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The durability of primary molar restorations: II. Observations and predictions of success of stainless steel crowns

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Abstract

As part of a large retrospective study of the durability and lifespan of 2229 restorations in primary molars of 226 pediatric patients attending a dental school clinic, the histories of first-placement stainless steel crowns were examined. The histories of crowned primary molars in 131 patients were followed for up to 9 years, computerized, and their durability assessed in terms of crown replacements and length of service, using computer-appropriate definitions for failure and success. Of 331 crowns studied, 88% (N = 291, including 54 over formocresol pulpotomies) were successful either to tooth exfoliation or to the end of the study. The distribution of the 12% "true" failures (N = 40, including 19 over formocresol pulpotomies) showed a decreasing occurrence with increasing age of the child at first placement. The relative risk (odds ratio) for failed crowns to be associated with a formocresol pulpotomy was high (3.97). The mean lifespan of failed crowns increased with placement age (15.3 months for children younger than 4 years; 24.1 months for 4-7 year olds; and 28.8 months for those older than 7 years), while the mean lifespan of successful crowns was 68.2 months for children younger than 4 years. Use of this data pool allowed the statistical prediction that crowns placed in 4 year olds and younger show a success rate which is approximately twice that of Class II amalgams, for each year up to 10 years of service.

Literature Review

The stainless steel crown is an established approach to restoring a primary molar with 3 or more carious affected surfaces (McDonald 1983). Clinicians also weigh its use compared to amalgam for the restoration of molars with 2 extensively carious surfaces. The issue of durability of stainless steel crowns compared to multisurface amalgam restorations continues unresolved in the pediatric dental literature, and clinicians frequently select the restoration based upon personal experience.

Several investigators have attempted comparisons of durability in an effort to provide recommendations for the most appropriate restorative approach. From a clinical study of 79 stainless steel crowns and 150 multisurface amalgams placed in primary molars of 74 children by one pediatric dentist in private practice, and followed from the initial placement (mean age of child 4.2 years) until the teeth exfoliated, were extracted, or the patient failed to return for care, Braff (1975) reported a success rate (i.e., no need for replacement of initial restoration) of 70% for crowns and 11% for amalgams. The mean follow-up for crowns was 30.4 months and 33.5 months for amalgams. Later retreatment of crowned teeth involved an average of 0.4 visits per tooth, and retreatment of amalgam-restored molars required an average of 2.2 visits per tooth. Braff concluded that stainless steel crowns were significantly superior to multisurface amalgams in the restoration of primary molars and suggested crowns were more economical. The comparative lifespan of stainless steel crowns and two-surface amalgams was reported more recently in a retrospective study of 114 patient charts representing 280 restorations (Dawson et al. 1981). The average length of service of crowns in first and second primary molars was 40.2 months and 38.2 months, respectively, and 22.9 months and 22.7 months for two-surface amalgams. Before 8 years of age, 71.4% of two-surface amalgams needed replacement, whereas only 12.8% of crowned first molars and 11.8% of crowned second molars needed additional treatment. The authors concluded that the stainless steel crown was the restoration of choice for primary molars, particularly for multisurface lesions in the first molar, before eruption into occlusion of the first permanent molar (Dawson et al. 1981).

These retrospective studies were conducted on small samples of patients and restorations, and did not require evidence from both the progress notes and radiographs in assessing restoration failure or success. In an effort to overcome these deficiencies in clinical studies, a case historic approach (Gordon 1978; Lilienfeld and Lilienfeld 1980) has been used to develop a data pool of

first-placement restorations in primary molars to study restoration durability and lifespan, and predicting long-range success. The observations have been reported for amalgams (Levering and Messer 1988); this paper reports the findings on stainless steel crowns. The study objectives were to: (1) describe the durability of crowns in primary molars; (2) quantitate the length of service of the crowns; and (3) compare success predictions for crowns with those previously described by the authors for amalgams. The single criterion of whether the restoration ever required replacement was used to determine durability, using definitions adapted from Allan (1969) for failure and success. Since conditions under which a restoration was placed with respect to patient cooperation could not be determined retrospectively, the observations were classified by the age of the child at restoration placement.

