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Restoration longevity among geriatric and adult special needs patients

Short title: ***Restoration longevity***

Authors:
Daniel J Caplan, DDS, PhD; Professor and Head, Department of Preventive and Community Dentistry, University of Iowa College of Dentistry, Iowa City, IA

Yan Li; University of Connecticut

Wenjie Wang; University of Connecticut

Sangwook Kang; Yonsei University

Leonardo Marchini, DDS, MSD, PhD; Assistant Professor, Department of Preventive and Community Dentistry, University of Iowa College of Dentistry, Iowa City, IA

Howard Cowen, DDS, DABSCD; Clinical Professor; Department of Preventive and Community Dentistry; University of Iowa College of Dentistry, Iowa City, IA

Jun Yan; University of Connecticut

Corresponding author:
Daniel J. Caplan, DDS, PhD; N339 DSB; University of Iowa College of Dentistry; Iowa City, IA 52242; Phone 319-335-7206; Fax 319-335-7187; Email dan-caplan@uiowa.edu

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Abstract

Purpose/aim: This study aimed to describe the survival trajectory of dental restorations placed among a population of geriatric and adult special needs patients over a 15-year span, with particular interest paid to longevity of subsequent restorations in teeth that received multiple restorations over time.

Methods and materials: Dental restorations of different types and sizes in patients age ≥65 years treated between 2000-14 at the University of Iowa College of Dentistry were followed until they were either replaced or the teeth were extracted or endodontically treated. Survival analysis and extended Cox regression models were used to generate hazards ratios for selected predictor variables.

Results: A total of 9184 restorations were followed in 1551 unique patients. 28.7 percent of the restorations failed during the follow-up period, and overall the restorations had an average lifespan of 2.48 years. Restoration size and restorative material were associated with restoration longevity. Restorations that were not the first eligible restoration for that tooth in the database also had poorer survival than the first restoration for that tooth.

Conclusions: In this sample of elderly outpatients attending an academic dental clinic, restoration size, material, and sequence were related to restoration longevity over a 15-year period. This information could be helpful to elderly patients who are considering various restorative treatment options as they participate in dental treatment planning and informed consent.

Key-words: Longevity, Survival, Failure, Dental restoration, Older adults

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Introduction

The American elderly population is expected to grow (by 94.2%), from 43.1 million people in 2012 to 83.7 million by the year 2050.[1] The growing population of elderly is having a pronounced impact on society, and an even more dramatic impact on the U.S. health care system.[2] Elderly people present with more chronic diseases, and consequently bear a disproportional share of the global burden of disease.[3]

Disease and disabilities that may come with age have been linked to poor oral health,[4] which in turn has been linked to life-threatening systemic health complications. [5,6] Caries in permanent teeth was the most prevalent health condition worldwide in 2010,[7] and is one of the most prevalent conditions among the elderly population as well, mainly among those who are frail. [8]

Cavitated dental lesions are commonly treated with different materials and direct restorations, and the longevity of these restorations has been the focus of much research and debate.[9-19] However, the vast majority of these studies[9-19] evaluated restorations placed for the general population, so most published studies do not account for the challenges faced by the frail elderly population. These challenges are numerous, and may be grouped as systemic health-related factors, oral health-related factors and social-related factors. Systemic health-related factors commonly include dementia,[20] depression,[21] diabetes,[22] stroke, [23] arthritis,[24] and polypharmacy,[25] among others. Oral-health related factors include wearing removable dentures, presenting with a heavily restored dentition, or having poor oral hygiene, gingival recession (with consequent root exposure) and xerostomia.[25, 26] Social-related factors include financial limitation, dependence on caregivers, institutionalization, ageism, and access to appropriate care, among others.[27]

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Considering the lack of studies addressing the longevity of restorations placed among the geriatric and adult special needs population, the aim of this paper is to describe the trajectory of restorations placed in a geriatric and special needs clinic over a period of 15 years, and evaluate possible factors that influence restoration longevity in this traditionally underserved population. Of particular interest was to quantify the degree to which subsequent restorative therapy on a given tooth was related to restoration longevity. Our hypothesis was that controlling for all available patient- and restoration-level variables, the initial restoration recorded in the database would experience greater longevity than would subsequent restorations (in teeth that received multiple restorations over time).

Material and Methods

Since the mid-1980's, the University of Iowa College of Dentistry's Geriatric and Special Needs (SPEC) Clinic has offered comprehensive dental care to geriatric patients, patients on numerous medications, and adults with behavioral, psychological, or other health conditions that make it difficult for them to be treated elsewhere. In the SPEC clinic, care is provided to patients by senior dental students and graduate students under faculty supervision. Consent for dental treatment is obtained from the patients or their health care powers-of-attorney.

