Metal crowns vs. restorations on teeth L and S: Survival analysis in a national census sample of private insurance claims

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Abstract

Background. The effectiveness of stainless steel crowns (SSCs) versus direct restorations when placed in lower primary molars (teeth L and S) is uncertain. We evaluated effectiveness gauging longevity of treatment.

Methods. Private dental insurance claims (2004-2016) were obtained from a national dental data warehouse. Paid insurance claims records (n=1,323,489) included type of treating dentist, treatment placed, age of patient.

Results. Specialty of dentist, type of treatment, and patient age were significant in predicting failure after the first restoration. We found high survival rates for all treatments (>90%) after five years; however, as soon as within three years of treatment there was a difference of ~6% better survival for SSC.

Conclusions. L and S teeth first treated with SSC lasted longer without new treatment compared to teeth first treated with direct restorations. The difference was small. Teeth treated by pediatric dentists had better survival.

Practical Implications. First primary molars initially treated with SSC last longer without new treatment compared to direct restorations. Overall dental care costs of the former were considerably higher.

Key Words: Stainless Steel Crown, General Dentist, Pediatric Dentist, Primary Teeth

Introduction

The exact outcomes expected from different approaches at treating restorable dental carious lesions in the lower first primary molars have been the subject of considerable debate[1-3]. There are perceptions that general dentists (GDs) are less adept at using pulpotomies and stainless steel crowns (SSC) in their child patients, compared to pediatric dentists (PDs)[4]. Even under similar case presentations, GDs may be more likely to place Class II restorations instead of SSC[5]; the reverse would be treatments of choice by many PDs. The importance of these clinical and financial issues is whether one course of treatment or the other is in fact more effective (because it will last longer in serviceable conditions) for the cost incurred by the health system.

Existing literature provides partial guidance about these two issues; however, opinions tend to predominate over statements supported by evidence. Population based studies have been circumscribed to small convenience samples. Some observations highlight limitations when treating proximal lesions in children younger than 4 years old or those whose first permanent molars have not erupted[6,7]. Generally accepted best practices are as flexible as recommending SSC "when the restoration is expected to last longer than two years or when the patient is younger than six[8]"; such guidelines appear ambiguous. The population-based studies have reported that SSC are less likely to require re-treatment compared to multi-surface amalgam restorations[7,9]; and show higher longevity over eight and five year follow-up periods[10-12]. While some SSC also were deemed to fail over time, one of the larger-scale reviews concluded that Class II amalgams failed 26% at five years, whereas SSC had only 7%[11,12]. The situation for composite restorations was generally poorer than amalgams[13]. Estimates for five year survival were 68% for SSC, 60% for amalgams, and 40% for composites[13]. A Cochrane review from 2015 found recently more studies than the original 2007 review; the key findings were that SCC placed for carious lesions or following pulp treatment were more likely to avert failure or pain in the long term compared to direct restorations[3].

While mere survival figures over fixed periods of time in convenience samples is an important first step in ascertaining the comparative effectiveness of SSC vs. direct restorations in primary molars, other factors affect such estimates. The largest unknown is whether the population groups studied in fact portray the diverse factors that drive a decision to restore, or repeat, treatment. Treatment planning decisions can be modified by the caries risk of the child, the family's socioeconomic status, caries experience in the child's parents, dietary habits and mutans streptococci levels[8], as well as the potential for long-term follow-up care and parental compliance in home care. How to weigh those factors in the clinical management is extremely complex. None of the studies cited have explicitly incorporated diagnostic codes, stringent case definitions, nor precise treatment indications[3]. Another layer of complexity raises when we examine reports not only in the context of the features of patients, but also in light of the clinical decision making processes by dentists[14].

Given the high cost of undertaking longitudinal prospective trials, we propose the second-best approach at contrasting the survival performances between SSC and direct restorations: to examine what happens in real life using private dental insurance claims. Even though secondary analysis of dental insurance claims does not afford an in-depth understanding about why some teeth were treated in a certain way while other teeth were treated with a different approach, it offers a description of the overall performance of the various treatment courses in real life. We chose to conduct this examination focused on teeth L and S of the primary dentition. Their anatomic characteristics provide one singular situation whereby the clinical training of dentists and their familiarity with placing SSC might condition the decision to choose direct restorations over SSC[7]. The objectives of the present research were: 1) To examine the survival of SSC or direct restorations in mandibular primary first molars (teeth S and L) in a national census sample of private dental insurance claims. 2) To examine whether survival performances were more characteristic of either treatment approach when undertaken by different providers, such as GDs vs. PDs vs. any other dental specialist. And 3) to calculate the overall direct costs paid for dental care on those teeth initially treated with either SSC or direct restorations.