Materials and Methods

Selection Criteria

The 7 criteria used to select 226 patients (123 males, 103 females) treated in the University of Minnesota Pediatric Dental Clinic have been described previously (Levering and Messer 1988). These records represented a data pool of 2229 first-placement restorations (1898 amalgams, 331 stainless steel crowns) in primary molars, placed by dental students between 1970 and 1982. Individual histories of crowned molars in 131 patients were taken from the records (progress notes and radiographs) by arrival condition and surfaces of treatment rendered thereafter, coded, and analyzed by the Statistical Analysis System (SAS) package program.

Fluoride History

Earlier we reported no statistically significant difference in the frequency of occurrence of first placements and replacements among primary molar amalgams with respect to fluoride history (Levering and Messer 1988). Therefore, the histories of crowned molars from patients with and without an optimal fluoride history were pooled.

Restorative Technique

All crowns were placed according to manufacturer's instructions[a] on traditional crown preparations using rubber dam and standard armamentarium (Finn 1967).

Of the 331 crowns, 73 were placed on vital primary molars following a one-step formocresol[b] pulpotomy using traditional procedures and armamentarium (Finn 1967).

[a] Ion Crowns — Minnesota Mining and Manufacturing Co; St Paul, MN, and Unitek Crowns — Unitek Corp; Monrovia, CA.

Criteria for Stainless Steel Crown Failure

Expanding the criteria of Allan (1969), crowns classified as "true" failures showed: evidence in the record of replacement (or need for replacement); any other form of retreatment (including pulpotomy); or tooth extraction (or need for extraction) due to pulpal or radicular pathology.

Since crowns were not examined clinically, a computer-appropriate definition was used to assign the time to failure of a crown. This was defined as the number of months between placement of the crown and the last treatment series in which the crown was recorded as successful, plus one-half of the time interval in months from the last record of success to the first treatment series in which the crown was recorded as a failure. This definition assumed that failure occurred at the midpoint between treatment series.

Criteria for Stainless Steel Crown Success

Expanding the criteria of Allen (1969), successful crowns showed the converse of the criteria for failure; i.e., no evidence of or need for crown replacement, retreatment including pulpal therapy, or tooth extraction.

The period of success was defined as the time interval in months between placement of the crown and the last treatment series in which the crown was recorded as successful. Successful crowns included those still present and deemed successful at the end of the study.

Distribution of Stainless Steel Crowns

Table 1 shows the distribution of crowns, the age range of the child at first crown placement, and the 4 observation periods (to: exfoliation; end of study; extraction; or crown replacement) over which crowns were followed. Of 331 crowns, 4% (N = 12) were initially placed in children younger than 4 years, 48% (N = 160) in

[b] Sultan Chemists Inc; Englewood, NJ.

TABLE 1. Distribution of Periods of Observation Available for 331 Stainless Steel Crowns in 131 Children

Period of Observation of Tooth After First Placement of Stainless Steel Crown	*Distribution of Stainless Steel Crowns (% total SSCs)*			
	<4 Years[a]	*4–7 Years*	*>7 Years*	*Total SSCs*
To tooth exfoliation	1 (0.1)	33 (10)	50 (15)	84 (25)
To end of study[b]	7 (3)	100 (30)	100 (30)	207 (63)
To tooth extraction	2 (0.6)	17 (5)	7 (2)	26 (8)
To replacement of crown	2 (0.6)	10 (3)	2 (0.6)	14 (4)
Total SSCs	12 (4)	160 (48)	159 (48)	331 (100)

[a] Age of child at first placement of stainless steel crown.
[b] Stainless steel crowns still successful at end of study.

those aged 4-7 years, and 48% (N = 159) in children aged older than 7 years. Of particular interest were 84 crowns followed to tooth exfoliation, because they were judged successful from first placement to physiological tooth loss. The largest group, 207 crowns followed to the end of the study, were successful with an unknown outcome. Failure was indicated by crowns later replaced (N = 14) or the tooth extracted (N = 26).

