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Longevity of Crown Margin Repairs Using Glass Ionomer Cement: A Retrospective Study

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Clinical Relevance

Repairing defective crown margins can extend the functional life of existing crowns.

SUMMARY

Objective: The objective of this study was to determine the survival time of crown margin repairs (CMRs) with glass ionomer and resin-modified glass ionomer cements on permanent teeth using electronic dental record (EDR) data.

Methods: We queried a database of EDR (axiUm; Exan Group, Coquitlam, BC, Canada) in the Indiana University School of Dentistry (IUSD), Indianapolis, IN, USA, for records of patients who underwent CMRs of permanent teeth at the Graduate Operative Dentistry Clinic. Two examiners developed guidelines for reviewing the records and manually reviewed the clinical notes of patient records to confirm for CMRs. Only records that were confirmed with the presence of CMRs were retained in the final dataset for survival

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analysis. Survival time was calculated by Kaplan-Meier statistics, and a Cox proportional hazards model was performed to assess the influence of age, gender, and tooth type on survival time (a<0.05).

Results: A total of 214 teeth (115 patients) with CMR were evaluated. Patient average age was 69.4 ± 11.7 years old. Posterior teeth accounted for 78.5% (n=168) of teeth treated. CMRs using glass ionomer cements had a 5-year survival rate of 62.9% and an annual failure rate (AFR) of 8.9%. Cox proportional-hazards model revealed that none of the factors examined (age, gender, tooth type) affected time to failure.

Conclusion: The results indicate the potential of CMRs for extending the functional life of crowns with defective margins, thus reducing provider and patient burden of replacing an indirect restoration. We recommend future studies with a larger population who received CMR to extend the generalizability of our findings and to determine the influence of factors such as caries risk and severity of defects on survival time.

INTRODUCTION

Numerous studies have investigated the efficacy of repairing direct restorations.[1-6] These studies reported that repairing restorations increased the longevity of the defective direct restorations. However, no studies investigating survival rates of indirect restoration margin repairs due to caries are found in the dental literature.

A crown margin repair (CMR) can be described as a procedure that is performed to remove caries or other defects at the margin of an indirect restoration where the lesion or defect is accessible. Ideally, removal of the caries lesion is performed at the expense of the crown rather than removing excessive sound tooth structure to access the lesion. In vitro studies have investigated margin adaptation and microleakage of margin repairs of indirect restorations (Figures 1-4). These studies showed that glass ionomer cements, direct gold and amalgam may be suitable materials to restore these defective margins.[7,8]

Restoration replacement is more time consuming and expensive, and potentially more traumatic to the tooth, than repair. Therefore, extending the longevity of a restoration seems to be the most reasonable plan to preserve tooth health, if it can be done efficiently and reliably.[9] Major U.S. insurance companies will reimburse replacing a crown between 5 and 10 years, depending on the specific plan.[10,11] Moreover, recent studies indicate a rising population of adults ages 65 years and older who have natural teeth and less tooth loss.[12,13] However, this population may have limited dental insurance coverage since Medicare does not offer coverage for dental expenses and obtaining additional dental insurance could be expensive, especially for people who are retired.[14] The crown margin repair (CMR) concept makes logical sense but lacks supporting data to consider it evidenced-based dentistry.

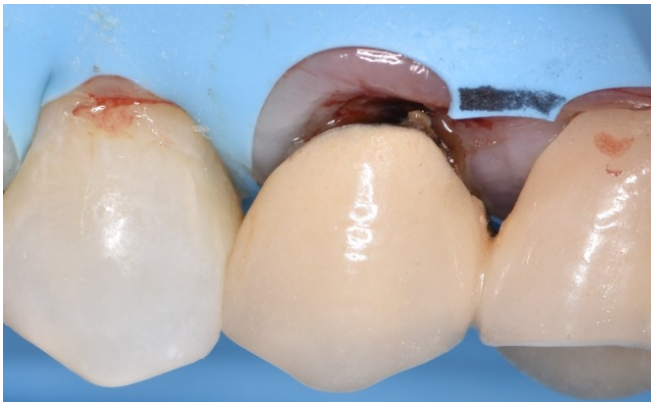

Figure 1. *Tooth 13: Preoperative defective carious PFM margin. Abbreviation: PFM, porcelain fused to metal.*

