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RETROSPECTIVE STUDY

Retrospective Study of Retention of Stainless Steel Crowns and Pre-veneered Crowns on Primary Anterior Teeth

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Abstract: ***Purpose:*** *The purpose of this retrospective chart review was to explore the retention of anterior pre-veneered stainless steel crowns (NuSmile) and conventional stainless steel crowns (3M ESPE) placed on primary anterior teeth.* ***Methods:*** *Records for children were reviewed over four years using the electronic record system axiUm. Data collected included child's age at time of crown placement, date of placement, tooth number, type of crown, patient behavior, treatment environment, provider type, crown presence, absence, and cementation success or failure at subsequent recall visits.* ***Results:*** *A total of 637 anterior crowns in children treated with either or both crown types met this study's inclusion criteria. Of these crowns, 483 were NuSmile Signature crowns and 154 were stainless steel crowns. There was a nine percent failure rate for the NuSmile Signature crowns and a seven percent failure rate for the stainless steel crowns. There was no statistically significant difference in crown retention rates between the two groups (P<0.05).* ***Conclusions:*** *A full-coverage restoration that can follow the lifespan of the primary anterior dentition in high-risk children is needed. The results from this study indicate good crown retention rates for both crown types with no statistically significant difference between them (P<0.05).* *(Pediatr Dent 2015;37(7):530-4) Received February 10, 2015 / Last Revision July 25, 2015 Accepted July 28, 2015*

KEYWORDS: ANTERIOR PRIMARY TEETH, PRE-VENEERED STAINLESS STEEL CROWNS, RETENTION

For decades now, early childhood caries (**ECC**) has persisted as a significant problem in dental health care, challenging our preventive, diagnostic, and restorative skill sets.[1] ECC is most common in 18- to 36-month-old children, although it can be seen at even younger ages.[1] At this young age, these children lack the cognitive abilities to cope and are often uncooperative with treatment. Behavior can sometimes limit the treatment choices of the clinician. Conscious sedation or general anesthesia may be needed, and a failing restoration can present a significant problem regarding replacement.[2] It is important to note that many high caries risk children grow up in lower socioeconomic groups,[3] where follow-up is inconsistent and retreatment may not be an option for financial reasons or due to distance traveled for care.

Restoration of primary anterior teeth is quite challenging, even if behavior is removed from the equation. The small clinical crown, relatively large size of the pulp chamber, proximity of the pulp horns to the interproximal surface, and thin enamel require a restoration that is conservative in depth, with close attention to detail paid to both the preparation itself and the material placed.[4] According to the clinical guidelines of the American Academy of Pediatric Dentistry[5] and supporting studies, full-coverage restorations for anterior carious incisors are indicated in any of the following circumstances: (1) caries is present on multiple surfaces; (2) the incisal edge is involved; (3) there is extensive cervical decalcification; (4) pulpal therapy is indicated; (5) caries may be minor, but oral hygiene is very poor (high-risk patients); (6) the child's behavior makes moisture control very difficult, creating difficulties for Class III restorations[4]; (7) children who require general anesthesia should be given strong consideration for the use of stainless steel crowns.[5,6]

There have been six common types of full-coverage restorations offered for anterior primary teeth, but each present with limitations.[7] Preformed polycarbonate crowns have poor retention and excessive wear, and placement is difficult; therefore, these crowns are not used today.[7] Resin crowns, or strip crowns, are more esthetic, but their retention depends on the amount of enamel present after caries removal. They are also very technique-sensitive.[7] Many feel the open-faced stainless steel crown (**SSC**) is the most time-consuming of all the crowns to complete and lack the esthetic appeal expected by parents.[7] The SSC is relatively easy to place and durable and can be used on teeth with little remaining tooth structure[6]; however, SSCs have no esthetic value at all. In fact, some parents reported that they would rather have the incisors extracted if metal crowns were the only restorative option.[8] Pre-veneered stainless steel crowns (**PVSSCs**), such as the NuSmile Signature crown (NSC; Orthodontic Technologies of Houston, Houston, Texas, USA), emerged in the 1990s and were developed to remedy the concern for a more esthetic option.[8] These PVSSCs are likely the most widely used esthetic anterior restoration today. The zirconia crown is the newest addition to the armamentarium among manufacturers of esthetic pediatric crowns and is quickly growing in popularity.

