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Survival Analysis of Complete Veneer Crowns vs. Multisurface Restorations: A Dental School Patient Population

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Abstract: The purpose of this study was to compare the longevity of crowns versus large multisurface restorations in posterior teeth. The investigation used the treatment database at Virginia Commonwealth University School of Dentistry. The inclusion criteria for the final data set used for analysis were: only one restored tooth per patient, premolars with three or more restored surfaces, molars with four or more restored surfaces, molars and premolars restored with complete veneer metal crowns, or crowns veneered with metal and porcelain. The Kaplan-Meier approach was used to visualize the survival curves, and the Cox proportional hazards model was used for analysis of predictor variables. The investigation indicates crowns survive longer than large restorations and premolar restorations survive longer than molar restorations. The median survival for crowns exceeded 16.6 years, with the median survival of premolar restorations being 4.4 years and molar restorations 1.3 years. An interaction between age and treatment was discovered, with overall survival decreasing as patient age increases. The doctor supervising the treatment also affected survival with treatment supervised by specialists lasting longer than treatment supervised by nonspecialists.

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When dentists encounter patients with severely damaged teeth, there are generally two treatment options: a restoration that involves placing the material directly into the patient's tooth, or a crown made indirectly that covers the entire coronal tooth structure. The difference in cost between these two choices sometimes exceeds 500 percent per tooth. Third-party providers usually only reimburse a portion of the cost from either treatment option, and sometimes compensation is much less for the more expensive indirect treatment. Therefore, cost may become an overriding consideration when making the choice of treatment.[1]

Although cost is important in treatment planning, the long-term survival of the tooth and its restoration should be the prevailing consideration in making a choice.[2] Due to the smaller fees and reduced pressure of a dental school, one would expect this environment to be an ideal place where this treatment decision may be made with less concern over cost and consequently more emphasis on quality and longevity.

The purpose of this study was to determine the difference in the survival of direct restorations when compared to indirect restorations in the dental school environment, adjusting for variables such as gender, age, tooth treated, type of treatment, and supervising doctor. The results of this study should yield valuable information for quality assurance for patients, providers, and interested parties and may help dispel the notion that direct restorations are likely to last just as long as crowns when placed under optimum conditions.

Literature Review

Restorative treatment decisions show a wide variation in the literature, with factors such as practice environment impacting treatment planning.[3-5] For example, a study comparing random samples of full veneer crown preparation dies done at the University of Colorado School of Dentistry student clinic found the mean convergence angle of their preparations were comparable to those done in clinical practice, thereby verifying that work completed in a dental school was similar to that undertaken in general practice.[6] In regard to the frequency of restoration choice, a survey of work authorizations in commercial dental laboratories found work ordered by general dental practitioners was distributed across the dentition in a similar manner to the work done

for patients attending the dental school located in the same geographic area.[6]

Although some studies suggest variables such as age may affect treatment decisions involving the restoration choice,[7] others indicate that age and gender seem to have no significant effect on the survival of the restoration.[8] Comparisons of oral care provided by predoctoral dental students at the University of Washington with care reported by general dental offices by the Washington Dental Service in Seattle[9] found patient age patterns were similar, with dental students completing more procedures for young children and for older adults. The relative percentage of all services completed by both students and practitioners was similar for examinations, radiographs, amalgams, composites, single crowns, and root canals. It was concluded that the relative distribution of clinical services provided by the students was comparable to those procedures reported by dental offices.

Although the literature contains studies analyzing direct dental restorations,[10-13] few studies compare the survival of these restorations with indirect single tooth crowns. The studies that exist may be categorized into retrospective observational studies involving cohorts,[13-20] prospective cohort studies,[21,22] a cross-sectional survey,[23] and an observational case control study, in which patients were selected, treated with one of the four ceramic crown systems, and had their survival results analyzed from records.[24] Another study involved longitudinally following metal-ceramic crowns placed in patients from a prosthodontic specialty practice where the method of treatment was meticulously described and the criteria for evaluating failure carefully outlined. Of the 87 percent teeth examined, 52 percent of the crowns had been in service for five to ten years.[22]

One clear limitation of some studies was failure to consider dropouts. Survival analyses, which take into account censoring mechanisms, can yield unbiased estimates of restoration success.