For this analysis, electronic data were obtained for all dental procedures delivered during the 15-year period from 1/1/00 - 12/31/14. Electronic health record numbers were scrambled by IT personnel and no Personal Health Information was included in the working dataset, and

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subsequently the Institutional Review Board at the University of Iowa declared this project exempt from Human Subjects Review due to the anonymous nature of the data.

Initially we identified all patients of at least 65 years of age who had at least one ADA procedure code representing an intracoronal or extracoronal restoration placed in the SPEC clinic during the 15-year period. The specific ADA restorative codes were 1) D2140-D2161 for amalgam restorations; 2) D2330-D2335 for anterior composite restorations; and 3) D2330.1-D2335.1 anterior glass ionomer cement (GIC) restorations. Associated with each restorative procedure was the following information: Tooth number, surfaces (mesial, occlusal / incisal, distal, facial / buccal, lingual); number of surfaces restored (1,2,3+); restoration type (amalgam, composite, glass ionomer, crown, bridge retainer); year of the procedure (2000-04, 2005-09, 2010-14); payment method (Medicaid, self-pay, private insurance); and restoration sequence (first restoration captured in the database versus subsequent restoration). The patient's age at the time of each procedure, and sex were also available from the records.

We then identified all procedures of any type received by these patients at any COD clinic after the date of the index restoration placement. For all restorations, follow-up began on the date of restoration placement. We excluded all restorations that were placed on the patient's last visit to the COD because no follow-up would have been recorded. A restoration was deemed to have undergone an event (i.e., failure) if after placement it was replaced with another intracoronal or extracoronal restoration (i.e., if the new restoration had any of the same surfaces coded in the index restoration); if the tooth was accessed for endodontic therapy; or if the tooth was extracted. For restorations that incurred an event, the end of follow-up for that restoration was the event

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date, while restorations that did not incur an event were censored as of the date of the patient's second last visit to any COD clinic for any reason.

Restorations that were followed included "intracoronal" amalgam, composite, and GIC restorations (placed in specific surfaces within teeth), plus "extracoronal" crowns and bridges (placed over all coronal surfaces of a tooth). For the intracoronal restorations, replacement by a subsequent restoration of any of these types on the same tooth and any of the same surfaces indicated a failure, as did subsequent placement of a crown or bridge on that tooth. For extracoronal restorations, failure was considered to have occurred when a later restoration was placed in any surface on that tooth. For both intracoronal and extracoronal restorations, extraction or endodontic therapy on the tooth also indicated a failure. Thus each restoration would incur one of two eventual outcomes: censoring or event (failure). For restorations that incurred an event, there were seven mutually exclusive types of failure (subsequent amalgam, composite, GIC, crown, bridge, extraction, or endodontic therapy).

Because each tooth could have had multiple restorations, and because each subsequent restoration could be considered as both an "event" for the preceding restoration and as a new restoration that could be followed in its own right, statistical analyses were conducted that reflected the correlated nature of the observations. All data analyses were conducted using R[33]. Univariate analyses were conducted to assess distributions of each patient- and restoration-level variables. First we evaluated histograms to assess the distribution of continuous variables and to perform range checks. Frequency tables of single variables and contingency tables of different combinations of variables also were generated to assess patterns and dependence structures

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among variables. Based on those procedures, we defined and selected the subset of variables to be employed in subsequent statistical models.

We considered the following predictor variables: sex, age, payment mechanism (insurance), restorative material (amalgam, composite, GIC), tooth type (molar, premolar, anterior), provider type (pre-doctoral student, graduate student / faculty), restoration size (number of surfaces included), and whether that restoration was the first restoration in the database for that tooth that was eligible for the analysis. To account for the within-patient dependence, a Cox proportional hazards model with a patient level random effect[31, 32, 35] was fitted. This model is an extended Cox model, where the hazard of an individual restoration depends not only on the predictor variables and baseline hazard but also on an unobserved patient level random effect (also known as frailty). In other words, there will be a random effect for each subject (patients identified by "scrambled ID") in this paper. It has been routinely used in modeling clustered event times in dental research[28, 29]. In particular, the model is specified by

$$h(t|X,Z) = h_0(t)\ exp(X^T\beta + Z),$$

where $h(t|X,Z)$ is the hazard function of a restoration on a patient with predictor vector X and unobserved frailty Z, and h_0 is an unspecified baseline hazard function. The baseline hazard could be different for each combination of the values of stratified variables.

We used the R package "survival" [30] to fit the frailty Cox model and check the Proportional Hazards assumption[36]. If the effect of a predictor did not pass the proportional hazards assumption check, we used two remedies. The first was to use this variable, if it was categorical, to stratify so that each strata has its own baseline hazard function. The second was to allow the

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effect of this predictor to change over time in a piecewise constant fashion. The reported models have all satisfied the proportional hazards assumption.