While there are several studies that have reviewed the performance of crowns on posterior primary teeth, there seem to be little published data on the use of SSCs on anterior teeth.[9] In 2003, Guelmann et al. conducted a laboratory study investigating retention of Kinder Krowns (Mayclin Laboratory,

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Minneapolis, Minn., USA), NuSmile Signature crowns (NuSmile, Houston, Texas, USA), Dura crowns (Space Maintainers Laboratory, Chatsworth, Calif., USA), and Unitek stainless steel crowns (3M, ESPE St. Paul, Minn., USA) on a typodont model and found that, when both crimping and cementing were completed, the Kinder Krown proved to be the most retentive.[10]

Two papers studied the clinical success rates and parental satisfaction of PVSSCs. Roberts, et al. reported on Whiter Biter II crowns (Whiter Biter Inc, Exeter, Calif., USA), which are no longer available, and Shah, et al. investigated Kinder Krowns.[11,12] Roberts evaluated 38 Whiter Biter crowns in 12 children. Although 24 to 32 percent of crowns lost some or all of their resin facings, parental satisfaction was still excellent, and crown retention to the tooth was found to be 100 percent.[11] Shah evaluated 46 teeth with Kinder Krowns in 12 children and also found positive parental satisfaction, with all crowns being retentive at 100 percent during the three-year recall period; all crowns were placed under ideal conditions using general anesthesia.[12] Finally, the most recent study to evaluate clinical success of primary teeth treated with preveneered crowns was published in 2007 by Maclean et al.[13] Their study evaluated the NuSmile Signature crown. This retrospective study had a large sample size of 226 NuSmile Signature crowns in 46 patients but a fairly short evaluation timeline of nine months on average. This study evaluated many variables, such as crazing, fracture, and wear, and found the retention rate of the NuSmile Signature crowns was 99 percent at the evaluation time.

SSCs have been the easiest and most durable full-coverage restoration for decades, and the addition of the PVSSCs, such as NuSmile Signature crowns, resolves many of the esthetic concerns of parents. Still, they are relatively inflexible, allow for very limited crimping to increase retention, and must fit onto the teeth passively, requiring significant removal of tooth structure.[7,8]

Despite these drawbacks, PVSSCs still remain very popular among practicing clinicians. Although studies have compared the clinical success of these PVSSCs to one another, there has yet to be a study comparing their retention rates to the classic SSC.

The purpose of this retrospective chart review was to compare the clinical retention rates of NuSmile Signature preveneered crowns (**NSCs**) and conventional stainless steel crowns, two of the most commonly used restorations for full coverage of primary maxillary anterior lateral and central incisor teeth in pediatric patients. The retention rate in relation to patient behavior and the treatment environment (sedation, general anesthesia, nitrous oxide/oxygen) and age of the patient, were also examined.

Methods

Sample selection. The University of Texas Health Science Center at San Antonio (**UTHSCSA**) Institutional Review Board approved this retrospective chart review. This chart review was conducted using electronic dental records from the Laredo Health Department Dental Clinic serviced by pediatric dental residents, dental students, and faculty of the University Health Science Center San Antonio Laredo Regional Campus in Laredo, Texas, USA. Patient samples were identified using a search for the CDT codes D2934 for PVSSCs (**NSC**) and D2930 for SSCs via axiUm software (axiUm, Coquitlam, BC, Canada). One examiner reviewed dental records and evaluated chart data. The data were collected from patients who fit the inclusion criteria, and a list of eligible records was generated.