Results

Table 2 shows the distribution of crowns by outcomes. Of the 331 crowns studied, 12% were judged true failures (N = 40), and 88% successful (N = 291). With increasing age of the child at first placement of the crown, the percentage of true failures showed a fourfold decrease (25, 18, and 6%), and the percentage of successful crowns showed a corresponding increase (75, 82, and 94%).

Of a total 73 pulpotomies, 19 failed (16 + 3), resulting in extraction, and 54 (1 + 30 + 23) were successful (Table 2). Sixteen pulpotomy failures were seen in 4-7 year olds, contributing to the high failure rate of crowns in this age group. The odds ratio (Lee 1980) to determine relative risk was used to examine these data. For crown failures, the odds of the tooth having a pulpotomy was high (0.90); for successful crowns, the odds of having a pulpotomy was low (0.23). The odds ratio for failed crowns to be associated with a pulpotomy was high (3.97). Thus, for the group of failed crowns, the relative risk of being associated with a pulpotomy was higher than in the group of successful crowns. Among crown failures, the mean time to failure increased with increasing age of the child at crown placement (15.3, 24.1, 28.8 months); overall, the mean lifespan of the 40 failed crowns was 24.5 months The 291 successful crowns included those still present in the dentition at the end of the study (N = 207, Table 1), therefore, the mean time of recorded success (68.2 months for children younger than 4 years; 36.1 months for 4 years and older) must be considered minimal values.

The long-term success of stainless steel crowns was explored, using the Weibull statistical distribution.[1] Predictions of failure were computed for 1- to 10-year periods of service. Table 3 (next page) shows that, for periods of service of 1-7 years, crowns placed in children aged under four years are predicted to have a higher failure rate than those placed in children 4 years and older. This trend is greatest for the lower periods of service and thereafter diminishes until 8 years when 32% of crowns are predicted to fail in both age groups. Subsequently, the failure rate is slightly higher in the older age group than the younger age group. Table 3 repeats the previously published predictions for Class I and Class II amalgams (Levering and Messer 1988) to allow comparisons. In comparing crowns with Class I amalgams, crowns placed in children younger than 4 show a slightly higher failure rate for 1-6 years of service, a similar rate for 7 and 8 years, and a slightly lower rate for 9 and 10 years of service. In comparison with Class I amalgams in the older age group, crowns show very similar failure rates for 1-3 years of service; thereafter, crowns show an increasingly higher failure rate, rising to 39% by year 10. In comparing crowns with Class II amalgams, crowns placed in the younger age group show a failure rate approximately half that of amalgams, for each year up to 10 years of service. This trend is also apparent in the older age group, but the failure rate of crowns is slightly less than half that of Class II amalgams for each year up to 10 years of service.

The converse of the percentage failure figures shown in Table 3 represent the percentage successes predicted.

[1] Kapur and Lamberson 1977; Lee 1980; Schlesselman 1982.

TABLE 2. Distribution of Recorded Outcomes of 331 Stainless Steel Crowns With Reference to Age of Child at Crown Placement and Mean Times to Failure or Success

Recorded Outcome of Stainless Steel Crowns	*Distribution of Recorded Outcomes (% total SSCs)*[a]									*Total SSCs*
	<4 Years[b]			*4–7 Years*			*>7 Years*			
	FCP[c]	*No. FCP*	*Total*	*FCP*	*No. FCP*	*Total*	*FCP*	*No. FCP*	*Total*	
"True" failure:										
Number SSCs	0	3	3 (25)	16	12	28 (18)	3	6	9 (6)	40 (12)
Mo. to failure as mean ± SD		15.3 ± 17.1			24.1 ± 15.7			28.8 ± 21.4		
Success:										
Number SSCs	1	8	9 (75)	30	102	132 (82)	23	127	150 (94)	291 (88)
Mo. to success[d] as mean ± SD		68.2 ± 11.0			36.1 ± 16.3			36.1 ± 16.3		
Total SSCs	1	11	12 (100)	46	114	160 (100)	26	133	159 (100)	331 (100)

[a] Percentage of crowns with or without formocresol pulpotomies in each age group.
[b] Age of child at first placement of stainless steel crown.
[c] FCP refers to treatment of the primary molar with a vital formocresol pulpotomy in association with first placement of a stainless steel crown.
[d] Number of months of success is a minimal value since this group includes stainless steel crowns still successful at the end of the study.