Figure 2. *Isolated defective carious PFM margin. PFM, porcelain fused to metal.*

Glass ionomer CMRs have been performed in the Indiana University School of Dentistry (IUSD) Graduate Operative Dentistry Clinic for many years. Glass ionomer cements are contraindicated in restorations that are subject to occlusal loading; however, this is not a concern when repairing crown margins. A 5-year survival rate of up to 80% was demonstrated when using glass ionomer cements to restore cervical lesions at a dental hospital in the United Kingdom.[15] There are no studies found in the dental literature in which the longevity of glass ionomer CMRs has been investigated.

Figure 3. *Carious lesion removed at expense of crown to ensure complete excavation of lesion and minimize excess loss of sound tooth structure.*

Figure 4. *Completed crown margin repair with resin-modified glass ionomer.*

Therefore, the objective of this study was to determine the longevity of glass ionomer CMRs completed in the Graduate Operative Dentistry Clinic between 2006 and 2018. The results of this study will inform the viability of CMRs as a cost-effective treatment for defective crown margins, especially among adults ages 65 years and older and patients whose crown replacement may not be eligible for insurance coverage.

METHODS AND MATERIALS

This was a retrospective study of CMRs completed on patients seen in the Graduate Operative Dentistry Clinic, IUSD, Indianapolis, IN, USA, between January 1, 2006, and January 1, 2018. One cannot do a simple query in axiUm (Exan Group, Coquitlam, BC, Canada) for CMRs using glass ionomer cements, as both resin composite and glass ionomer cement share the same Code on Dental Procedures and Nomenclature (CDT codes).[16] Also, there is no code for a CMR procedure.

In this study, the inclusion criteria included patients 18 years and older who underwent CMR on permanent teeth in the IUSD Graduate Operative Dentistry Clinic, Queried CDT codes for anterior and posterior resin/GI restorations (Table 1). A list of keywords and phrases was developed after a review of 100 randomly selected records (Table 2). Any restoration that included an occlusal surface was excluded. Failure variables included extraction, new crown and re-repair. Failure variables were identified by reviewing treatment notes after a failure variable was identified.

The data set included patient demographics such as patient ID, age, gender, dates of treatments, procedure codes in the form of CDT codes, tooth type, tooth surface, existing findings such as conditions and treatment received elsewhere, and treatment notes. This data set was placed in an Indiana University-approved secure folder, and server that complies with the federal regulations for privacy and security (https://www.hhs.gov/hipaa/for-professionals/privacy/index.html), and with the Indiana University Office of Information Security policies.

Two reviewers who are dentists manually reviewed all patient records to confirm that the clinical treatment notes contained a treatment history for CMR. The reviewers developed a guideline to determine the words

Table 1: *Inclusion and Exclusion Criteria*

Inclusion Criteria	**Exclusion Criteria**
• At least 18 years old • Anterior resin composite (02330, 02331, 02332, 02335) • Posterior resin composite (02391, 02393, 02393, 02394) • Manual review confirmed GI or RMGI use • Manual review confirmed existing crown	• Manual review did not confirm GI or RMGI use • Manual review did not confirm existing crown

Abbreviations: GI, glass ionomer; RMGI, resin modified glass ionomer.

Table 2: *Initial Search Words and Span of Text*	
Initial Search Words, Phrases, or Span of Text	
• Glass ionomer • GI • Resin modified glass ionomer • RMGI • Crown • Repair	• Crown margin • Margin • Defective margin • Recurrent caries • Recurrent decay • Secondary caries
Abbreviations: GI, glass ionomer; RMGI, resin modified glass ionomer.	

and span of text that indicate the presence of CMRs in the clinical notes (see Supplementary Table 1). They reviewed a random set of 100 patient records and calculated an inter-rater reliability score of 82.3% using Cohen's kappa statistic for agreement. The reviewers then individually reviewed the remaining records. Consensus was reached on any disagreements through discussion. Only records confirmed with the presence of CMR by the two reviewers were retained in the final dataset for survival analysis.

