorations were included in the study. Ninety-one already-replaced restorations were reviewed from dental records. The other 388 restorations still in function were evaluated according to the modified USPHS criteria by two investigators. Longevity and prognostic variables were analyzed with the Kaplan-Meier survival analysis and multivariate Cox proportional hazard model. The clinical performances of the two materials were evaluated according to the ratings of the USPHS criteria and com-

pared using the Pearson chi-square test and Fisher exact test. The longevity was not significantly different between RC and GI (median survival time, 10.4 ± 0.7 and 11.5 ± 1.1 years, respectively). The main reasons for failure were loss of retention (82.2%) and secondary caries (17.8%). The longevity of cervical restoration was significantly influenced by tooth group and operator group (Wald test, $p<0.05$), while material, gender, presence or absence of systemic diseases, arch, and reason for treatment did not affect the longevity. Contrary to the longevity, the clinical performance of RC was superior to GI in the criteria of retention, marginal discoloration, and marginal adaptation, but similar in secondary caries, wear, and postoperative sensitivity.

INTRODUCTION

In the clinic, dentists usually select restorative materials based on properties such as esthetics, physical strength, handling characteristics, biocompatibility, and wear resistance. As cervical lesions seem to be more frequently observed on the buccal surfaces of premolars and molars, tooth-colored restoratives should be considered as the materials of choice for restoration of cervical lesions.[1] Accordingly, those materials typically include resin composite (RC) and glass ionomer (GI, in this study includes conventional glass ionomer cement and resin-modified glass ionomer).[2] In general, RC has been the material of choice for cervical lesions due to superior esthetics, adequate strength, and versatility.[3] However, restoring cervical lesions with RC has several technical difficulties that can affect the clinical results. Difficulties in isolation, difficulties in adhesion to dentin margin, and polymerization shrinkage stress of RC make the restorative procedures very sensitive to the operator's technique.[4-6] Compared to RC, glass ionomers have been selected by virtue of adhesion to the tooth structure and fluoride release.[2,7,8] The GI restorative technique is relatively easy compared to that of RC restoration. However, esthetic results and mechanical properties of GI restorations are inferior to those of RC restorations.[2,9]

Even with the elastic bonding concept based on laboratory studies, the clinical longevity of cervical RC restorations was not affected by the stiffness of adhesive and RC.[10-12] Higher GI retention rates have also been attributed to laboratory observation of diffusion-based adhesion to calcium ions in dentin, as well as the low modulus of elasticity.[2] In non-prepared noncarious cervical lesions where direct occlusal force was not applied, the retention rate of restorations filled with various GIs was not shorter than those filled with RC, based on the results of short-term prospective studies within three years of restoration.[3,13-16] However, according to the United States Public Health Service (USPHS) criteria, the clinical performance of RC was superior to resin-modified glass ionomer cement and polyacid-modified resin composite.[3,13-15] Since the prognosis of cervical restoration may be greatly affected by various factors related to the material, patient, and the environment, it is difficult to predict the prognosis of restorations with laboratory results only. Clinical studies are needed to provide clinicians with predictive information on restorative materials and their prognostic variables.

With this retrospective clinical study, we investigated the longevity and prognostic variables of cervical restorations filled with RC and GI, which were retained with hybrid layer mechanical adhesion and chelating chemical adhesion, respectively. The clinical performance of the restorations in function was also compared between the two materials. The null hypothesis investigated was that there were no differences in the longevity and clinical performance between the cervical restorations filled with RC and GI. In order to investigate the hypothesis, the lifespan of the already-replaced restorations was determined from evaluation of dental records. The other restorations in use were clinically evaluated by two investigators according to modified USPHS criteria.

MATERIALS AND METHODS

Participants

Patients who had received restorative treatments in the Department of Conservative Dentistry, Seoul National University Dental Hospital before July 1, 2008, that is, who had restorations more than one year prior to initiation of the study, and revisited the department from July 6, 2009 to August 28, 2009, were enrolled in this study. Patients with systemic diseases that could affect the longevity of restorations were excluded. These included dry mouth, severe disability, wasting diseases such as uncontrolled diabetes mellitus, and impaired immune function. Permanent teeth in patients over 20 years of age were selected, and primary teeth with prolonged retention were excluded. The oldest restoration observed in this study was delivered in 1986. Since the 1980s, various restorative products and techniques were used in the department.