Methods and Materials

Project was approved by an IRB at Indiana University (#1508889495).

Participants and Study Locations

Data were obtained from a commercial dental insurance claims data warehouse that accrues claims from more than 50 dental insurance plans and multiple carriers in the U.S. The data warehouse does not include all dental plans in the country but a very large proportion of them. De-identified nationwide data for children 18 years old and younger were obtained to include length of time between first and subsequent treatments (identified by their Current Dental Terminology (CDT) codes, a standardized system for identification and billing prevalent in the American market), a unique identifying number; age in years; and dental provider information (including whether general dentists (GDs), pediatric dentists (PDs), or any other specialty had filed the claim). The data extraction encompassed all records between May 2004 and June 2016.

CDT codes were primarily D2391, D2392, D2393, D2394, D2140, D2150, D2160 and D2161 for direct restorations; and D2930, D2933, and D2934 for SSC. Other codes were used only for calculating costs: codes relevant to teeth L and S for restorative, endodontic, and surgical procedures.

Study Procedure and Data Sources.

Analyses included only paid claims. We focused on the first billed and paid claim involving L and S for direct restorations (amalgam or composites) and for SSC; any other restorative, endodontic, or extraction subsequently billed and paid on L and S; age of the patient; and the specialty of the dentist undertaking the first treatment.

Data Transformation and Statistical Analysis

Data transformation followed the rationale summarized in Fig. 1. Briefly, a tooth could have a dental history whereby it was healthy and was naturally exfoliated; the analytic dataset would not register any claims. A tooth could also be treated with an extraction; we did not consider that single event in the analyses. Our analyses focused on the treatment outcomes of teeth L and S when they were first restored either with a direct restoration or with a SSC. We used the first observation in the data for each tooth for the type of restoration placed (SSC) or direct restorations (class I+II+III composites or amalgams). For teeth that were not treated at least a second time, the follow up time was censored at the earlier of a) the last data recorded for the patient or b) age 11 (average typical exfoliation age for L or S, which was assumed to be the end point of a non-extracted tooth since exfoliations were not recorded in the claims database).

We used the dataset in three analytic approaches.

First we simply addressed a yes/no failure analysis. We fitted generalized logit models to compare the effects of specialty of practitioner and age of patient on the distribution of the type of restoration. We included random effects to account for the correlation among patients within provider and between the two teeth within a patient.

Secondly, a generalized estimating equation (GEE) model was created by using type of practitioner, type of restoration and patient age as predictor variables to estimate the odds of failure after first restoration. Kaplan-Meier (product limit) estimator was used to estimate the survival function after the teeth received their first restoration. This method took account of the right-censoring data, which occurs if a patient did not have the second restoration before age 11. Log rank tests were performed to compare the survival distribution between types of restorations or among types of practitioners. We also analyzed the dataset with Cox regression models, which account for the nesting of patients within provider and teeth within patients; the results were very similar to the Kaplan Meier tests. We report only the latter.

Data allowed us to account for all of procedures performed on the same tooth and paid by a private insurance dental plan. Because of the complexity of teeth L and S being treated with direct restoration or SSC more than once and in any order, and by different practitioners, the results above depict the categorizations pertaining to the first treatment on a given tooth. In our survival curves we classified failure as the first instance in which an additional procedure was performed on the same tooth. Our survival curves do not account for multiple failures.

Finally, we calculated the costs of the treatments undertaken on each tooth throughout its dental history. No adjustments were undertaken to values to any given year (first in 2004 or last in 2016), or adjusted for inflation. There were very rare instances of implausible data, such as a tooth being treated with an extraction and subsequently receiving a restoration. Any claims billed and paid that did not make clinical sense were discarded. Costs were compared between teeth that were first treated using SSC against teeth that were first treated using direct restorations using two-sample t-tests.