Data Analysis

Kaplan-Meier survival curves, including 95% confidence intervals, were used to estimate the survival time for CMRs. The mean annual failure rate (AFR) of the investigated CMRs was calculated according to the formula: $(1-y)z = (1-x)$.[17] Factors that may affect crown margin repair survival were evaluated using Cox proportional hazards models. Factors examined included age, gender, and type of tooth treated. The Cox model also included a frailty term to account for correlation among multiple teeth within a patient. A 5% significance level was used for all tests.

RESULTS

Our query of IUSD electronic dental record (EDR) database (axiUm for CDT codes) indicating resin restorations initially identified 2324 restorations. Words, phrases, and span of texts that indicated CMRs were recorded from the manual review of treatment notes (Figure 5). The manual review of treatment notes eliminated 2110 restorations. After a final review, 214 teeth in 115 patients were included in the analysis. The mean age of the patients was 69.4 years with a standard deviation of 11.7 and a range from 32.3-98.9 years. The sample consisted of 48.7% males (n=56) and 51.3% females (n=59).

Of the 214 CMRs, anterior teeth accounted for 21% (n=46) (upper and lower anterior teeth were combined due to the small number of lower anterior teeth; Table 3). Lower posterior teeth accounted for 38% (n=81), while upper posterior teeth accounted for 41% (n=87) (Table 3).

The results revealed 62.9% 5-year survival, with a 95% confidence interval, using the Kaplan-Meier survival curve (Figure 6). This can be restated as an 8.9% AFR. Only 29.4% (n=63) were observed with a failure (Table 4). The average time to an observed failure was 2.7 years (Table 4). The remaining CMRs were censored at the last follow-up visit. The average follow-up time before censoring was 3.1 years (Table 4). Lower posterior teeth had the longest time to failure or follow-up time (3.4 years) and also the longest censoring time (3.3 years) (Table 3). For anterior teeth that were treated as censored, the average follow-up time was 3 years (Table 3), and for anterior teeth that were treated as failures, the average time was 2.5 years (Table 3).

Cox proportional-hazards model was performed to examine if age, gender, or tooth type affected time to failure; in addition, a frailty term was included in the model to account for correlation among multiple teeth within a patient in the study. The results showed none of the factors affected time to failure ($p>0.05$ for all).

Table 3: *Average Time (Years) to Failure or Follow-up Time (Years) by Teeth Type*[a]

Failure	Tooth Type	N	Mean	Standard Deviation	Minimum	Q1	Median	Q3	Maximum
No	Anterior	30	3.01	3.94	0.00	0.40	0.72	5.85	13.07
No	Lower posterior	60	3.44	3.50	0.00	0.54	2.25	5.23	12.55
No	Upper posterior	61	2.70	2.74	0.00	0.60	1.61	3.80	9.18
Yes	Anterior	16	2.48	2.07	0.00	1.02	1.14	5.07	5.73
Yes	Lower posterior	21	3.34	2.31	0.44	1.69	3.18	3.96	9.42
Yes	Upper posterior	26	2.31	1.90	0.02	0.96	1.62	3.55	6.45

[a]*For anterior teeth that were treated as censoring, the average follow-up time was 3.01 years; for anterior teeth that were treated as failure, the average time to failure was 2.48 years. Abbreviations: Q1, quartile 1; Q3, quartile 3.*

Table 4: Average Time (Years) to Failure or Follow-up Time (Years) by Teeth Type[a]

Failure	N	Mean	Standard Deviation	Minimum	Q1	Median	Q3	Maximum
No	151	3.06	3.31	0.00	0.52	1.61	4.52	13.07
Yes	63	2.70	2.11	0.00	1.02	2.10	3.91	9.42