A study involving ceramic crowns was noteworthy because it included survival analysis between types of crowns. The study design incorporated a high level of standardization, and the analysis employed current statistical methods. The study involved performance of forty-two crowns in twenty-two patients placed during the past seven years by one dentist from one dental practice. Crown fabrication and cementation techniques were recorded, and Kaplan-Meier analysis revealed a probability for survival for seven years as 81 percent with a 95 percent confidence interval of 66-96 percent.[25]

A recent study investigating reasons why teeth received subsequent treatment revealed that teeth with crowns were less likely to receive additional treatment than teeth with large amalgam restorations.[26] Of the 518 teeth followed for a ten-year period, 32 percent of the teeth with crowns and 64 percent of the teeth with large amalgams received additional treatment. In addition, the patient's age, gender, and history of parafunctional grinding were also associated with the possibility of subsequent treatment.

However, some study conclusions may not be reliable because the observations come from convenience samples. Specifically, they use data from private practicing dentists who selected patients because they volunteered and were judged "suitable" and committed to the project, or wished to continue attending the practice and could be followed.[16,22] That is, selection bias could limit the generalizabilitiy of these studies.

Considering the predominance of these treatment choices and the variation that persists indicating one type of treatment over the other, additional studies are warranted.

Methods

Our longitudinal retrospective study uses a 672,453-observation treatment database provided by Virginia Commonwealth University School of Dentistry. The use of this data was approved by the university's Internal Review Board (VCU IRB #2906). The patient's identity was protected by not including names or addresses in the original data set. The initial data set included all treatments rendered between 1981 and 2002. The outcome variable is survival of large direct restorations compared to crowns made of all metal or metal veneered with porcelain, stratified by premolar and molar teeth.

The treatment data set included the patient's chart number, social security number, gender, birth date, and race. In addition, the data set contained the treatment procedure number, treatment site or tooth number, date the treatment was started, date the treatment was completed, and clinic number of the doctor who supervised the treatment.

Because the data set was designed to be used as an administrative instrument for student accounting purposes, instances existed where the same social security number was used for multiple patients, likely representing a mother filling out a chart for herself and her children. In addition, if a patient discontinued

treatment for a lengthy period of time and then reappeared at the school, a new chart number would likely be assigned. Therefore, to ensure a unique identifier for each record, the chart number, or social security number if present, was concatenated with the gender and year of birth.

Qualifying teeth included in the analysis were molars and premolars receiving an all metal or porcelain fused to metal crown, premolar teeth receiving a restoration including three or more surfaces, and molar teeth receiving a restoration including four or more surfaces. To ensure that each observation was independent, only one tooth was followed per patient, and when a patient had multiple teeth that were eligible, one tooth was randomly selected.

Failure of the qualifying restored tooth was defined in the following manner: the tooth was lost due to extraction, or the tooth required an additional restoration, crown, or other treatment. This included occurrences where the tooth sustained endodontic therapy. Censored teeth were defined as those that received no additional treatment, and the censor date was assigned as the last date the patient was seen. As a result of these criteria, a total of 28,931 crowns or restorations were eligible for analysis.

Table 1. Demographics of final data set used for analysis

	N	%
Gender		
Male	3,962	41.4%
Female	5,608	58.6%
Race		
African American	1,524	15.9%
Caucasian	4,479	46.8%
Other	508	5.3%
Unspecified	3,059	32.0%
Age		
<35 Years	2,417	25.3%
35-44 Years	2,356	24.6%
45-54 Years	1,959	20.5%
≥55 Years	2,838	29.7%
Tooth Site		
Premolars	4,235	44.3%
Molars	5,335	55.7%
Restoration Type		
Molar Crown	4,653	48.6%
Molar Restoration	682	7.1%
Premolar Crown	570	6.0%
Premolar Restoration	3,665	38.3%
Specialist		
Yes	2,022	21.1%
No	7,548	78.9%

Supervising dentists were categorized into specialists (those receiving specialty training related to prosthodontics) and nonspecialists.