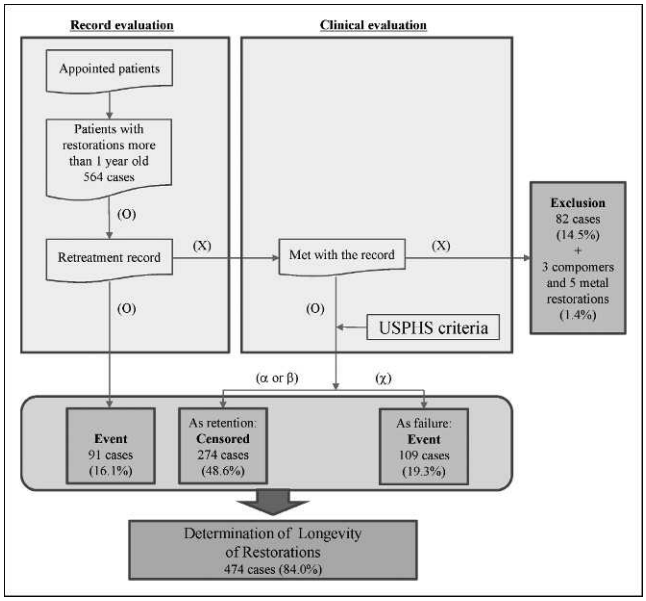

Figure 1. *Schematic representation of the survey procedure. First, if there was a record on retreatment or further treatment, the longevity of the restorations was defined as the time from the initial treatment to the retreatment. Second, if a patient had restorations with no records of retreatment or further treatment, the patient was clinically evaluated. Restorations confirmed to have not been replaced or treated further were evaluated according to the modified USPHS criteria. For clinically acceptable restorations rated as Alpha or Bravo, the lifespan was defined as the period from the initial treatment to the date of examination. When a restoration was rated as Charlie, clinically unacceptable, even in just one criterion, it was regarded as a failure and recommended to be retreated. Its longevity was determined as the period from the initial treatment to the date of examination.*

Because the aim of this study was to compare the longevity and clinical performance of the representative restorative materials used in the cervical restorations, that is, RC and GI, the restorative materials were divided into the two materials without considering restorative techniques in this study.

Survey Procedures

Under the approval of the Institutional Review Board of Seoul National University Dental Hospital, dental records were evaluated prior to the patients' visits. Based on the presence or absence of records on retreatment or further treatment of each restoration, including replacement, prosthetic treatment, endodontic treatment, and extraction, the survey procedure was divided into two pathways (Figure 1).

First, if there was a record on retreatment or further treatment, we concluded that an event had happened with the restoration. The longevity of the further-treated restoration was determined as the period from the initial treatment to the retreatment or further treatment. Information, including the date and details of and the reasons for retreatment, was collected from the records. Patient information included year of birth, gender, and premedical and predental history. Treatment information included tooth number, date of treatment, restorative material, operator, and diagnosis (reason for treatment).

Table 1: *Distribution of Restorations by Position of Teeth*

Restorative Materials	Anterior	Premolar	Molar	Total
Resin composite	155 (83.3%)	159 (80.3%)	63 (70.0%)	377 (79.5%)
Glass ionomers	31 (16.7%)	39 (19.7%)	27 (30.0%)	97 (20.5%)
Total	186	198	90	474

Second, if a patient had restorations that had no record of retreatment or further treatment, the patient was clinically evaluated after informed consent. For the existing restorations, two trained observers independently determined whether the characteristics of each restoration were consistent with the treatment record and whether the restoration had been replaced or further treated. In cases where it was unclear if there had been no further treatment of the existing restoration or whether the characteristics of the restoration agreed with the medical record, the case was excluded from the study. The two observers then independently evaluated the restorations in function according to the modified USPHS criteria (Table 1). If there was a disagreement between the observers, it was resolved by consensus. When the restoration was rated as Alpha or Bravo, the restoration was considered censored. Its censored lifespan was defined as the period from the initial treatment to the date of examination. Related information was also collected from the records.