Criteria. Data collected at the time of the crown placement included: patient age; tooth number; cementation of NSC or SSC; patient behavior; and treatment environment. Data collected from subsequent recall visits included: number of months the crown remained on the tooth; current status of the crown; (present, lost to trauma, natural exfoliation, infection); loss of crown from the tooth; and recementation. If the patient returned for subsequent recalls, the status of the crowns was followed using the patient's clinical notes and charts until the end of the study. Radiographs were referenced if chart notes lacked detail regarding the teeth of interest to the study. A recall visit of at least six months was used to verify crown retention, and if the patient did not return for a six-month recall, those charts were excluded. If a crown debonded and was able to be recemented, based upon the health of the remaining tooth structure, it was recorded. Reasons why a crown was not recemented included presence of an infection requiring extraction, mobility due to natural exfoliation, or trauma requiring the remaining tooth be removed. The criteria for inclusion for this study were: (1) primary maxillary anterior lateral and central incisor teeth with caries lesions treated with full crown restorations; (2) restorations placed between the study time January 2009 to June 2013; (3) healthy ASA I and ASA II patients; (4) crowns completed under the care of UTHSCSA Laredo pediatric dental residents, pediatric dentistry faculty, or dental students; (5) crowns that could be followed for at least one six-month recall appointment.

Analysis. The assessment of whether a crown was retained on the tooth was based upon chart note documentation, indicating crown presence, absence, or recementation. Radiographs were used to supplement chart notes if a doctor was able to obtain radiographs. A clinical success was recorded when the crown remained on the tooth at least six months and was recorded as retained until failure or when the tooth naturally exfoliated. A crown was considered to fail if the crown debonded (retention loss) from the tooth. A crown lost to trauma or tooth loss due to pulpal infection were not considered a retention failure, since unknown factors, such as type of traumatic injury or possible unknown pulp exposure during tooth preparation, could have played a role in crown or tooth loss.

Table 1. BEHAVIOR RATINGS USED TO QUANTIFY BEHAVIOR

Behavior rating	Behavior description
Excellent	Quiet and cooperative
Good	Whimper with mild objections
Fair	Crying with minimal disruption
Poor	Struggling, interfering with treatment
Unknown	Behavior not recorded by provider

Variables such as child age at placement, type of crown, patient behavior, treatment environment, provider type, and crown presence, absence, or recementation were also collected from the patient electronic record and presented as percentages. Behavior was evaluated as either being excellent, good, fair, poor, unknown, or not applicable due to the use of general anesthesia (**GA**). The definitions are represented in Table 1. Behavior ratings of excellent or good were grouped together. The treatment environments/behavior management for crown placement was either GA, conscious sedation (**CS**), nitrous oxide/oxygen (**N**), or no management needed.

The retention status of the NSCs and SSCs, classified as either still present in the mouth, not present due to natural exfoliation of the tooth, or extracted due to trauma, infection, or over-retention of the tooth in the mouth, was reported as percentages. The difference in the results between the retention rates of the esthetic anterior NSCs versus the conventional SSCs was analyzed using the student's *t* test. Descriptive statistics allowed for averages to be calculated. Differences in the length of time the successful crowns remained bonded to the tooth were analyzed using the Mann-Whitney rank sum test. A significance level was considered at 95 percent ($P<0.05$).

Results

A total of 637 primary maxillary anterior crowns in children previously treated with either or both of the crown types met the inclusion criteria for this study. A total of 483 (76 percent) were NSCs and 154 (24 percent) were traditional SSCs; 55 (eight percent) were placed by faculty, 580 (91 percent) by either first or second year residents, and two (one percent) by pre-doctoral dental students. A total of 582 crowns were fully retained, according to the criteria of this study: 439 (91 percent) of the NSCs and 143 (93 percent) of the SSCs. The average age of the child at crown placement was 47±13 months. The mean time between placement and evaluation was 18±11 months.