Table 3. Prediction of Failure of Class I and Class II Amalgams and Stainless Steel Crown Restorations with Reference to Age of Child at First Placement of the Restoration

Predicted Time to Failure (years)	Percentage Prediction of Failure (95% confidence limits)[a]					
	<4 Years[b]			≥4 Years		
	Class I Amalgam	Class II Amalgam	Stainless Steel Crowns	Class I Amalgam	Class II Amalgam	Stainless Steel Crowns
1	5% (0.02, 0.09)	17% (0.12, 0.24)	8% (0.01, 0.41)	4% (0.02, 0.06)	6% (0.05, 0.08)	3% (0.02, 0.06)
2	9 (0.05, 0.18)	28 (0.20, 0.38)	13 (0.02, 0.58)	7 (0.05, 0.12)	13 (0.11, 0.16)	7 (0.04, 0.13)
3	14 (0.07, 0.25)	37 (0.26, 0.49)	17 (0.03, 0.69)	11 (0.07, 0.17)	19 (0.16, 0.23)	11 (0.06, 0.20)
4	18 (0.09, 0.32)	44 (0.32, 0.57)	21 (0.04, 0.76)	14 (0.09, 0.21)	25 (0.21, 0.30)	15 (0.08, 0.27)
5	21 (0.11, 0.38)	49 (0.37, 0.64)	24 (0.04, 0.81)	17 (0.11, 0.25)	30 (0.25, 0.36)	20 (0.11, 0.34)
6	25 (0.13, 0.44)	55 (0.41, 0.69)	27 (0.05, 0.85)	19 (0.13, 0.29)	35 (0.29, 0.41)	24 (0.13, 0.41)
7	29 (0.15, 0.49)	59 (0.45, 0.73)	29 (0.06, 0.88)	22 (0.14, 0.33)	40 (0.33, 0.46)	28 (0.16, 0.46)
8	32 (0.17, 0.54)	63 (0.49, 0.77)	32 (0.06, 0.88)	25 (0.16, 0.37)	44 (0.37, 0.51)	32 (0.18, 0.52)
9	35 (0.19, 0.58)	66 (0.52, 0.80)	34 (0.07, 0.92)	27 (0.18, 0.40)	48 (0.41, 0.55)	35 (0.20, 0.57)
10	38% (0.21, 0.62)	69% (0.55, 0.83)	36% (0.07, 0.93)	29% (0.19, 0.43)	51% (0.44, 0.59)	39% (0.23, 0.62)

[a] Prediction based upon the Weibul statistical distribution with lower and upper confidence limits.[11-13]
[b] Age of child at first placement of the restoration.

For example, using the 24% failure prediction for crowns, it is predicted that 76% of crowns first placed in children 4 years and younger would be successful for at least 5 years of service, and 76% of crowns placed in those aged 4 and older would be successful for at least 6 years of service. Similarly, from the 32% failure rate of crowns predicted for both age groups, it is predicted that 68% crowns would be successful for at least 8 years.

Discussion

The stainless steel crowns placed in the present study by dental students showed comparable or slightly better experience of success than those cited in earlier reports where restorations were placed by experienced clinicians (Braff 1975; Dawson et al. 1981). The present success of 88% crowns is similar to the 87.2% (first molars) and 88.2% (second molars) cited by Dawson et al. (1981) for successful crowns which did not require additional treatment by the age of 8 years, and is superior to the 70% reported by Braff (1975) studying 79 primary molar crowns. The relatively high number of failed pulpotomies (N = IG) in the 4- to 7-year-old group was a major factor in the high failure rate among these crowns. Other authors have not identified the relative contribution made by pulpal therapy to the outcome of crowns.