Third, when a restoration remained in the oral cavity but was rated as "clinically unacceptable" Charlie even in a single criterion of the modified USPHS criteria, it was regarded as a failure and recommended to be retreated. For the clinically unacceptable restorations, longevity was defined as the period from the initial treatment to the date of examination.

Statistical Analysis

To evaluate the longevity of the cervical restorations filled with RC and GI, survival analysis was performed using Kaplan-Meier survival estimates. The effect of the assumed variables related to patients and teeth on the survival of restorations was analyzed using a multivariate Cox proportional hazard model by entering all variables simultaneously, and the relative risks were obtained. Patient age, gender, presence of systemic disease, type of tooth, restorative material, operator groups, and reasons for treatment were evaluated as potential prognostic variables. The operator groups were divided into three categories: professors, residents, and students. The reasons for treatment were subdivided into three categories: restoration of carious lesion, restoration of noncarious lesion, and replacement of previous restoration. Pearson chi-square test was performed on the numbers of restorations with acceptable (Alpha and Bravo) and unacceptable (Charlie) ratings according to the modified USPHS criteria to compare the clinical performance of the two restorative materials.

RESULTS

Surveyed Group and Case Distribution

Based on the date of treatment, the subjects were 23 through 81 years of age with a mean age and standard deviation of 63.9 ± 10.8 years. Based on the date of evaluation, the ages ranged from 20 to 80 years with a mean age of 57.4 ± 10.4 years. The lifespan of the restorations was from 0.1 to 22.9 years. The restoration with the longest service time was the one restored with conventional glass ionomer. Sixty-nine patients (52.7%) were male and 62 patients (47.3%) were female. Forty-seven (35.9%) patients had various systemic diseases. Hypertension was the most common (22 patients), followed by controlled diabetes (10 patients).

Data for 564 cervical restorations were collected from 131 patients during the survey. According to patient records, 91 (16.1%) restorations had been retreated or further treated. Among the restorations in function, 274 (48.6%) were rated as Alpha or Bravo according to the modified USPHS criteria and, as a result, were regarded as being censored. There were 109 restorations (19.3%) that were rated as Charlie and regarded as failure. Eighty-two restorations (14.5%), which were in function but did not agree with the medical records, were excluded from the study because their longevity was uncertain. Five metal restorations and three compomer restorations (1.4%) were also excluded from the survival analysis. Therefore, a total of 474 (84.0%) of 564 cases were included in this study (Figure 1). The main reasons for cervical restoration failure were loss of retention (82.2%) and secondary caries (17.8%).

Table 2: *Survival Time of the Cervical Restorations According to the Materials*

Variables	Survival Quartiles, y		
	75% ± SE	50% ± SE	25% ± SE
Materials			
Resin composite	15.1 ± 1.0	10.4 ± 0.7	5.1 ± 0.4
Glass ionomers	12.9 ± 0.1	11.5 ± 1.1	3.5 ± 0.4
Total	13.0 ± 0.7	11.0 ± 0.6	4.5 ± 0.4

Among the restoratives used for the cervical restorations, RC (n=377, 79.5%) was the most frequently used for all teeth in the maxillary and mandibular arches, followed by conventional glass ionomer cement (n=74, 15.6%) and resin-modified glass ionomer cement (n=23, 4.9%). Due to insufficient frequency of resin-modified glass ionomer and its similarity with conventional glass ionomer in the properties and the adhesion procedures, both materials were grouped as GIs in order to increase the statistical power (Table 2). RC was used more frequently as the restorative of choice in the anterior region (83.3%) than in the posterior region (premolar, 80.3%; molar, 70.0%). The other restorative materials used were compomer (n=3, 0.5%), amalgam (n=4, 0.7%), and gold inlay (n=1, 0.2%), which were not included in the survival analysis due to lack of cases. As a result, the survival estimates for the restorations were compared between RC and GI using Kaplan-Meier survival analysis.