[a]*For teeth that were treated as censored, the average follow-up time was 3.06 years; for teeth that were treated as failure, the average time to failure was 2.70 years. Failure included extracted, new crown, and re-repair. Abbreviations: Q1, quartile 1; Q3, quartile 3.*

DISCUSSION

To the authors' knowledge, this study is the first to investigate the longevity of indirect restoration margin repairs. Major findings of this study demonstrated that CMRs had a 62.9% 5-year survival rate, with no significant differences on which tooth the repair occurred. Due to these findings, treating defective crown margins by repairing with glass ionomer cement should be considered as a potential treatment option. CMRs may extend the survival of the crown and ultimately the tooth. Another significant outcome of this study was the manual review of the records identified words, phrases, and group of words that confirmed the existence of CMRs. This manual review of 2324 possible CMR restorations revealed important keywords such as "margin repair," "repair margin," and "crown margin" that indicated a CMR (Table 4). Numerous combinations and variations of crown, margin, and/or repair were used in conjunction with CDT codes and previous treatment notes to confirm that a CMR was completed. This list of keywords and phrases is a rich resource to identify CMRs using EDR data.

Of the 2324 restorations that were identified in the initial data query, only 214 CMRs were confirmed. There are several reasons that may explain the low number. First, accurate or standardized dictation of treatment notes varied in describing CMR procedures.

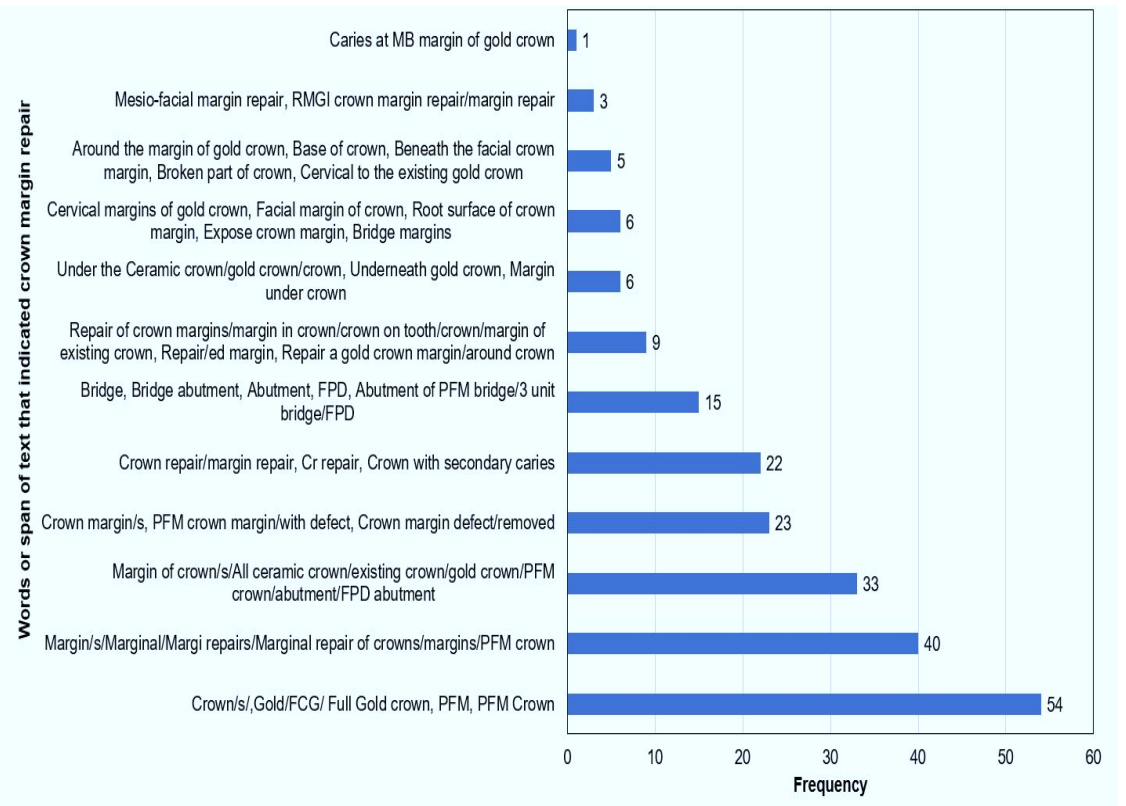

Figure 5. *Crown margin repair keywords from manual note review. Abbreviations: Cr, crown; FCG, full gold crown; FPD, fixed partial denture; MB, mesial buccal; PFM, porcelain fused to metal; RMGI, resin modified glass ionomer.*