Observations of the final data set used for analysis fulfilled the following criteria: only one restoration or crown per patient, the patient was eighteen years or older, and there was no discrepancy between the date of placement of the qualifying restoration and the date of the next treatment. Date discrepancies were likely the result of how clinical encounter sheets are sometimes completed chairside. Possible scenarios could be credit given for work by filling out an encounter sheet sometime after the restoration was actually completed, or an encounter sheet was resubmitted with a date different from the actual restoration completion date. The final data set yielded 9,570 observations for analysis and included treatment rendered between January 13, 1983, and September 6, 2002.

The Kaplan-Meier approach was used to plot the survival distributions of teeth restored with multisurface restorations vs. teeth restored with complete crowns veneered in metal or porcelain. A Cox proportional hazards (PH) model was used for analysis of explanatory variables and possible interactions between these variables. The data set preparation and analysis were accomplished using SAS 8.02 and JMP 5.0.1 (SAS Institute Inc., Cary, North Carolina).

Results

Teeth qualifying for treatment included 682 molars with crowns, 4,653 molars with restorations, 570 premolars with crowns, and 3,665 premolars with restorations. Restorations accounted for 87 percent of the total treatment. Of the 9,570 patients receiving treatment, 59 percent were female. Nonspecialists accounted for 79 percent of the supervising dentists. Table 1 contains the demographic data for the observations in regard to gender, race, age, tooth site, restoration type, and supervising dentist specialty status.

Preliminary Kaplan-Meier survival analysis revealed that, for crowns, tooth site had no significant effect on survival ($p=0.1042$), and therefore premolar and molar crown observations were collapsed. Thus, tooth site and restoration type were combined into three treatment categories: crowns, molar restorations, and premolar restorations. Then a univariate Kaplan-Meier survival analysis was done on each of the predictor variables. The results appear in the

"unadjusted" column of Table 2. Age was grouped into four relatively equal categories for the analysis. The Kaplan-Meier analyses revealed that all variables except gender indicated statistically different survival (Table 2).

Cox proportional hazards modeling was used to test a multivariate model and explore possible interactions among the explanatory variables. Table 2 contains the results of the adjusted model, revealing age, treatment, and specialist to be significant, in addition to a significant interaction between age and treatment. Therefore, the final multivariate model includes the significant covariates of age, treatment, specialist, and the age-treatment interaction (p values <.0015).

Table 2. Univariate and multivariate analysis results of variables predicting survival for crowns and restorations

	df	Unadjusted[1] Chi Sq	Unadjusted[1] p-value	Adjusted[2] Chi Sq	Adjusted[2] p-value
Gender	1	3.7	0.0561	1.76	0.1852
Age (Quartiles)	3	31.8	<.0001	49.05	<.0001
Treatment	2	775.3	<.0001	523.44	<.0001
Specialist	1	42.5	<.0001	10.23	0.0014
Gender and Age	3			3.85	0.2785
Gender and Treatment	2			2.33	0.3117
Gender and Specialist	1			0.08	0.7799
Age and Treatment	6			58.65	<.0001
Age and Specialist	3			1.93	0.5868
Treatment and Specialist	2			5.75	0.0565

[1]Unadjusted results by Kaplan-Meier, log rank chi square test.
[2]Adjusted results by Cox proportional hazards.

To illustrate the interaction between age and treatment, four Kaplan-Meier plots appear in Figure 1. The ten-year survival of crowns in the <35 year age group is 89 percent, compared to 68 percent in the ≥55 age group. Molar restorations' ten-year survival in the <35 year age group is 31 percent, compared to only 17 percent in the ≥55 age group with premolars showing better survival probabilities of 61 percent and 23 percent respectively. Overall, survival worsens as the patient's age increases.

To illustrate the effect of specialists, an additional Kaplan-Meier plot appears in Figure 2. At five years, 44 percent of the restorations supervised by dentists have survived, compared to 58 percent supervised by specialists. At ten years, 32 percent of the restorations supervised by dentists have survived, compared to 49 percent supervised by specialists.