Statistical analysis. The crowns observed over a four-year time span in this study were placed between January 2009 and June 2013 and required at least one follow up within six months. During the evaluation time, 44 (nine percent) NSCs failed to be retained and 11 (seven percent) SSCs failed; there was no statistically significant difference in crown retention rates between the two crown types ($P<0.05$).

SSCs were retained significantly longer than NSCs (27±16 months and 17±10 months respectively; $P<0.001$). Crowns retained on the teeth during this study period were placed at similar ages in the children for both crown types—an average of 48 months old for SSCs and 45 months old for NSCs. Table 2 summarizes these results.

Treatment characteristics. This study also examined child behavior at the time of crown placement and the treatment environment/behavior management. Of the 439 retained NSCs, 126 (29 percent) were placed on patients exhibiting excellent/good behavior, 36 (eight percent) on patients exhibiting fair behavior, 13 (three percent) on patients exhibiting poor behavior, 262 (60 percent) on patients under GA (behavior did not apply), and two (one percent) on patients who did not have behavior recorded. Of the 143 retained SSCs, 32 (22 percent) were placed on patients exhibiting excellent/good behavior, 23 (16 percent) on patients exhibiting fair behavior, 24 (17 percent) on patients exhibiting poor behavior, and 64 (45 percent) on patients under GA (behavior did not apply).

Of the 439 successful NSCs, 262 (60 percent) were placed on patients under GA, 159 (36 percent) on patients with CS, 17 (four percent) on patients with N, and one patient (0.02 percent) with no management needed. Of the 143 Successful SSCs, 64 (45 percent) were placed under GA, 13 (9 percent) on patients with conscious sedation, 63 (44 percent) on patients with N, and three (two percent) with no management needed. Results are shown in Table 3 and reflect both the number and percentage of retentive crowns in relation to the behavior management that was used.

When reviewing the history of the retained NSCs placed over a four-year span, we found that 352 (80 percent) were still present in the mouth at the most recent recall (average of 18±11 months). Sixty-two (14 percent) were retained and exfoliated naturally, and 25 (six percent) were eventually lost, either due to trauma or infection that required extraction of the tooth with the NSC still bonded.

When reviewing the history of the retained SSCs, 85 (59 percent) were still present at the patients' most recent recall, 38 (27 percent) were retained at the time of natural exfoliation, 18 (13 percent) were lost due to infection of the tooth, and two (one percent) needed to be extracted because they became over-retained in the mouth.

Of the 55 crowns that debonded (failure), 44 (nine percent) were NSCs and 11 (seven percent) were SSCs. Thirty-five (80 percent) of the NSC failures were recemented and did not experience subsequent problems; however, one was replaced by an SSC. The reason for this was not documented in the patient chart. Five (11 percent) were not recemented due to the presence of infection, and two (four percent) were not replaced, because the teeth were near natural exfoliation. Two (four percent) NSC crowns debonded multiple times. A review

Table 2. RESULTS: CROWN RETENTION VERSUS CROWN LOSS OF 637 ELIGIBLE CROWNS

Crown type	Crowns retained N (%)	Crowns lost N (%)	No. of months crowns followed Mean±SD
483 NuSmile	439 (91)	44 (9)	17±10
154 SSC*	143 (93)	11 (7)	27±16

* SSC=stainless steel crown.

Table 3. BEHAVIOR MANAGEMENT TECHNIQUE AND THE RESULTING RETENTIVE CROWNS

Behavior management	NuSmile N (%)	Stainless steel N (%)
General anesthesia	262 (60)	64 (45)
Sedation	159 (36)	13 (9)
Nitrous oxide/oxygen	17 (4)	63 (44)
None	1 (0.2)	3 (2)

of the failure history of the 11 debonded SSCs revealed that nine (81 percent) were recemented and did not experience subsequent problems. Two SSCs were not recemented, as the tooth was either near exfoliation or it had an infection requiring extraction.