In comparing lifespans of crowns with those reported in the literature, interpretive care is required since other authors combine the months of service provided by failed restorations with those still judged successful, in computing mean lifespans. The present study separates these outcomes, and success figures in months are necessarily conservative since this group combines those crowns successful to tooth exfoliation with those still successful at the end of the study. Therefore, the lifespans to failure ranging from means of 15.3 to 28.8 months and the lifespans of ongoing success ranging from means of 36.1 to 68.0 months are not comparable to the 38.2 months (for second molars) and 40.2 months (for first molars) reported by others as lifespans for crowns (Dawson et al. 1981). In addition, exfoliating crowned molars in the older age groups reduce the months of success.

The findings of the present study comparing the durability and lifespans of crowns and Class II amalgams, and demonstrating the superiority of the crowns, support the conclusions of others that crowns are a more durable restoration (Braff 1975; Dawson et al. 1981). Clinically, the statistical predictions made suggest that, under conditions comparable to those of the present study, if a choice exists between a Class II amalgam and a crown in a child younger than 4 years, and the restoration is desired to last for up to 10 years, the likelihood of failure of the amalgam is approximately twice that of the crown, for a similar lifespan. If such a choice is to be made for a child 4 years or older, the likelihood of failure of the amalgam is a little less than twice that of the crown for a similar lifespan. If a choice between a Class I amalgam and a steel crown is under consideration, and particularly in a child younger than 4 years, either restoration will have a similar likelihood of success and the decision may be based on other factors.

Predictions can be further exemplified, (Table 4, next page) by considering the hypothetical situation of the 3 restoration types (Class I amalgam, Class II amalgam, crown) being placed in primary molars of 2 children, ages 3 and 6 years, and then followed to tooth exfoliation at age 10 (i.e., 7 and 4 years of service, respectively). Within the bounds of 95% confidence limits, the predicted failure of Class I amalgams is approximately half that of Class II amalgams, but is very similar to that of crowns after 7 years of service for placements in the 3 year old (both 29%) and also after 4 years of service for placements in the 6 year old. Success predictions for all 3 restoration types in the older child are approximately

twice that of the younger child. Therefore, in a population similar to that followed in the present study, a dentist could expect 86% of Class I amalgams, 75% of Class II amalgams, and 85% of crowns placed in 6 year olds to be successful for 4 years.

TABLE 4. Hypothetical Prediction of Failure of Class I and Class II Amalgams and Stainless Steel Crowns Based Upon the Child's Age at First Placement of Restoration

Age of Child At First Placement of Restoration	*Desired Period of Service of Restoration*[b]	*Hypothetical Percentage Prediction of Restorations That Will Fail (95% confidence limits)*		
		Class I Amalgam	*Class II Amalgam*	*Stainless Steel Crowns*
3 years	7 years	29 (0.15, 0.49)	59 (0.45, 0.73)	29 (0.06, 0.88)
6 years	4 years	14 (0.09, 0.21)	25 (0.21, 0.30)	15 (0.08, 0.27)

[a] Predicted based on the Weibul statistical distribution with lower and upper confidence limits (Kapur and Lamberson 1977; Lee 1980; Schlesselman 1982).
[b] Assumes a 10-year period of service of the tooth, to exfoliation.

Conclusions

Based on a retrospective audit of stainless steel crowns placed by dental students in primary molars, the following conclusions are drawn:

1. The success of crowns placed on primary molars increases with age of the child at initial placement.
2. Crowns placed over formocresol pulpotomies show a greater relative risk (3.97 times) of failure than those placed over vital coronal pulps.
3. Crowns placed in children younger than 4 years are predicted to show a success rate which is approximately twice that of Class II amalgams, for each year up to 10 years of service.

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