In summary, the Cox proportional hazards analysis indicated that 1) survival decreases with the age of the patient, 2) crowns survive longer than restorations and premolar restorations survive longer than molar restorations, and 3) specialist supervision lengthens survival time.

Discussion

Within the constraints and assumptions for the data, Kaplan-Meier survival curves and Cox proportional hazards analysis clearly indicate crowns survive longer than large restorations, with an overall median survival of crowns exceeding 16.5 years, premolar restorations 4.4 years, and molar restorations 1.3 years.

An interaction between restoration treatment and age was found; specifically, restorations placed on premolars show lower survival times as age increases. Gender of the patient was found to be not significant; this is consistent with published data. The doctor supervising the treatment had an effect on survival, with treatment supervised by specialists lasting longer than treatment supervised by nonspecialists.

When considering the noticeably lower survival times of direct restorations, it should be noted that many of these large restorations may have served as foundations for crowns. Therefore, although they "failed" by the definition of survival in this study, since they were covered with a crown, they were still in place within the patient's tooth. Within the data set, there were 1,816 instances where a restoration was "replaced" (probably covered) with a crown, representing nearly 20 percent of the treatment. Due to the nature of the data entry, there was no clear way to distinguish or test this assumption.

Conclusion

Overall, this study revealed that survival of both crowns and restorations decreases with the age of the patient; crowns survive longer than restorations, with premolar restorations surviving longer than molar restorations; and specialist supervision lengthens survival time. The study validates the useful information available from dental school data sets and potential for additional research. It also suggests treatment in