Data were analyzed using SAS version 9.4 (SAS Institute, Inc., Cary, NC).

Results

Basic results

The data included 1,323,489 records specific to teeth L and S in the 12 years making up the dataset. Such records pertained to 750,859 unique patients and to 106,252 unique providers. Of these, GDs provided the first treatment billed for L or S in 62.9% of the cases and PDs provided 34.9%; all Other specialties combined billed and were paid only 2.1% of the relevant procedures.

Mean age for children first receiving a restoration on teeth L or S was 6.5±1.9 years; for SSC, age was 5.8±1.7 years. Claims paid for children 4 years of age and younger (117,732, 16.6% of total) were the smaller group and then increased to reach its peak at ages 5 (128,793, 18.1%) and 6

(138,772, 19.5%). Claims for later ages continued to decrease. We did not estimate survival rates nor costs for data in study participants older than 11 years of age.

GEE model to estimate odds of failure after first treatment

Type of practitioners, type of treatment (SSC or direct restorations) and patient age were significant in predicting the odds of failure after the first treatment (all p<0.0001). The odds of failure placed by GDs and Other practitioners were higher than treatments placed by PDs. The odds for direct restoration were higher than SSC. The odds decreased as age increased.

Survival analysis between time of first treatment to time of second treatment, across all dentists

The Kaplan-Meier survival curves for the length of time after first treatment until occurrence of endpoint (second treatment or extraction) were calculated for direct restorations and SSC (Figure 2). For GDs, PDs and Other practitioners, the survival rates for SSC was significantly higher than for direct restoration (P<0.0001).

Survival analysis between time of first treatment to time of second treatment, among dentist groups by specialty

The Kaplan-Meier survival curves for the length of time after first treatment until occurrence of endpoint (second treatment or extraction) were calculated for GDs, PDs, and Other practitioners for direct restorations (Figure 3) and for SSCs (Figure 4). For those teeth that received the same type of first treatment, the survival rate was significantly different across practitioners (both log rank test P<0.0001) but it was always above 90% after two years of follow up. Treatments placed by PDs had the highest survival for direct restorations and SSCs (p<0.001). Direct restorations placed by GDs had higher survival than those placed by Other dental specialists (p<0.001), but survival for SSCs did not differ between GDs and Other dental specialists (p=0.67).

Cost analyses

The average total cost (±SD) of a tooth first treated with direct restorations (n=589,840) was US$98.68±58.50 (median $88.00; maximum $1,726.60). These costs over a tooth-life of treatments were lower ($p<0.0001$) than the costs of a tooth first treated with SSC (n=120,793), which was US$170.63±80.31 (median $158.50; maximum $1,408.00).

Discussion

This is the first large scale study of actual dental insurance paid claims depicting the dental history of direct restorations and SSC on teeth L and S. Because this is a health services research project incorporating a nationwide sample of data from private dental insurers, we are able to provide a 12-year perspective of treatment trends and cost impact for that specific segment of the US dental market. We could not account for publicly-funded, out-of-pocket, or donated dental care in the present study, as there is no national registry depicting such segments of the market that would ideally complement our data.

SSCs appear to be superior to direct restorations in the short term. This feature does not mean that they may not be superior in the longer term; it means that our research framework was more solid by limiting the appraisal to assigning a track to teeth (direct restoration or SSC) as signified by the first paid claim. A yes/no failure analysis indicated that age of the child was a significant factor predicting failure; this is not surprising because age would differentially affect decisions to treat L or S with direct restorations or SSC[11,8]. Age is an inherent issue in gauging clinical performance in child dental care because of teeth having a pre-specified life expectancy. An extensive yet dated review showed SSC lasted longer than multi-surface amalgams[10]. The obvious question is whether treatment and re-treatment had in fact equal probabilities of taking place. In the present study, we depict what happened in real life and was paid for by private dental insurance plans.

Our results confirmed prior reports undertaken in a small sample that showed survival rates >90% for SSCs evaluated within 4.5 years, compared with amalgam[9]. Another small sample study found that SSCs had the highest survival followed by amalgam, then composite, and glass ionomer restorations[13]. The present study showed high survival rates for all treatment (>90%) after five years; however, as soon as within three years of treatment it was possible to distinguish a difference of about 6% better survival for SSC. Such patterns merit the following four lines of discussion.

