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ORIGINAL RESEARCH

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Evaluation of periodontal health in healthy primary molars in comparison with molars restored with stainless steel crowns

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Abstract

Background: Children with large carious lesions are best treated with stainless-steel crowns (SSC). However, few studies have evaluated periodontal health after SSC restorations. **Methods**: A total of 33 children between the ages of 4 and 10 with primary molars restored with SSC were included in the study. SSC-restored molars and healthy primary teeth were evaluated for gingival status. Gingival and periodontal parameters evaluated included plaque index, plaque accumulation, gingival index, probing depth, and bleeding on probing. **Results**: Gingival inflammation scores were significantly higher in SSCs than in healthy teeth. Plaque accumulation, gingival index, probing values, and bleeding were significantly higher in SSC-treated molars than in healthy teeth. **Conclusions**: Molars restored with SSCs had higher gingival inflammation scores and deteriorated gingival health than healthy molars.

Keywords

Stainless steel crowns; Primary molars; Gingival health

1. Introduction

Primary teeth are vital to oral cavity and should be preserved until they naturally erupt. Dental caries, however, is one of the most prevalent diseases among children. Often, extensive carious lesions in primary teeth make restoration challenging. Current scientific evidence suggests that stainless steel crowns (SSCs) are the best restorative options for these cases [1–3].

Children may develop chronic marginal gingivitis after extensive dental restorations, which progresses to periodontitis in puberty. Often, ill-fitting crowns and subgingival margins cause this condition by accumulating dental plaque. SSCs for primary teeth are pre-formed and have a subgingival margin [4]. It is possible for microorganisms to attach to crowns, causing gingivitis or secondary caries [5, 6].

SSCs are comparatively less likely to cause periodontal disease than healthy teeth, according to the current literature. Zirconia crowns have better gingival health than SSCs due to their supragingival margins [6–8]. SSCs had greater plaque deposition and gingival inflammation than zirconia crowns, but zirconia crowns wear the antagonist teeth further and cause chipping [8]. However, few studies comparing SSCs to healthy teeth reported worse periodontal health in crowned teeth [9, 10].

A better understanding of the connection between SSCs and gingivitis in children needs to be conducted.

This study aimed to compare periodontal health and plaque accumulation in primary molars rehabilitated with SSCs and healthy primary molars. We hypothesized that primary molars restored with SSCs present worse periodontal health than healthy ones. Neither group exhibits significant differences in periodontal health, according to the null hypothesis.

2. Materials and methods

This split-mouth clinical trial was conducted with 33 children at the Department of Pediatric Dentistry of the Dental Hospital of the University of Barcelona (UB). The split-mouth study protocol was carried out and approved by the ethics committee of the Dental School of the University of Barcelona (protocol 40/2021 on 26 October 2021). It was conducted during February, March, April and May of 2023. Upon explanation of the study's purpose and procedure to parents or legal guardians, informed consent was obtained.

Inclusion criteria: (1) healthy (classification of American Society of Anesthesiologists (ASA) I and II); (2) 4–10 years old; (3) at least one primary molar restored with SSCs (D or E) and another healthy primary molar (D or E). Patients took antibiotics within three weeks before sample collection and patients who had a professional dental cleaning by a health professional in the last month were excluded. Exclusion criteria: (1) ASA III; (2) non-consenting parents or guardians; (3) patients who have difficulty removing plaque; (4) non-cooperative patients. 33 patients were selected (18 boys and 15 girls). 4 to 10 years old, with a mean age of 6. Before collecting samples, the principal investigator examined all subjects clinically. A professor from the University of Barcelona's Master's Degree in Pediatric Dentistry supervised the placement of

SSCs. Students followed the following protocol: removal of the carious lesion and pulp treatment if needed, followed by tooth preparation with diamond bur and SSC cementation with glass ionomer cement (Ketac Cem). A single investigator collected clinical data. To process samples, patients' general data (name, date of birth, age, gender) were recorded and an identification number was assigned. In addition, data on diseases, allergies, medications and oral hygiene habits were recorded (frequency of brushing, brushing independently or with parental assistance, and toothpaste with or without fluoride). We then performed an intraoral examination with a sterile mirror, periodontal probe, and curette. To evaluate the general oral cavity condition, several parameters were collected. An odontogram was completed and the dmft index was taken (decayed primary teeth, missing and filled).

