



RESEARCH ARTICLE

A 16 Year Retrospective Study of Survivability of Crowns placed in a Canadian Dental School Environment

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Abstract

Statement of problem: Single unit fixed dental restorations are placed on teeth which are heavily restored exhibiting some coronal breakdown either from, caries or trauma, endodontically treated posterior teeth requiring restoration due to tooth structure loss, or an esthetic requirement. With a gravitation to preserving the natural dentition for as long as possible, long-term clinical studies are required to assess the success of full coverage restorations, survivability, and reasons for failure.

Purpose: The purpose of this study was to determine the survivability, and reasons for failure, of crown restorations fabricated and placed a Canadian dental school undergraduate clinic, The University of Manitoba, Rady Faculty of Health Sciences, Dr. Gerald Niznick College of Dentistry, in Winnipeg, Manitoba, Canada.

Materials and Methods: Patient records including digital and paper charts were examined by searching AxiUm, the University of Manitoba's dental management software. Ethics approval was obtained from the University of Manitoba Research Ethics Board (H2016:295) (HS20000). All crowns placed between January 1, 2002 and May 30, 2018 was reviewed. Time to failure was recorded and categorized as short-term (within sixty months), or long-term (sixty to 192 months). Reason for crown failure was collected. Kaplan-Meier statistics with an associated P value comparing each fixed restoration were used to derive survival curves using Origin Lab Pro statistical software.

Results: Between June 1, 2002 and May 30, 2018, 2302 metal ceramic crowns, 2354 full metal crowns, 187 porcelain/ceramic crowns, 14 partial veneer crowns, and 50 CAD/CAM lithium disilicate (LiSi₂) crowns were placed in patients attending the University of Manitoba Dr. Gerald Niznick College of Dentistry undergraduate student dental clinic. Over the course of 192 months, 191 metal ceramic crowns (8.3%), 177 full gold crowns (7.5%), 12 porcelain/ceramic crowns (6.4%), 4 partial veneer crowns (36.4%), and 4 CAD/CAM LiSi₂ crowns (8.0%) failed over the course of 16 years.

Short term failures (five years or less) consisted of 93 full metal crowns (4.0%), 108 metal ceramic crowns (4.7%), 9 porcelain crowns (4.8%), 2 partial veneer crowns (14.3%), and 4 CAD/CAM LiSi₂ crowns (8.0%).

Of failures occurring in the first sixty months, full metal crowns and CAD/CAM LiSi₂ failures primarily consisted of a need for endodontic treatment due to a loss of tooth vitality (39.8% and 50% respectively). For metal ceramic crowns and all-ceramic crowns, failure was primarily due to the fracture of the ceramic material making up the crown (46.3% and 77.8% respectively).

After 192 months of service, the survivability of full metal crowns was 92.5%, metal ceramic crowns 91.7%, all ceramic/porcelain crowns 93.6%, partial veneer crowns 63.6%, and CAD/CAM LiSi₂ crowns 92.0%.

Overall, the main reasons for failure beyond 60 months up to 192 months for full metal and metal ceramic crowns was recurrent caries, at 61.9% and 42.2% respectively.

Conclusions: Within the parameters of this study, full metal, metal ceramic, all ceramic, CAD/CAM LiSi₂, and partial veneer crowns had good survival rates (92.5%, 91.7%, 93.6%, and 92.0% respectively).

More than half of all crown failures occurred within the first 60 months (55.7%). The most common reason for failure over the entire 192 month span of the study was recurrent decay, followed by crown restoration material failure.

Clinical Implications: Dental practitioners have many options for restoring the teeth, however the consideration for esthetics versus functionality and strength for large restorations can prove challenging.

The dental professional must ensure that the appropriate and best option for the patient is chosen to improve the longevity of the tooth and crown, while preventing further deterioration to remaining tooth structure.

This can also dictate the type of material available to use as a restorative option, as the amount of remaining tooth structure is critical to the restorative process.

Keywords: Full coverage, crowns, restoration, failure, survivability.

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Introduction

Crowns are used to reinforcing heavily restored teeth, largely decayed teeth, endodontically treated teeth, or teeth damaged by trauma. Crowns are the restoration of choice especially in posterior, largely non-visible or not readily accessible by direct restorative means [1]. Full cuspal coverage restoration for a tooth with any of the previously mentioned conditions can be a long-term solution in many situations and may offer the best prognosis as well. With the increase in use of metal ceramic crown and all ceramic crown restorations as the choice material for crown restorations, [2-5] it is important to know if their survival is comparable to, superior to, or inferior to the conventional full metal restorations.