First, the difference in survival was clear and statistically significant; but it was also small. Better definition of what profiles of patients would benefit the most at what ages from placing (and replacing) SSC or direct restorations remains to be established in a more finely grained contrast.

A salient issue is why some L and S are restored with direct restorations and others are restored with SSC. One immediate scenario is to consider whether the skillset needed to place either one differs between clinicians, or whether the clinical expertise drivers weigh differently on non-clinical considerations. The financial gain is not remarkably different so it does not appear to be a major driver; our research is not tailored to address this issue. Actual payments in a census sample obviates many such considerations because we can safely assume that we do not hypothesize why dentists did something but actually examine what it is they (106,252 dentists) in fact did. Our findings showed that treatment courses undertaken by PDs have lower failure experience with either type of treatment compared with GDs or Other dentists. We propose that PDs may have lower experience of failure with direct restorations due to the criteria they typically use to treatment plan a direct restoration instead of a SSC. As previously discussed regarding amalgams, some of its demonstrated limitations for proximal lesions include children younger than 4 or those whose first permanent molars have not yet erupted, as well as individuals at high risk of caries[6,7]. We suggest PDs may be trained to recognize these conditions more readily, and are thus more likely to provide a SSC in these cases. It is also possible that GDs recognize these conditions just as effectively but perhaps due to a low level of comfort in providing SSCs, they opt to instead provide a direct restoration. Training for non-PDs is rather sparse as far as SSC are concerned in dental education. Coupled with the fact that the GD provider pool was much larger than the PD pool, direct restorations were three times more common than SSC as the first treatment for L or S.

In the larger scheme of treatment performance, even when GDs and Other dentists placed SSCs, their survival curve closely resembled that of PDs.

Finally, one obvious factor in the clinical pathway is whether all L or S challenge the clinician with the same constellation of clinical factors, so that management decisions are just as likely to follow either route. But it is commonly proposed that SSC or direct restorations will be treatment-planned for different clinical scenarios[11,2,8]. The larger Cochrane systematic review recently published pointed out that due to a lack of detail on the extent of carious lesions[3]. One of the major contributions to the topic is that we may confidently rest on the assumption that a census sample ought to depict all interpretations of clinical information (whether correctly undertaken or not, according to best practices or not). There was one indication that SSC and direct restorations were differentially prescribed according to clinical presentation: the overall costs of the treatments paid for each tooth first treated with SSC and for each tooth first treated with direct restorations. The accumulated costs for the former were about 70% higher than teeth first treated with a direct restoration. One reason is that teeth receiving endodontic treatment are likely assigned to SSC[15]. The variation in such cumulative experiences was large; in fact, the maximum costs were very high, which can reasonably be ascribed to rare outliers. It is just enough one tooth had hit that cumulative cost to pull such cost ceiling away from the median cost. Our findings shed new light on the cost comparisons between direct restorations and SSC; past reports have offered disparate results[16-18].

Although the present study offers a large scale survival analysis of SSC and direct restorations in a very large sample, there are some limitations in the study design that must be described to place the value of our findings in the appropriate context. This is a secondary data analysis on existing dental insurance records from a data warehouse accruing claims from the entire country; while representing a large proportion of the market, the records are not a universal collection of private dental insurance claims. We decided to omit the detailed survival history of those cases where multiple procedures were performed on the same tooth over time; not all those services were billed and paid to the same dentist. The same dentist did not necessarily provide all of the individual procedures; in fact, not even the same type of dentist (PD, GD, Other) may have provided the treatments. Finally, the structure of the data and confidentiality clauses did not allow to follow teeth across dental plans; therefore, in the absence of a unique identifier per person/teeth, we were circumscribed to survival estimates for as long as the employer, subscriber, and child remained in the same dental plan. The latter feature could have been expected to partially undermine the assumptions for long-term survival analysis; we did offset such concerns by assembling an extremely large dataset and focusing our analysis plan on the time interval between the first and the second treatments per tooth.