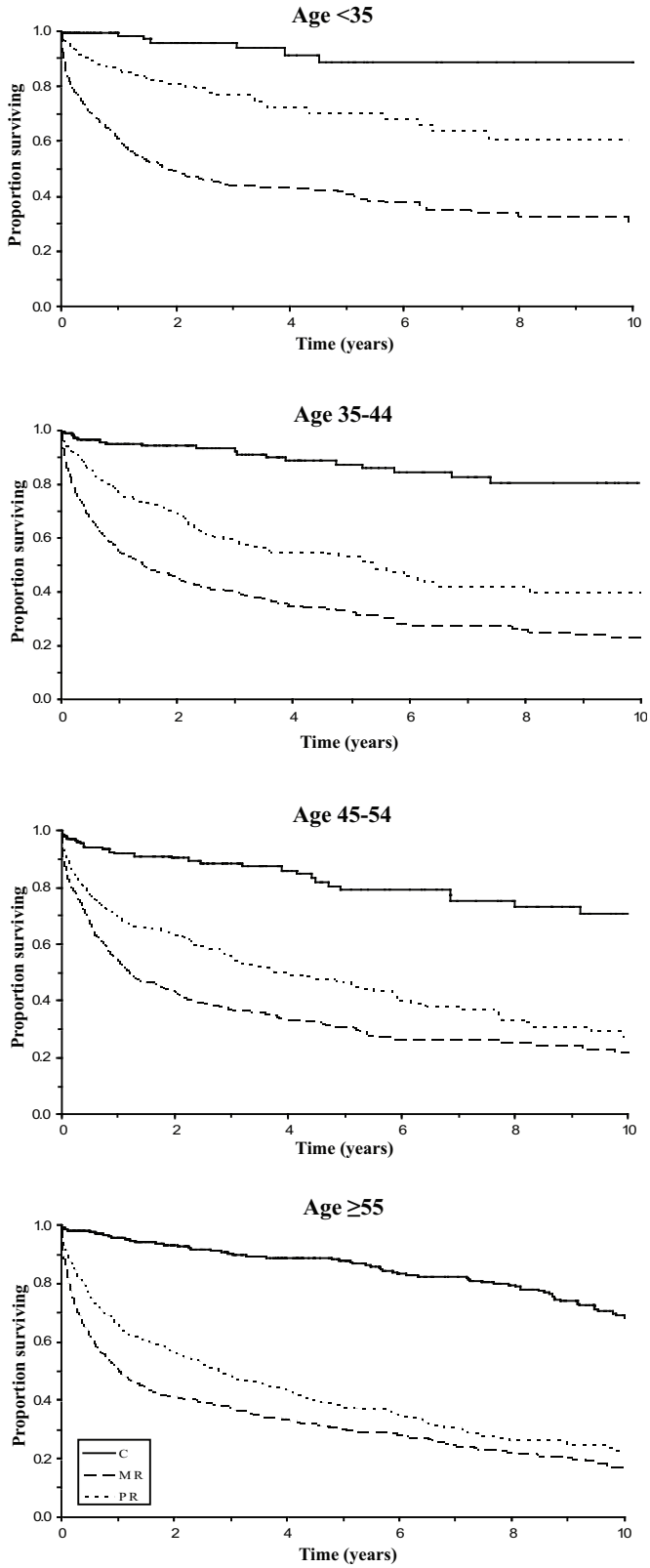

Figure 1. Kaplan-Meier survival curves of crowns versus premolar and molar restorations grouped by four age categories

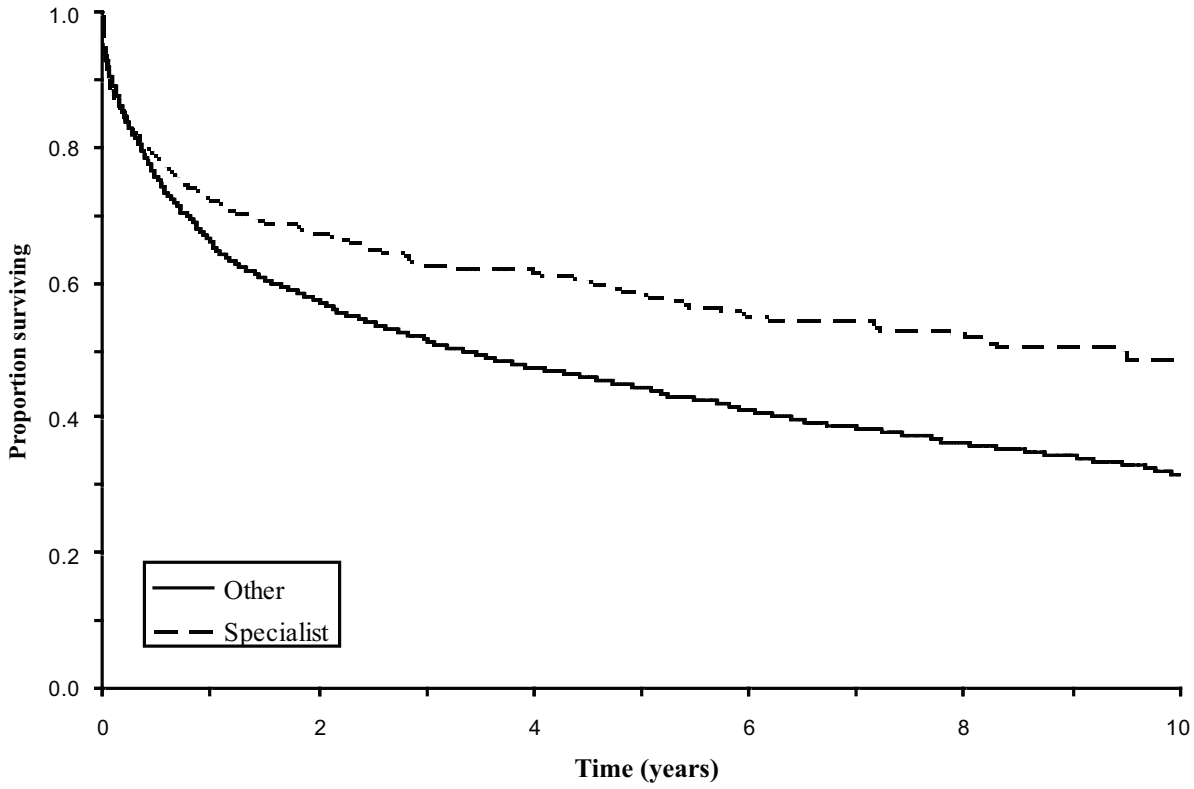

Figure 2. Kaplan-Meier survival curves comparing crowns and restorations supervised by dentists with those supervised by specialists

the dental school setting compares favorably with that in the private sector.

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