Comparison of Survival Estimates According to Prognostic Variables

Although GI (63.7 ± 5.2%, cumulative survival rate ± standard error) showed a lower cumulative survival rate after five years than RC (74.7 ± 2.6%), the survival estimates of GI and RC were not significantly different (Breslow test, $p>0.05$; Figure 2a). The median survival times of RC and GI were 10.4 ± 0.7 and 11.5 ± 1.1 years (median ± standard error), respectively (Table 2). Among the

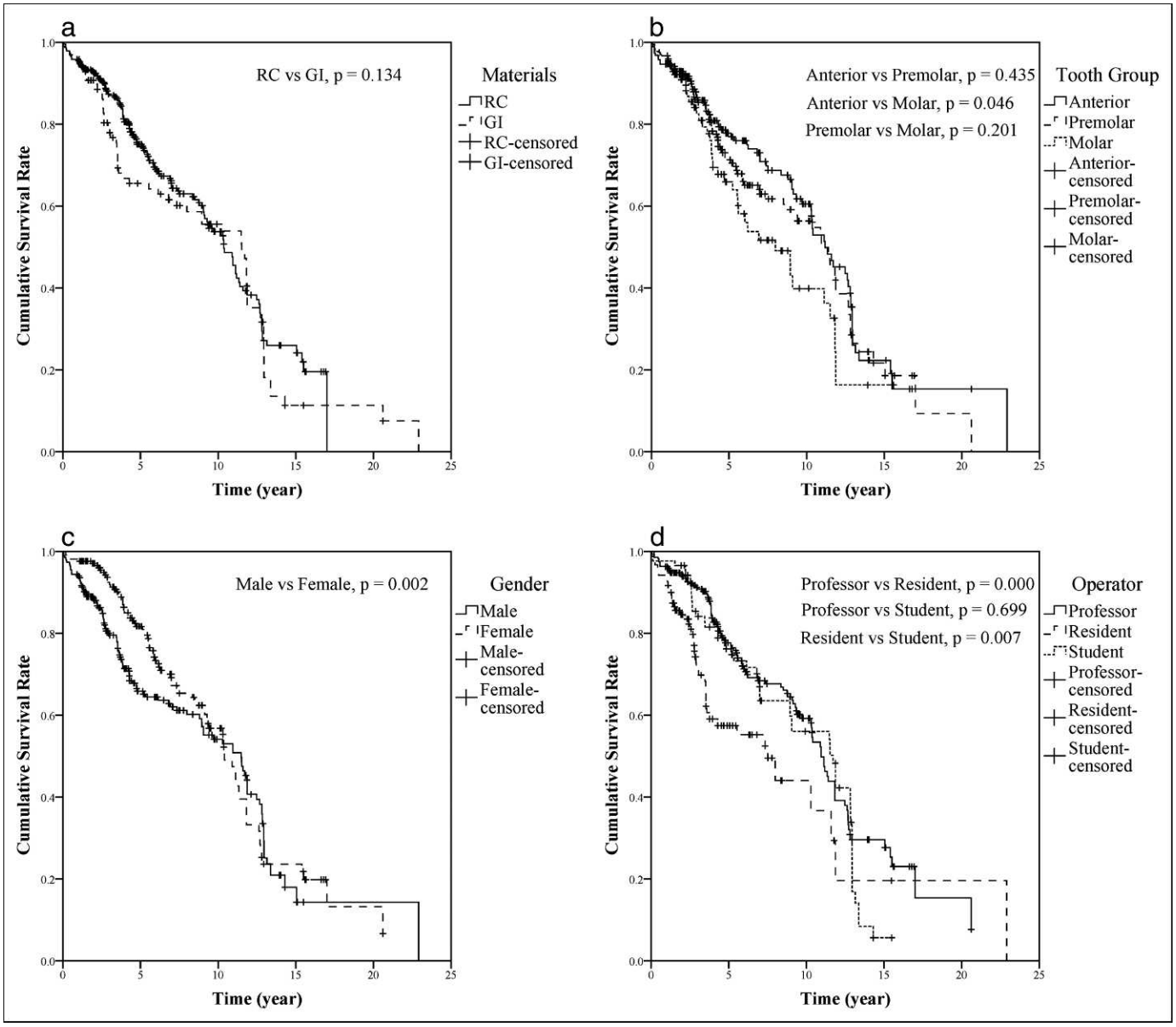

Figure 2. *Comparison of survival estimates according to prognostic variables using Kaplan-Meier survival analysis. (a): Materials. There was no significant difference in the survival estimates between resin composite and glass ionomers. (b): Tooth groups. The survival estimates showed significant differences among anterior teeth, premolars and molars. (c): Gender. The survival estimates showed significant difference between male and female patients. (d) Operators. Among the groups of professors, residents, and students, the survival estimate of the restorations practiced by residents was significantly lower than those performed by professors and students.*