Discussion

This is the first known retrospective study comparing retention rates of the popular prefabricated resin-veneered stainless steel NSC to the gold standard SSC. Previous studies repeatedly showed SSCs to be highly retentive for anterior and posterior restorations in the primary dentition.[6,10,11] Roberts et al. reviewed the clinical retention of Whiter Biter crowns, which are resin-faced SSCs. In this study, all the crowns were placed while the child was under general anesthesia.[10] Not all children can go to the operating room or have enough decay to justify general anesthesia; hence, a study that considers retention of crowns placed under different treatment environments was warranted. The present study confirmed that both NSCs and SSCs perform equally well in terms of retention (91 percent and 93 percent retention rates, respectively).

This data collected showed a statistically significant difference regarding longevity for the two crowns reviewed (Table 2). The SSCs were recorded to be in the mouth close to 10 months longer than the NSCs. When the Laredo clinic opened, the NSCs were not available in the clinic; therefore, SSCs were the only full-coverage anterior restorations for primary teeth. Approximately six months after the Laredo clinic opened, the decision was made to purchase the NSCs and initiate their use for full coverage of anterior primary teeth. The use of the NSCs slowly increased over the next six months as the dentists practicing in the clinic became more accustomed to preparation design and placement technique of the crowns. Therefore, although there was a significant difference in longevity for the two crowns evaluated, the difference may have occurred simply because the NSCs were not available the first six months of the clinic operation. Additionally, there was a gradual increase in the use of the NSCs over the next few months, making the use of SSCs more common during the first year of the clinical program. However, the failed retention rates for both crowns were less than 10 percent; therefore, both crowns should be considered as a highly retentive, protective restoration option for the primary maxillary anterior teeth in a high-risk population.

PVSSCs require increased preparation of tooth structure, cannot be crimped, and must fit on the tooth passively as opposed to their stainless steel counterparts, which can be contoured to fit the tooth. These differences may have played a role in crown selection in this study. When behavior was excellent, good, or non-contributory in general anesthesia cases, the clinician placed a slightly higher number of NSCs; when behavior was fair or poor, the clinician placed a higher number of SSCs. Perhaps they were chosen for their ease of placement during moments of challenging child behavior.

Unfortunately, this study did not evaluate parental satisfaction of either crown, nor did it consider crazing or loss of resin facing of the NSC as factors contributing to success or failure. Loss of resin facing or chipping was not recorded in our charts and cannot be evaluated on a radiograph; we simply did not have this data to report. Walia et al. conducted a recent randomized controlled study that examined the clinical outcomes of 129 teeth treated with resin strip crowns, pre-veneered stainless steel crowns, or zirconia crowns. Outcomes of these crowns were evaluated and included restoration failure, tooth wear of opposing teeth, and gingival health over a six-month period. Zirconia crowns were fully retained (100 percent), followed by the pre-veneered SSCs at 95 percent. Strip crowns were retained at 78 percent.[14]

For our purposes in a high-risk population, success was considered to be crown retention to the tooth. Children at high risk for caries or with ECC often require conscious sedation or general anesthesia, and a failing restoration can mean a significant problem regarding replacement. A crown can still serve its purpose as a full-coverage restoration with or without the resin facing, but the loss of resin facing can be a major concern for parents and school-age children. Given the similar retention rates displayed by these two restorations, and considering the significant esthetic differences between them, the use of the more esthetic PVNSC crowns should be strongly considered when choosing between restorative options.

Conclusions

Based on this study's findings, the following conclusions can be made:

1. During the study period, stainless steel crowns and NuSmile Signature crowns both appeared to be highly retentive restorations for primary maxillary anterior central and lateral incisor teeth, with less than 10 percent of crowns being lost.
2. SSCs were retained significantly longer than NSCs.

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