A retrospective study conducted by a dentist in his private practice found that over a span of 50 years, under a strict recall regiment, with ideal abutment teeth, 6 crowns out of 223 failed and the rest survived (97.3%) [6]. Another study in private practice showed a crown survival probability of 94.3% at 8 years and 88.8% at 11 years post-crown insertion [7]. As well, an 18 year retrospective study of crowns placed in an undergraduate dental clinic yielded a survival rate of 78% after 18 years, with the most common cause of failure being caries, followed by periodontal disease [8].

According to a Cochrane study, research in this area is yet undecided and inconclusive as there is insufficient evidence to support or refute the notion that metal free restorations for fixed prosthodontics are superior to metal-ceramic or other metal based fixed restorations [9].

This study will examine what kind of survival results are achieved in a supervised undergraduate dental school environment and if the results are comparative to other similar studies conducted.

Materials and Methods

The University of Manitoba Research Ethics Board (H2016:295 (HS20000)) granted approval for the retrospective

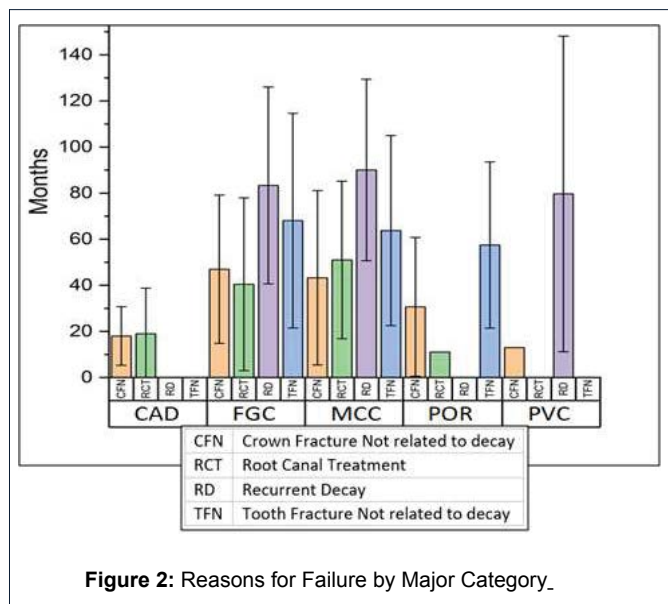
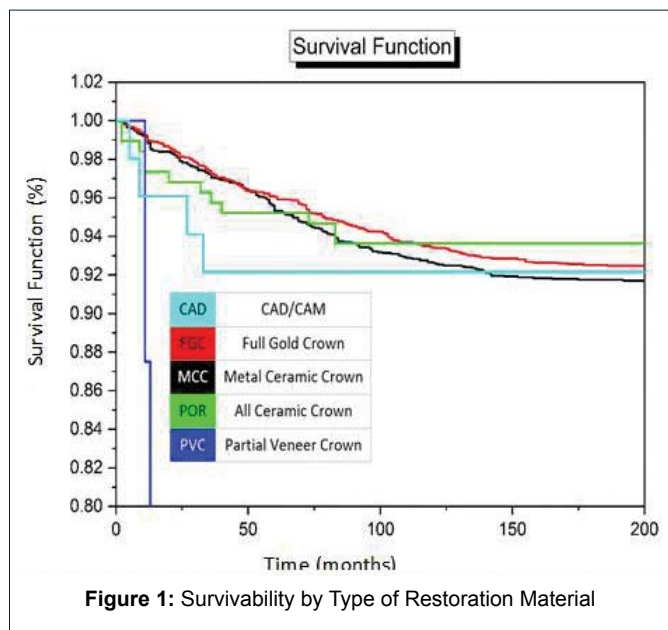
study conducted at the University of Manitoba Dr. Gerald Niznick College of Dentistry. The college's electronic dental management software (AxiUm, version 7.03.00.25) was used to collect the data from the charts of patients of all ages. Crown failure was classified as any crowned tooth that required some form of treatment subsequent to crown placement; including root canal therapy, placing further restorations on the tooth or caries control, re-fabricating the crown, or extraction of the tooth.

All patient charts were examined for single unit crowns placed from June 1, 2002 to May 30, 2018. Using AxiUm, a search for the codes corresponding to the types of crowns was conducted. To find failed crowns, the AxiUm software was searched for each crown placed, filtering out each patient's chart and searching to see if the tooth had a record of being treated after crown placement in the daily treatment notes. Any tooth that was crowned and had subsequent treatment after crowning was flagged for inspection of the cause of the additional treatment. The daily treatment record entered by the student clinician was examined for a definitive reason for failure and these were tallied into the table of reason for failure by restoration material (Table 1).

