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

Charles E. Janus, D.D.S., M.S.; John W. Unger, D.D.S.; Al M. Best, Ph.D.

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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W hen 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 Seattle9 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 generalizability 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

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treatment for a lengthy period of time and then reap-
appeared 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 por-
celain 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 eli-
gible, 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.

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 observa-
tions in regard to gender, race, age, tooth site, restora-
tion 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 restora-
tions, and premolar restorations. Then a univariate
Kaplan-Meier survival analysis was done on each
of the predictor variables. The results appear in the

<table>
<thead>
<tr>
<th>Table 1. Demographics of final data set used for analysis</th>
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<td><strong>Gender</strong></td>
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<td>Male</td>
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<td><strong>Race</strong></td>
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<td><strong>Age</strong></td>
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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).

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three treatment categories: crowns, molar restora-
tions, 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).

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.

<table>
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<th>Table 2. Univariate and multivariate analysis results of variables predicting survival for crowns and restorations</th>
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1Unadjusted results by Kaplan-Meier, log rank chi square test.
2Adjusted results by Cox proportional hazards.

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

Acknowledgment
We wish to express our sincerest thanks to Michael W. Morgan, Director of Information Systems, who graciously took time to prepare the initial data set.

REFERENCES