tooth groups, the median survival times of anterior, premolar, and molar teeth were 11.2 ± 0.9 years, 11.0 ± 0.9 years, and 8.0 ± 1.5 years, respectively. The longevity of anterior teeth was significantly different from that of molar teeth (Breslow test, p=0.046; Figure 2b). However, within each tooth group, the longevity of RC and GI was significantly different only in the anterior teeth (Breslow test, p=0.016), in contrast to the premolars and molars (p=0.733 and p=0.532, respectively). Although GI was used relatively more frequently in molars (Table 1), GI did not show any difference in the longevity among tooth groups (Breslow test, p>0.05). RC in the anterior teeth only showed significant difference from those in the molar teeth (Breslow test, p=0.009). The median survival times of the male and female groups were 11.5 ± 1.1 years and 10.4 ± 0.4 years, respectively. The survival estimates of both genders were significantly different (Breslow test, p=0.002; Figure 2c). The difference in the

Table 3: *Contributions and Odds Ratios of Prognostic Variables*

Variables	Groups	Wald[a]	Odds Ratio[b]	95% CI		p Value
Operator group		9.322				0.009
	Professor		0.89	0.61	1.32	0.572
	Resident		1.60	1.04	2.46	0.032
	Student		1.00			
Tooth group		3.742				0.154
	Anterior		0.68	0.47	1.01	0.045
	Premolar		0.79	0.54	1.16	0.234
	Molar		1.00			
Gender		0.510				0.475
	Male		1.13	0.81	1.32	0.475
	Female		1.00			

[a] *Contributions of prognostic variables were estimated by the Wald test of the Cox proportional hazard model.*
[b] *The odds ratio of each group for each prognostic variable was evaluated using Exp(B) of the Cox proportional hazard model.*

survival estimates between the presence and absence of systemic disease was not significant (Breslow test, $p=0.143$). The median survival times of the two groups were 11.2 ± 1.0 years and 11.0 ± 0.5 years, respectively. The longevity of the restorations in the upper and lower arch was statistically not different (Breslow test, $p=0.657$). The median survival times of the restorations in the upper and lower arches were 11.5 ± 0.5 years and 10.9 ± 0.9 years, respectively. The survival estimates of the restorations placed by residents were significantly lower than those performed by professors and students (Breslow test, $p=0.000$ and $p=0.007$, respectively; Figure 2d). There were no significant differences in survival estimates among the three categories for treatment (restoration of carious lesion, restoration of noncarious lesion, and replacement of previous restoration).

Among the variables evaluated with the Kaplan-Meier analysis, those demonstrating statistically significant differences in the survival estimates between groups were selected as covariates. These were tooth group, gender, and operator group. Their contribution and relative risks were compared with the Wald test and the Cox proportional hazard model, respectively (Table 3). The operator group was the most influential prognostic variable, followed by tooth group. Within each variable, the restorations placed by residents and in molar teeth showed significantly higher relative risks than those placed by professors and students and in anterior teeth, respectively ($p<0.05$). However, gender failed to be confirmed as a difference statistically ($p=0.457$; Table 3).

Comparison of Clinical Performance Between RC and GI

The number of RC restorations that were evaluated as clinically acceptable (Alpha or Bravo) according to modified USPHS criteria was significantly higher than the number of clinically acceptable GI restorations, including retention, marginal discoloration, and marginal adaptation (relative risks of GI/RC, 3.255, 7.649, and 6.784, respectively; $p<0.05$; Table 4). Between the two materials, the incidences of secondary caries, wear, and postoperative sensitivity were not significantly different (Fisher exact test, $p=0.512$, $p=1.000$, and $p=0.598$, respectively). In the criteria of retention, marginal discoloration, and marginal adaptation, RC demonstrated superior clinical performance in the oral cavity when compared to GI. With regard to color match, no comparison was available due to a lack of unacceptable cases with either material.