All individual reasons for crown failure were compiled and grouped into four overarching categories; recurrent decay, endodontic treatment, crown failure not related to decay, and tooth failure not related to decay. Unknown failure where the patient's chart records did not specify a reason for failure could not be counted as such as well as re-purposed crowns for fixed partial dentures or removable partial dentures were not denoted as failings of the crown. After collecting and tabulating the data, it was noted that the most critical period for crown failures was the first 5 years after placement intraoral. There were a considerable number of failures in the first 5 years of a crown's existence as compared with crown failures beyond 5 years (55.7% of all crowns in the study) placed from 2002 to 2018 (Figure 1 and Figure 2).

Table 1: Reasons for failure by type of restorative material

Failure Type	Full Metal	Metal Ceramic	All Ceramic	CAD/CAM LiS ₂	Partial Veneer
Recurrent caries	66	44			3
Tooth/root fracture	21	26			
RCT/periapically involved	48	31	1	2	
Periodontally non-restorable – hopeless prognosis	16	14			
Crown broke off	9	17	1		
Open margins	4	6		1	1
Pain/sensitivity	5	2	1		
Crown came off (failed)	11	18			
Open contact	1	2			
Worn crown	1	1			
Esthetics	1	10	4	1	
Chipped crown		17	5		
Mechanical failure/ operator error		2			
Unknown/Not specified	9	12	1		
Repurposed – (not failure)	7	9			



Results

Between June 1, 2002 and May 30, 2018, 2354 full metal crowns, 2302 metal ceramic crowns, 187 porcelain/ceramic crowns, 14 partial veneer crowns, and 50 CAD/CAM LiSi₂ crowns were placed in patients attending the University of Manitoba Dr. Gerald Niznick College of Dentistry undergraduate clinic.

Of these restorations, 177 full gold crowns (7.5%), 191 metal ceramic crowns (8.3%), 12 porcelain/ceramic crowns – composed of feldspathic porcelain or zirconia (6.4%), 4 partial veneer crowns (36.4%), and 4 CAD/CAM LiSi₂ crowns (8.0%) failed.

The overall survival probability for full gold crowns was 92.5%, metal ceramic crowns was 91.7%, porcelain/ceramic was 93.6%, partial veneer crowns was 63.6%, and CAD/CAM LiSi₂ was 92.0% over the 16-year span in the undergraduate

clinic.

The main reason for failure in full gold crowns was recurrent decay (41.8%), resulting in follow up treatment of crown restored teeth, followed by endodontic treatment (28.2%), any form of crown failure (15.3%), and tooth failure (14.7%),

The main reason for failure in metal ceramic crowns was crown failure not related to decay (34.6%), followed by recurrent decay (25.1%), tooth failure not related to decay (23.0%) and endodontic treatment (17.3%). Unknown failures where the patient’s chart records did not specify a reason for failure as well as re-purposed crowns were not marked as failed.

The main reason for failure of all ceramic/porcelain crowns was crown failure not related to decay (75.0%), followed by tooth failure not related to decay (16.7%), and endodontic treatment (8.3%). Examples of crown failure not related to decay include porcelain fracture, loss of retention, open margins, open contacts, or occlusal wear. A single case of unknown failure where the patient’s chart records did not specify a reason was not tallied as failure. The long term data in this category is limited as it was a recent treatment modality offered at the undergraduate clinic, therefore there is no long term data beyond 72 months of the study. The main reason for failure of all partial veneer crowns was recurrent decay (75.0%), followed by crown failure not related to decay (25.0%).

For CAD/CAM LiSi₂ crowns the reasons for failure were split between the need for endodontic treatment (50.0%) and crown failure not related to decay (50.0%). The long term data in this category is not available as it was a more recent treatment method put in place at the undergraduate clinic, no long term data beyond 60 months of the study existed.

Analysis of the data noted that the majority of the failures occurred in the first 60 months of the most common reason for full gold crown failures being a need for endodontic treatment at 37 of the 93 teeth, or 39.8% of the first 5 years’ failures. 108 (56.5%) of metal ceramic crowns failures occurred in the first 60 months, with the most common reason for failure due to crown failure not related to decay at 50 of the 108 teeth, or 46.3% of the first 5 years’ failures. 9 (75%) of porcelain failures occurred in the first 60 months, with the most common reason for failure due to crown failure not related to decay at 7 of the 9 teeth, or 77.8% of the first 5 years’ failures.