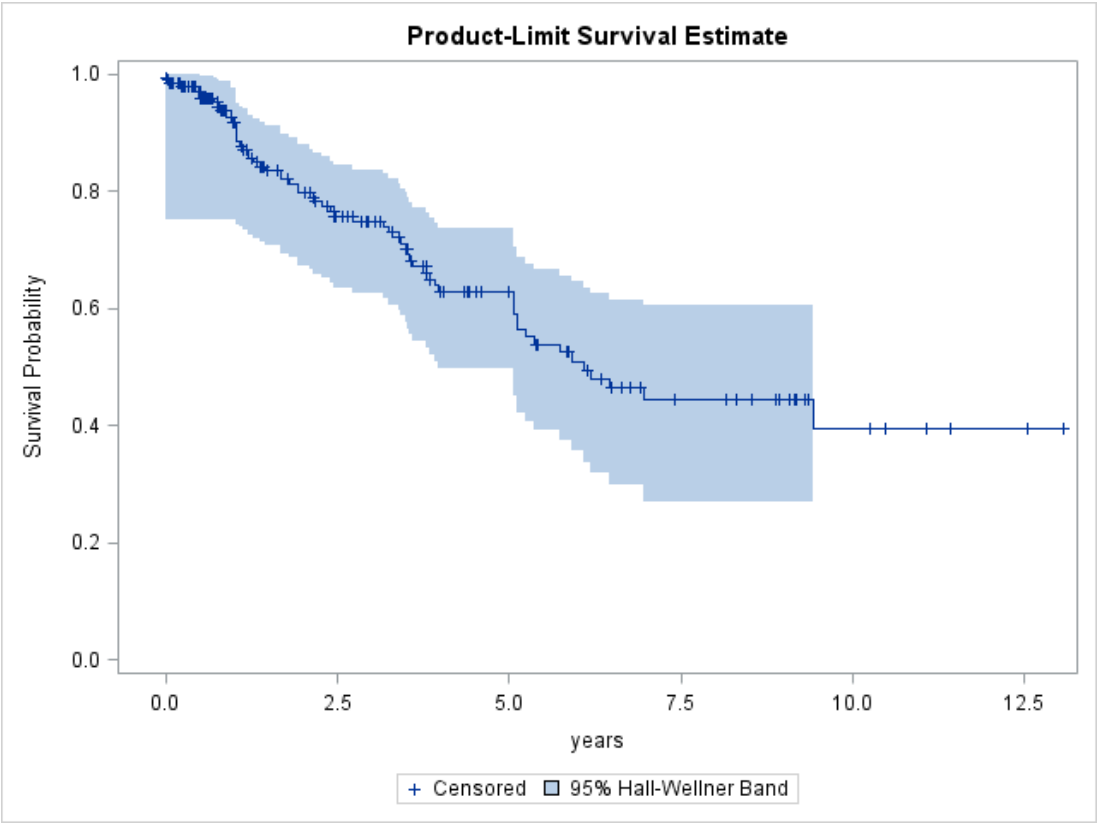

FIGURE 6. *Kaplan Meier survival curve with confidence intervals The survival rate with crown margin repairs using glass ionomer at 5 years was 62.9% with 95% confidence interval (54.2%, 71.6%).*

As CDT codes evolve, it may be beneficial to have codes that identify the repair of restorations versus initial placement or replacement of restored surfaces. In addition, glass ionomer cements should not be considered resin-based restorations, but should have their own coding index as amalgam, gold, resin composite, and ceramic do. More CMR repairs may have also been identified if patients' radiographs were used adjunctively with the treatment notes to confirm the presence of an existing crown for the of lack of detail in describing the clinical procedure in the treatment note.