DISCUSSION

In this study, the number of groups in each variable was minimized as much as possible because too many groups would produce higher-order interactions and complicate the interpretation of the results. A small sample size may also increase type II errors and decrease statistical power.[17] In order to reduce the number of groups, resin-modified glass ionomer was included in the GI group, together with conventional glass ionomer cement. A variety of glass ionomer-derived materials use the advantage of fluoride release and of the combined setting reaction of acid-base reaction of the glass ionomer component and the chain-reaction polymerization of the resin component.[7,8,18,19] By the same token, all of the samples were divided into two groups based on the presence or absence of systemic disease because there were too many types of diseases and only small sample numbers for each disease. As in prior studies,

Table 4: *Comparison of the Clinical Performance Between the Restorations Filled With Resin Composite (RC) and Glass Ionomers (GI) Evaluated Based on the Ratings of the Modified USPHS Criteria*

Criteria	Chi-Square Test/ Fisher Exact Test[a]		Odds Ratio	
	χ^2	*p*	GI/RC	95% CI
Retention	19.058	0.000	3.255	1.884-5.625
Color match[b]	NA	NA	NA	
Marginal discoloration	—	0.005[a]	7.649	1.974-29.642
Secondary caries	—	0.512[a]	1.488	0.465-4.756
Wear (anatomic form)	—	1.000[a]	1.113	0.127–9.747
Marginal adaptation	21.558	0.000	6.784	2.747-16.756
Postoperative sensitivity	—	0.598[a]	NA	

[a] *When the expected incidence in more than one cell was less than 5, the result of Fisher exact test was selected.*
[b] *The χ^2 value and odds ratio were not calculated because more than one cell had no incidence in the 2 × 2 tables.*
Abbreviation: NA, not available.

the reasons for treatment were divided into treatments for carious lesions, noncarious lesions including abrasions and erosions, and replacement of old restorations.[3,20]

In total, RC (79.5%) was used approximately four times more frequently than GI. RC was used especially in anterior (83.3%) and premolar teeth (80.3%), but in posterior teeth the relative frequency of GI restorations increased (30.0%) compared to anterior teeth. As this study was confined to cervical restorations and two restorative materials, the proportion of RC (79.5%) was higher than in prior studies (Mjör,[20] 52.7%; Forss,[21] 74.9%), in which metal restorations and posterior occlusal and proximal restorations were included. This means that RC was the most frequently selected material for cervical restorations due to its esthetic excellence and adequate mechanical properties. However, in the posterior teeth, selection of GI was increased due to the characteristic adhesion capability to tooth structure and the relative ease of use.[2,22,23]

According to the Kaplan-Meier survival analysis and multivariate Cox proportional hazard model, there were no significant differences in materials, gender, presence, or absence of systemic disease, arch, and reason for treatment. However, with regard to the tooth group and operator group, there were significant differences in the longevity between groups. We were unable to find any previous reports on the effects of systemic diseases on the survival estimates of dental restorations. Within the limitations of the current study, we did not attempt to associate individual systemic diseases with the survival estimates of restorations due to the small number of samples for each disease. However, the presence or absence of systemic diseases did not affect the survival estimates of cervical restorations. Additional studies with larger sample sizes for specific diseases such as diabetes mellitus, hypertension, heart disease, liver, and renal disease are needed.

There were no significant differences between the upper and lower arches or between genders, but there was between the anterior and molar teeth ($p = 0.045$, Table 3). Generally, abfraction had a similar prevalence in maxillary and mandibular teeth.[24] The occurrence of abfraction from tooth flexure did not differ by gender.[24,25] Although the failure rate of extensive restorations in posterior teeth was reported to be higher in male than in female patients,[26,27] no previous literature that reported significant differences in the longevity of cervical restorations between genders, was found. The relative risk between anterior and molar teeth may be attributed to occlusal forces inducing tooth flexure.

The clinical outcomes of dental restorations are known to be affected by operator technique, even when the same restorative material and protocol are used. The technique sensitivity is especially high in adhesive procedures and with esthetic materials.[28,29] In this study, the relative risk for the restorations performed by residents was significantly higher than for those performed by professors and students. The reason for this observation may be that the students were strictly supervised by instructors, but residents may have practiced relatively freely with a wide range of materials. Although Folwaczny and others[3] and Mjör and others[20] divided the reasons for treatment into carious lesions, noncarious lesions, and replacement of old restorations, they only reported the proportions of each treatment reason out of the total cases. They did not report the

survival estimates according to the treatment reasons. In the current study, there were no significant differences in the longevity among the three treatment reason groups.