Practical Implications

L and S teeth first treated with SSC lasted longer without new treatment compared to teeth first treated with direct restorations. The difference was small. Teeth treated by PDs had better survival profiles than teeth treated by GDs or all Other specialties. Overall dental care costs of teeth first treated with SSC were considerably higher than comparable costs in teeth first treated with direct restorations.

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Conflict of interest

The authors declare they have no conflicts of interest.

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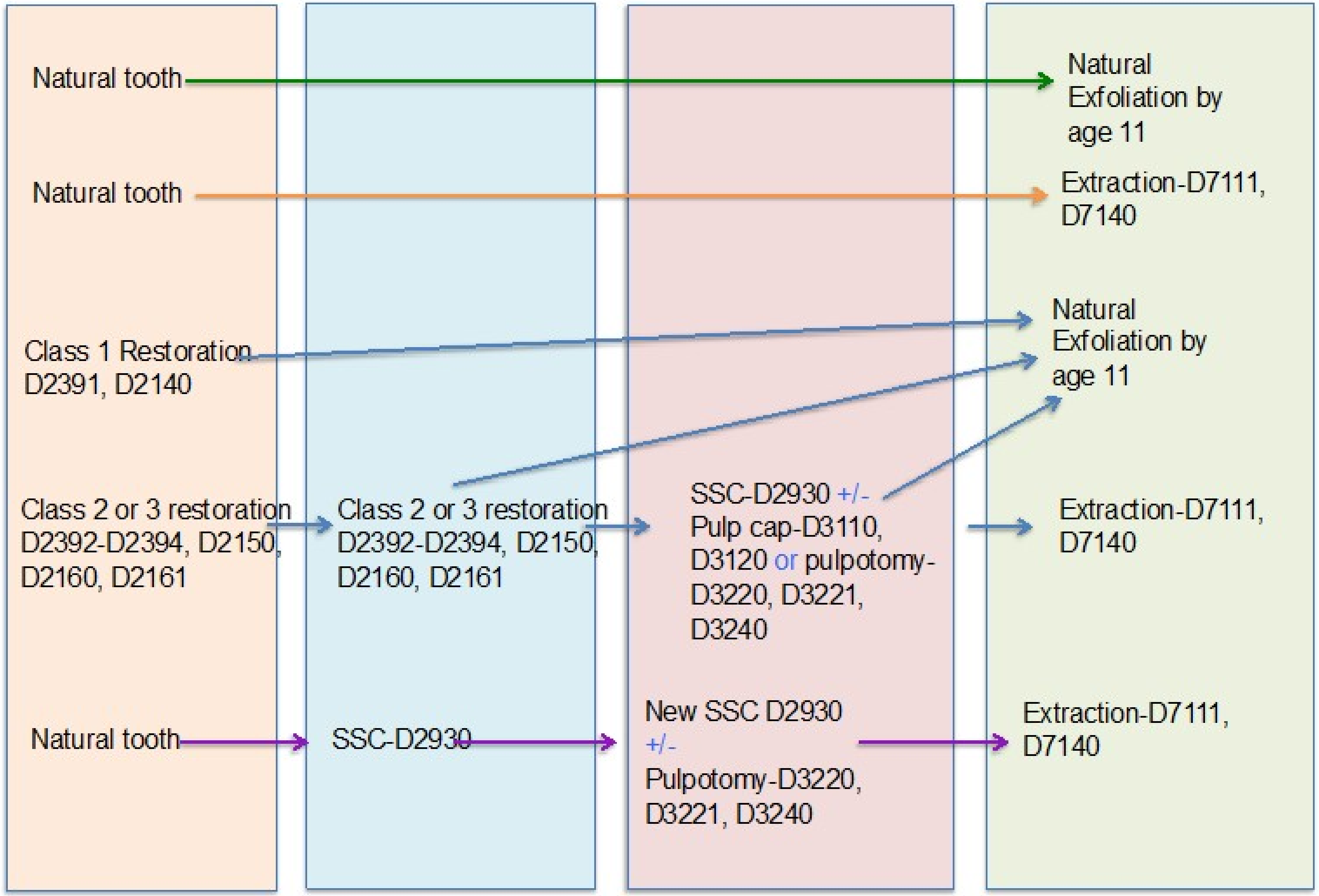
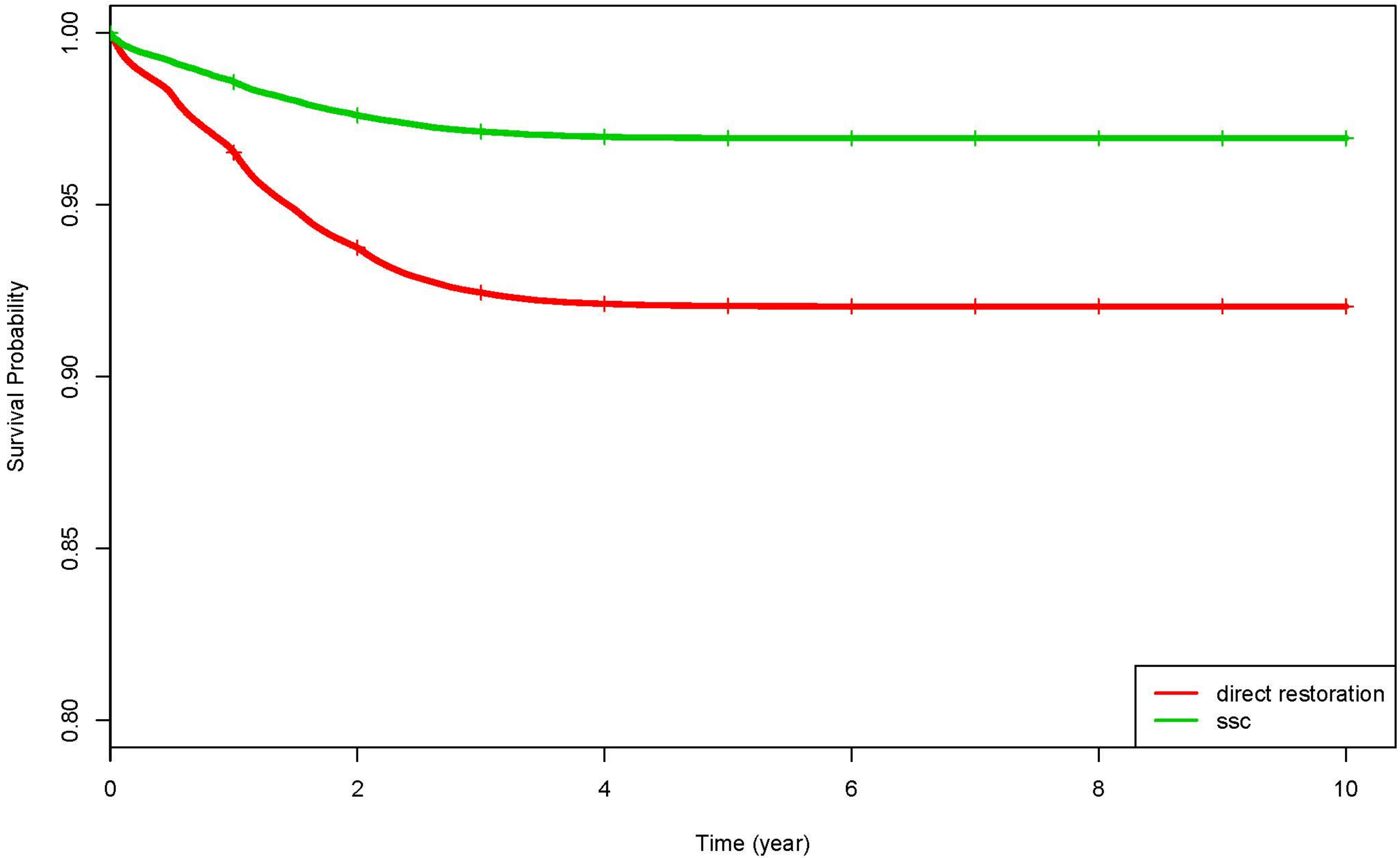
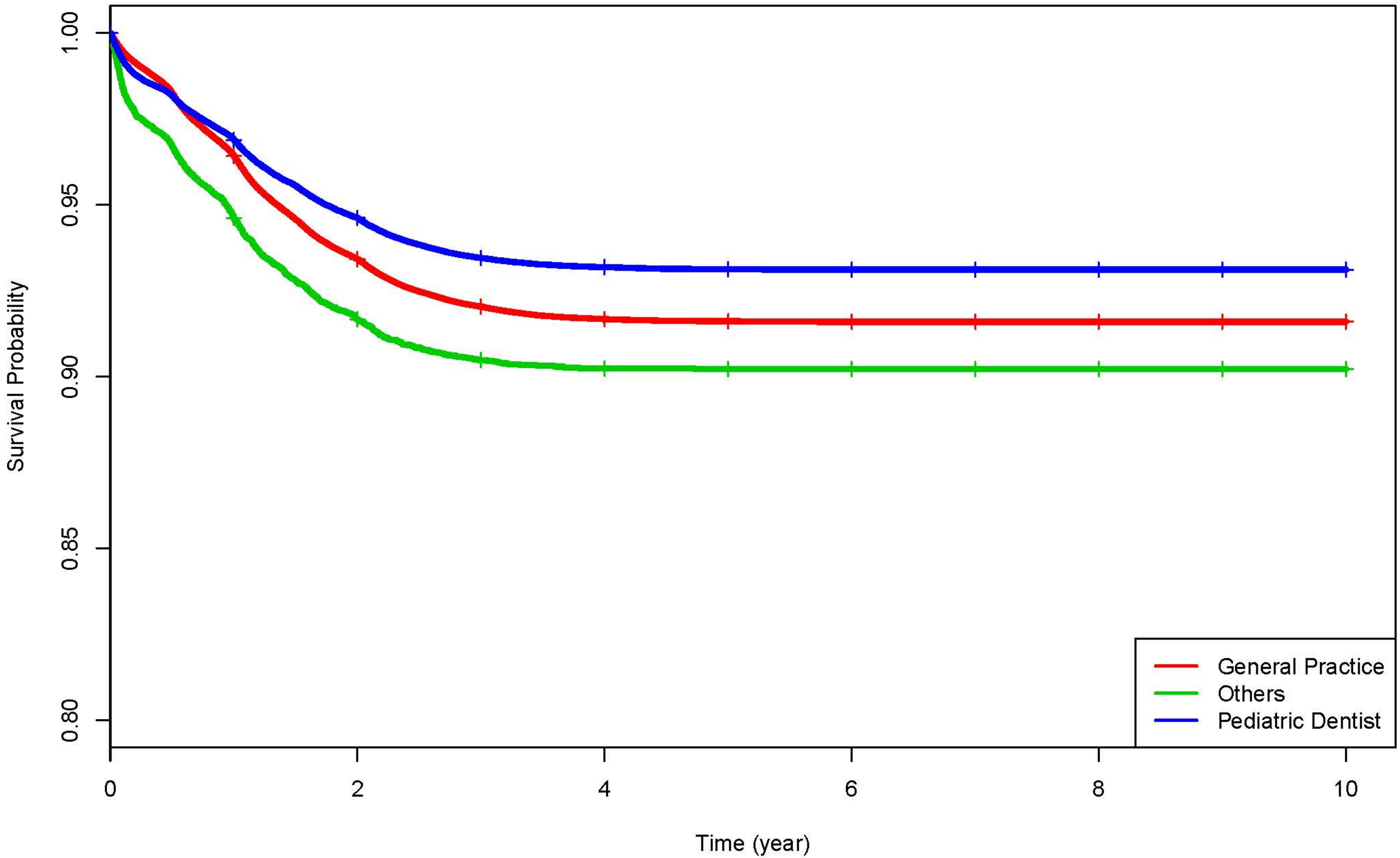
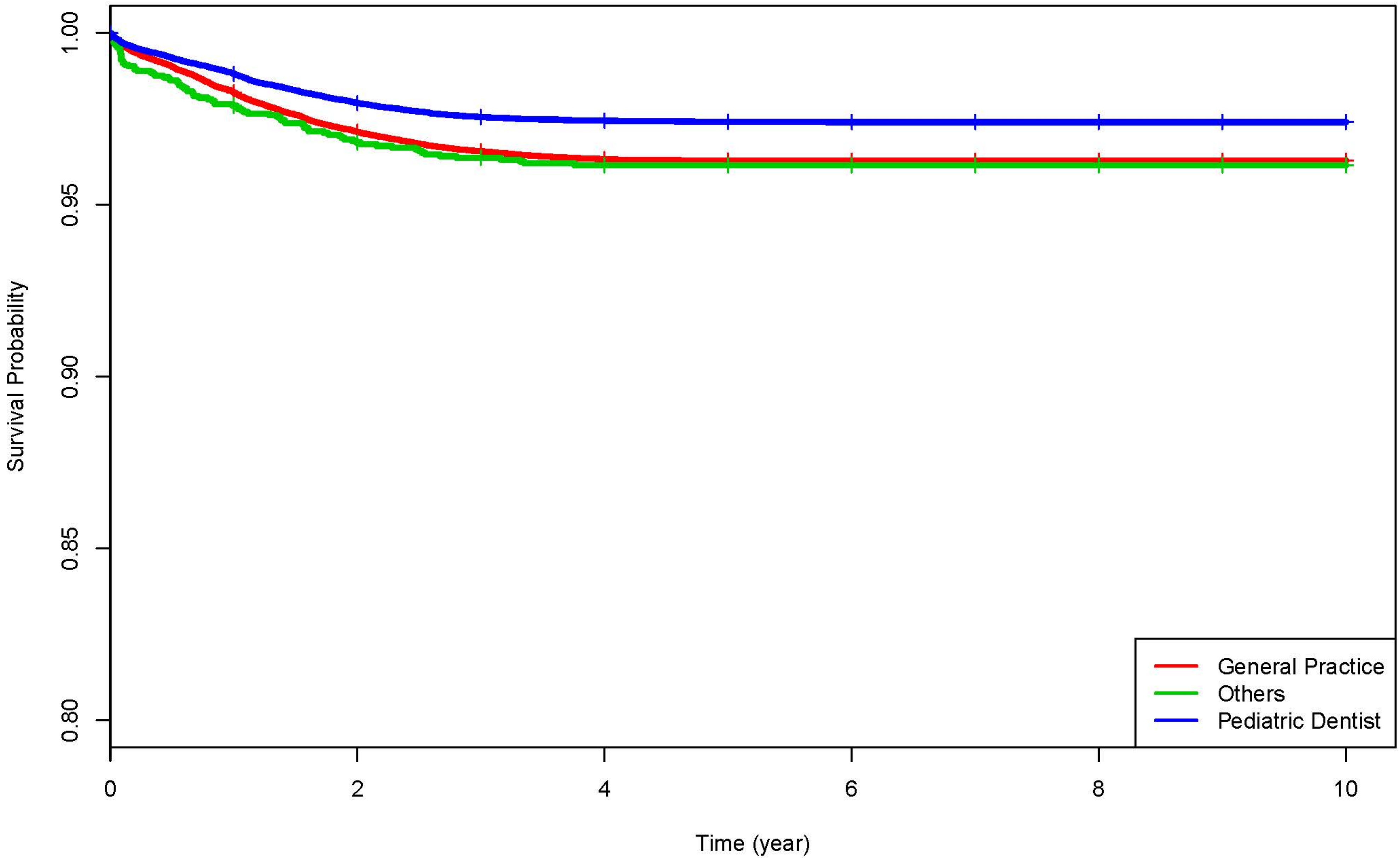

Natural tooth
Natural Exfoliation by age 11
Natural tooth
Extraction-D7111, D7140
Class 1 Restoration D2391, D2140
Natural Exfoliation by age 11
Class 2 or 3 restoration D2392-D2394, D2150, D2160, D2161
Class 2 or 3 restoration D2392-D2394, D2150, D2160, D2161
SSC-D2930 +/- Pulp cap-D3110, D3120 or pulpotomy-D3220, D3221, D3240
Extraction-D7111, D7140
Natural tooth
SSC-D2930
New SSC D2930 +/- Pulpotomy-D3220, D3221, D3240
Extraction-D7111, D7140



1.00
0.95
0.90
0.85
0.80
Survival Probability
0
2
4
6
8
10
Time (year)
direct restoration
ssc



Survival Probability
1.00
0.95
0.90
0.85
0.80
0
2
4
6
8
10
Time (year)
General Practice
Others
Pediatric Dentist



Survival Probability
1.00
0.95
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4
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8
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Time (year)
General Practice
Others
Pediatric Dentist