Results:

A total of 9184 restorations were followed, 4670 in female patients and 4514 in males (Table 1). Of these restorations, 3011 (32.8%) were amalgam restorations, 2565 (29.2%) were composite restorations, and 3295 (35.9%) were glass ionomer cement restorations, with crowns and bridge retainers accounting for only 2.6 and 0.8% of the restorations, respectively. There were 1551 unique subjects, 835 (53.8%) of whom were female, and the mean (SD) number of followed restorations per subject was 5.92 (6.32).

Figures 1A, 1B, and 1C show Kaplan-Meier survival curves[37] for amalgam, composite, and glass ionomer restorations in anterior teeth, premolars, and molars, respectively. These curves illustrate the relative survival time of different combinations of tooth type and restorative material, not taking into account the effect of potential confounding variables.

Table 2 shows the type of events that constituted failures. Most restorations did not incur an event, implying that they did not fail during the follow-up period, so in our statistical models we focused only on failures occurring due to placement of a subsequent amalgam, composite, or GIC restoration.

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Table 3 presents hazard ratios for various combinations of tooth type, restorative material, size, and sequence. Patterns that were repeated consistently across regression models were that a) restorations tended to fail sooner if a) restorations contained more surfaces; or b) restorations were not the first eligible restoration in that tooth in the database (statistically significant HRs ranging from 1.20 – 1.89, depending on tooth type and restorative material).

Discussion

In the present sample of restorations placed in an outpatient, geriatric and adult special needs population, three factors were consistently associated with shorter restoration longevity, controlling for all available variables: older patients, larger restorations, and restorations placed earlier chronologically.

- Restorations failing sooner in older patients is consistent with other published literature.[11, 13, 18] As patients get older, systemic health tends to deteriorate[3, 22], reducing their ability to practice effective oral hygiene and visit the dentist regularly.[4, 24] In addition, patients with deteriorating systemic health often take more medications, worsening the undesirable side effects of polypharmacy, including xerostomia. Xerostomia can lead to rapid progression of caries,[25] and secondary caries has been reported as a primary reason for restoration failure.[9, 13-15, 17]
- Larger restorations were also associated with shorter lifespan in previously published studies.[13, 18] It has been reported that multi-surface restorations fail more readily than single surface restorations, and every surface added to a restoration increases the risk of

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failure by 40%.[13] Among a geriatric and adult special needs population, this finding is particularly important, as there is a tendency for these patients to present with a more heavily restored dentition and generally larger restorations[26].

- Our finding that earlier restorations on a tooth had longer survival than subsequent ones is a novel finding, but is intuitive in some regards. All other things being equal, subsequent restorations (even if restoring the identical surfaces) likely remove more tooth structure, which likely is related to increased likelihood of failure. [11, 13, 18] As reported previously, restorations with 3 or more surfaces present with a higher relative risk of failure of 3.3 when compared to single-surface restorations.[13]

Some factors previously reported as associated with restoration longevity in previous studies, such as restorative material[11, 14, 19] and tooth type[13, 18], were not consistently associated with that outcome in the present study. In a general population, restorations placed in molars are subjected to higher masticatory forces, and thus more susceptible to failure. However, in a geriatric and special needs population, impaired masticatory forces associated with systemic[24] and oral health[8] factors may reduce the differences among tooth types.

Like other retrospective analyses using existing electronic databases, this study was limited to available, consistently-recorded variables, any of which could contain routine typographical errors. Nevertheless, to our knowledge this study is the first to assess restoration longevity in a geriatric and adult special needs population for as long as 15 years, allowing multiple restorations within teeth and multiple events over time. Future prospective studies among this

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population are warranted so that elderly patients can be more informed about their restorative treatment options

Conclusion

Restorations placed in a geriatric and special needs clinic presented an average lifespan of 2.48 years. For this patient pool, the larger the restorations (the more surfaces involved), the shorter was restoration longevity; and restorations that were the first eligible restoration on a given tooth in the database lasted longer when compared to restorations that were not the first intervention on a given tooth. To our knowledge, this information is the first of its kind to be published about restoration longevity in elderly adult populations, and should be useful to both patients and restorative dentists as they participate in dental treatment planning and informed consent processes.