Most studies have reported no difference in the retention of cervical restorations among RC and GIs.[3,13,14,30-32] Other studies, with prospective longitudinal designs for relatively short durations, reported that glass ionomer-derived materials, especially resin-modified glass ionomer, had better retention than RC.[3,15,33,34] Reports demonstrating longer retention of RC than GI were not found. In this study, we divided the cervical restorative materials into two groups, RC and GI. The longevity of the two material groups was evaluated in a retrospective cross-sectional design and, as a result, the data included many cases with longer service duration (maximum lifetime, 22.9 years) than those in a prospective design. Although retrospective cross-sectional studies have limitations to differentiate important factors such as individual restorative materials, a large number of restorations with relatively long lifetime can be assessed in a short time.[35] By assessing such long-lasting restorations, the factors affecting late failure of the restorations such as fractures, secondary caries, and wear and deterioration of the materials, and their clinically relevant problems can be suggested.[35] Such practice-based research can be a source for further well-controlled prospective longitudinal study. The survival estimates were not different between RC and GI, similar to the majority of studies. Compared with previous studies, we may expect that the retention of GI is not inferior to that of RC. Further prospective and longitudinal studies are needed on the longevity of both materials in a well-controlled design.

Although there was no significant difference in the longevity between the two restorative materials, significant differences were observed in the ratings of USPHS criteria. These ratings represent the clinical performance of the existing restorations in the oral cavity. When both materials were compared with taking into account the location, the retention was significantly different in anterior teeth (χ^2 test, $p=0.001$, odds ratio=5.420) and in premolar teeth (χ^2 test, $p=0.006$, odds ratio=3.067) and the marginal adaptation was also different in premolar teeth (Fisher exact test, $p=0.04$) and in molar teeth (Fisher exact test, $p=0.03$). In the other criteria, there was no significant difference in the clinical status between both materials at each location. However, when both materials were compared without considering their locations, RC demonstrated superior clinical performance than GI in retention, marginal discoloration, and marginal adaptation among the criteria ($p<0.05$; Table 4), in contrast to the Cox proportional hazard model. These data suggest that although the longevity of both materials was not different, the clinical performance of existing RC restorations is superior to that of existing GI restorations while in function. In many other studies, the superior clinical performance of existing RC restorations has been reported, in addition to the survival analysis.[3,13-15]

Most laboratory studies suggested GI as the restorative material of choice for cervical lesions because of clinically acceptable interfacial gaps, its capacity for absorbing occlusal load, and the low polymerization shrinkage stress of slowly-setting glass ionomers.[2,7,36-38] According to the ratings of the modified USPHS criteria, secondary caries, anatomic form (wear), and hypersensitivity did not differ between the two materials. Contrary to the occlusal wear, the wear of the cervical restorations due to abrasion and erosion, for example, was not different between RC and GI. The results of the current study agree with prior observations.[16,39,40] When the sealing ability of adhesive systems was not enough to prevent postoperative sensitivity, conventional glass ionomer was frequently used to reduce the discomfort. With the advent of the concept of hybrid layer formation using total-etch three-step adhesives, the incidence of postoperative sensitivity decreased greatly, so that there were no differences between direct and indirect restorations, total-etch and self-etch, and GI and RC.[41,42] There was no significant difference between the two materials in regard to secondary caries. Glass ionomer cement was recommended as the material of choice for high caries risk patients due to its *in vitro* fluoride release.[18,43] However, under anticariogenic and fluoride dentifrice exposure conditions, the GI restorations were reported not to provide additional protection against secondary caries.[10,44,45] The clinical effectiveness of fluoride release from these materials and the relevance of the *in vitro* data in the context of caries prevention should be evaluated in further studies.

CONCLUSIONS

The survival estimates of resin composite and glass ionomers as cervical restorative materials were not statistically different. However, the longevity of cervical restorations was significantly influenced by the tooth group and operator group. During function

in the mouth, RC demonstrated superior clinical performance to GIs in the criteria of retention, marginal adaptation, and marginal discoloration.

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Conflict of Interest

The authors of this article 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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