The reported survival rate could have been affected by factors not investigated in this study. First, failure and success were not assessed by an actual clinical examination associated with the study. Failures were described in this study as any intervention to the restored tooth, ie, extraction, re-repair, or new crown. It is possible that CMR restorations were still intact with sound restorative margins and that the tooth failed due to another reason. Only 29.4% of CMR restorations were associated with a failure (Table 5). The average time of the observed failures were 2.7 years, with only 3.1 years when a CMR was censored (Table 5). A longer observation period or formal patient recalls verifying the survival of the CMR could lead to a potentially higher survival rate. Second, the severity and extent of the defective crown margins were not observed. The severity of the defective margin would likely be a contributing variable in the longevity of a CMR. This would be useful in making clinical decisions as whether to repair or replace. Identifying CDT-coded surfaces would give some insight to this question; however, the number of recorded surfaces does not indicate the axial depth of the caries defect. Recording this measurement would be done most accurately by using a prospective study design.

Establishing a larger data set would strengthen the data on CMR longevity. This can be done by broadening search criteria to include more departments within the school or utilizing other electronic health record databases. Keywords that were identified in the manual review of treatment notes could expedite larger studies to more easily identify true-positives in future queries.

For this study, only CMRs completed with glass ionomer cements or resin-modified glass ionomer cement material were included. This was done because the general philosophy in the Graduate Operative Dentistry Clinic is to use glass ionomer materials for

CMRs, and this aided in identifying CMRs through axiUm queries and the manual review. There may also be a need to investigate CMRs with resin composite, amalgam, and gold.

A common philosophy of CMR technique was observed, where the caries lesion is removed at the expense of the crown rather than removing excessive sound tooth structure to access the lesion. It cannot be confirmed that all included CMRs were done with this technique, but rather that this is the common CMR philosophy taught in the IUSD Graduate Operative program. CMR technique, as described in the introduction, can be a stepwise assessment to determine whether a defective or carious crown margin should be repaired, or if the crown should be replaced. After initiating a CMR procedure, it may be determined that repairing will be impossible. This may be because complete caries removal cannot be confirmed or that the remaining supporting tooth structure is highly compromised. At that point, the CMR procedure should be terminated and crown removal with complete caries excavation should be done to assess restorability of the tooth.

If patients have active caries lesions, they should be considered at moderate or high risk for caries.[18] Ideally, when creating a comprehensive treatment plan for a patient, the first step is disease control.[19] For many patients, it may be prudent to repair defective margins and attempt to stabilize caries activity before completing the definitive care phase of a treatment planning sequence.

In a recent practice-based study, a 1.2%-3.5% AFR of single unit crowns was reported.[20] It may not be accurate to compare the two different treatment options—crown repair of on existing restoration versus a replacement crown—directly. Rather, risk factors and benefits of each option should be considered. A CMR defers more extensive treatment until later, which pushes subsequent treatment further out. This idea is supported by literature published by Benn and Meltzer.[21] The study showed a significant decrease in the operative workload by applying a mathematical model that investigated deferring initial treatment and projecting operative interventions on a tooth's life cycle.

CONCLUSION

In this retrospective study of EDR data, CMRs demonstrated a 5-year survival of 62.9% and an AFR of 8.9%. There were no differences in CMR survival based on tooth type, location (anterior/posterior; maxillary/mandibular), or patient age or gender. It is reasonable to assume that CMRs extend the functional life of crowns and should be considered as a valid treatment option to restore defective crown margins. Information gained in this study should be considered by dentists and patients when treatment planning crowns with defective margins, as well as be considered by others such as insurers, government officials, legislators, and administrators of community clinics to facilitate discussions of cost effectiveness and clinical outcomes.[22]

Regulatory Statement

This study was conducted in accordance with all the provisions of the human subjects oversight committee guidelines and policies of Institutional Review Board of the Indiana University School of Dentistry, Indianapolis, IN. The approval code issued for the study is 18008963625 .

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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