Crown failure not related to decay being any mechanical failure of the crown causing a need of replacement, including loss of retention, open margins, open contacts, or porcelain fracture. 2 (50%) of partial veneer crown failures occurred in the first 60 months, one being due to crown failure, the other related to recurrent decay. All 4 (100%) of the CAD/CAM LiSi₂ failures occurred in the first 60 months, 2 (50%) due to crown failure not related to decay, the other 2 due to needing endodontic treatment.

Discussion

Indications for the placement of crowns include prevention of future disease or breakdown. Treatment with crowns may

be necessary to accomplish these objectives: correcting an existing disease, restoring function, and improving appearance [1]. The purpose of the study was to examine the survival rates and reason for failure of all single unit crowns placed in a Canadian undergraduate dental clinic setting beginning from June 1, 2002 and ending May 30, 2018, and to compare the results to previous data garnered from other academic settings as well as private practices.

Due to the limitations of time and resources for this study, it was not possible to follow up on every patient with a clinical examination that had a crown placed at the dental college and no longer returned for regular treatment or transitioned to private practice for further treatment. Results for this study then were limited to patients who maintained regular dental and hygiene appointments at the school, and thus would be followed from crown placement until the end date of the study.

As not all patients treated at the Dr. Gerald Niznick College of Dentistry were followed up, failure may be slightly higher than the reported value. It was not possible to account for patients that no longer returned, and any crown failures would not be noted and factored into the study. Given the large sample size it is reasonable to be able to draw a conclusion from this data set.

Determining failure from a chart review is difficult and sometimes complicated as the daily treatment records often had limited information regarding what kind of failure had caused the tooth to need retreatment. Due to the timing of appointments and method of crown failure, it was also not always possible to determine the exact date of failure as some common crown failures such as open margins and recurrent caries would only be detected at a dental appointment. Often not noticeable to the patient besides for perhaps some minor sensitivity or other indication which a patient may dismiss as negligible, it is up to the dental professional to inspect any fixed prostheses at appointments and to assess their integrity.

After considering the data and the setting of the study, some factors which might affect the survival rate of crowns placed are as follows: first, the students which attend the dental college may influence longevity. Each student is a unique individual with a distinct set of skills and experience and attention to detail despite most students being taught by the same instructors throughout their dental education. There was no recording of how many failures occurred by a single student, so there is the possibility that some students' work may be inferior or superior to that of their colleagues, both past and present.

Secondly, regarding the tooth itself, position in the mouth and accessibility to the tooth as well as ability to achieve isolation are not accounted for in the failures. It is possible that teeth which were harder to prepare or maintain good moisture control for cementation may be at higher risk for failure.

Further, the type of cement was not noted in the failures, whether a specific type of cement was more liable to fail or not could not be shown. Yet another factor for failure is the crown preparation design. The amount of tooth structure remaining

after preparation often yields stronger, longer lasting teeth [10-12]. The type of crown can also affect the amount of remaining tooth structure, as full metal restorations require the least preparation and are more conservative, while all ceramic crowns typically require a shoulder or deep chamfer margin to provide the restoration with strength.

No two teeth are identical in preparation and response to treatment, so the amount of ferrule remaining, or the amount of previous restorative work completed may be a factor on longevity of the full coverage restoration.

Another interesting observation to note from this study is the number of endodontically treated teeth prior to crown placement. Teeth being endodontically treated prior to crown placement would possibly leave a tooth more susceptible to tooth fracture over a long time span. Over the 192 month span, 1290 teeth were treated with root canal therapy prior to a full coverage restoration being placed. 84 teeth required root canal therapy at some point after cementation of the definitive restoration, and most often within a span of a few months.

Comparing the results gathered in this study to those values found in literature, a survival rate between 91.7% and 93.5% was less than the 97.3% survival rate by the sole private practitioner over the course of 50 years, while comparable to the private practice study which found 94.3% survival at 8 years and 88.8% survival at 11 years, and better than the undergraduate clinic study which found 78% survival after 18 years. Thus the results collected in this study exhibit a satisfactory level of survival in the undergraduate dental clinic over the course of the 16 year study.

Conclusion

After examining all crowned teeth and determining the rate of failure and reasons for failure, the conclusion can be made that full metal, metal ceramic, all ceramic, and CAD/CAM LiSi₂ full cuspal coverage crown restorations had good survival rates over 192 months (92.5%, 91.7%, 93.6%, 92.0% respectively), with the most common reason for long term failure of the crowns being recurrent decay in full metal crowns and crown failure not related to decay in metal ceramic and all ceramic crowns. Short term failures were most commonly due to endodontic treatment needed in full metal crowns, and crown failure not related to decay in metal ceramic, all ceramic, and CAD/CAM LiSi₂ crowns.

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