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Figure 1 Kaplan-Meier survival curves for amalgam, composite, and glass ionomer restorations

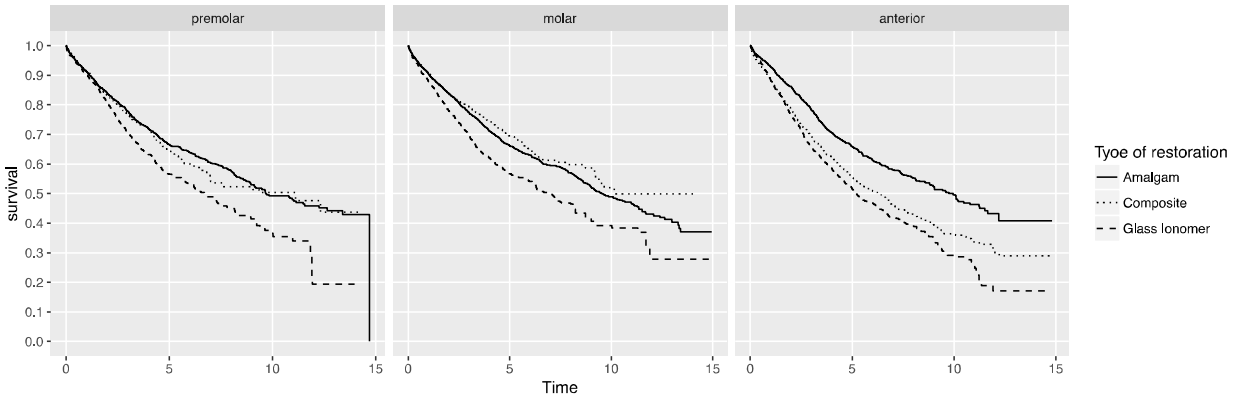

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Table 1: Univariate Frequency Distributions for Restorations Followed in this Analysis

Type of restoration	Total	Female	Male
Amalgam	3011	49.4%	50.6%
Composite	2565	53.4%	46.6%
Glass ionomer	3295	49.8%	50.2%
Crown	236	54.7%	45.3%
Bridge	77	55.8%	44.2%
Total	9184	4670	4514

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Table 2: Restoration Types and Reasons for Failure (≥age 65, Cohorts 4-6)

	Type of Restoration (originally placed)					
Type of Failure	**Amalgam**	**Composite**	**Glass Ionomer**	**Crown**	**Bridge**	**Total**
Censored (no failure)	71.2%	71.3%	70.2%	84.7%	84.4%	71.30%
Amalgam	6.9%	3.0%	2.6%	2.1%	3.9%	4.10%
Composite	3.8%	11.4%	3.6%	0.4%	0.0%	5.70%
Glass Ionomer	3.9%	5.2%	10.1%	2.5%	1.3%	6.40%
Crown	1.6%	0.8%	0.3%	1.7%	0.0%	0.90%
Bridge	0.3%	0.2%	0.1%	0.4%	0.0%	0.20%
Extraction	0.7%	0.9%	0.6%	0.4%	5.2%	0.70%
Endodontic Therapy	11.6%	7.2%	12.6%	7.6%	5.2%	10.60%
Total	3011	2565	3295	236	77	9184

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Table 3. Hazard Ratios and 95% Confidence Intervals for Multivariable Regression Models (age ≥65 years old, Cohorts 4-6 only)

Among	Restorative Material	Larger Restoration	Second or Later Restoration
Molars	**All**	M = 1.42 (1.14 - 1.76) L = 1.69 (1.32 - 2.17)	1.33 (1.10 - 1.62)
	Amalgam	M not significant L = 1.55 (1.15 - 2.08)	1.30 (1.01 - 1.69)
	Composite	Not significant	1.89 (1.11 - 3.22)
	Glass Ionomer	M = 2.14 (1.46 - 3.13) L = 2.89 (1.57 - 5.34)	1.51 (1.05 - 2.16)
Premolars	**All**	M = 1.58 (1.26 - 1.97) L = 1.53 (1.19 - 1.97)	1.35 (1.11 - 1.64)
	Amalgam	Not significant	Not significant
	Composite	M = 1.78 (1.14 -2.77) L not significant	1.57 (1.06 - 2.30)
	Glass Ionomer	M = 2.01 (1.38 - 2.93) L = 2.79 (1.75 - 4.43	1.51 (1.10 - 2.08)
Anterior	**All**	M = 1.37 (1.14 - 1.64) L = 1.85 (1.51 - 2.26)	Not significant
	Amalgam	Not included	1.44 (1.08 - 1.93)
	Composite	Not included	not significant
	Glass Ionomer	M = 1.36 (1.09 - 1.70) L = 1.79 (1.36 - 2.37)	not significant
All	**All**	M = 1.40 (1.26 - 1.55) L = 1.76 (1.57 - 1.98)	1.25 (1.09 - 1.43)
	Amalgam	M = 1.30 (1.05 - 1.62) L = 1.52 (1.22 - 1.90)	1.42 (1.21 - 1.66)
	Composite	M = 1.43 (1.01 - 2.02) L = 1.88 (1.33 - 2.66)	1.27 (1.07 - 1.50)
	Glass Ionomer	M = 1.65 (1.40 - 1.95) L = 2.23 (1.81 -2.76)	1.20 (1.03 - 1.40)