We evaluated the gingival status of the metal-crowned primary molars and the healthy primary teeth. The plaque index was evaluated using O'Leary index using dental plaque revealer in liquid format. Plaque accumulation in the gingival area was evaluated: (0) no plaque/debris on inspection and probing, (1) thin film of plaque only visible after probing, (2) layer of plaque covering the sulcus and gingival areas of the crown, without filling the interdental space and (3) thick layer of plaque already visible. Löe and Silness gingival index was used, in which the inflammation of each of the four gingival areas (buccal, mesial, distal and lingual) was assessed and a value was assigned from zero to three: 0 = normal gum, 1 = mild inflammation: color change and slight edema without hemorrhage on probing, 2 = moderate inflammation: redness, edema and shine with hemorrhage on probing, 3 = intense inflammation: intense redness and edema with a tendency to spontaneous hemorrhage. Probing depth was measured and bleeding after probing was recorded 20 seconds after probing (present = 1, absent = 0) at 4 points (vestibular, mesial, distal and lingual) to evaluate gingival health in specific areas of the teeth. All measurements were taken using sterile material. Using a Wilcoxon signed-rank test with a power of 80% to stimulate the data following the uniform Laplace and Normal distributions, the sample size was calculated at a 95% confidence level [11]. The significance level for the results was set at 5%. For multiple comparisons or multiple tests, the *p*-values were adjusted to control the false discovery rate (FDR).

Data analysis was performed using the R v 4.3.2. program. A descriptive analysis of the quantitative variables (mean and standard deviation) was carried out. Two tests were performed in each case: First, a Shapiro-Wilks was conducted to determine if the values were significantly different (95% confidence level) from those generated by a normal distribution. A paired Student *t*-test was conducted if this test was not rejected; otherwise, a Wilcoxon signed rank test was conducted. For the three cases, the reported *p*-value came from the later test. All this was carried out using the R package. The descriptive tables were generated using the compareGroups and createTable functions of the R package compareGroups. For this paired non-parametric test (Wilcoxon), we assumed that the distribution of differences between samples (healthy *vs.* treated) of individuals is symmetric and centred at zero [12].

3. Results

The study involved 33 children whose guardians agreed to participate. 66 samples were collected (2 from each patient). Samples were collected from D molars in 55% of cases and from E molars in 45% of cases. On average, the sample had worn the crown for 6.5 months. 55% were under 3 months, 9% between 3 months and 1 year, 30% one year and 6% more than 1 year.

50% of patients had a dmft index between 4 and 7 teeth, with a median index of 6 teeth. An extreme value of 16 was presented for a patient with 12 carious teeth. Plaque index values below 55% were found in 75% of cases, with an average of 38%. Four cases (12% of the total) had plaque index values greater than 70%. 24% of the studied population brushed once a day, 61% brushed twice a day and 15% brushed three times a day. 55% of the children brushed independently, and 45% were assisted by adults. 100% of patients used fluoride toothpaste.

Healthy teeth and teeth restored with stainless steel crowns differed significantly in plaque accumulation, gingival index, probing depth and bleeding on probing.

Regarding plaque accumulation in healthy teeth, 45.5% of the healthy teeth samples (15 of 33) showed level 0. On the other hand, 63.6% of the samples of crowned teeth (21 of 33) showed level 2 plaque accumulation. In healthy teeth, 75% had gingival index values below 1 and probing depth values below 2.5 mm. However, 75% of restored teeth had gingival index values above 1 and probing depth values greater than 2.5 mm. In healthy teeth, most samples did not present bleeding, while all crowned teeth presented bleeding (Table 1).

Plaque accumulation correlated significantly with gingival index, probing depth and bleeding on probing. The dmft and plaque index id not correlate with patients' oral hygiene.

Following analysis of the results, the null hypothesis was rejected.

4. Discussion

Primary teeth are both functional and aesthetic, and they should be maintained until exfoliation. Unfortunately, dental decay is widespread in children, and the carious lesions can be large in some cases. In primary teeth restoration, SSCs are used the most due to their high success rates [1, 13, 14]. Despite this, no consensus exists regarding how SSCs influence periodontal health [7, 10, 14–18].

The high dmft index observed in this study was probably due to the fact that the patients screened had a history of caries pathology, since they were all carriers of SSC. A majority of study participants brushed twice or more and used fluoride toothpaste. On the first visit to the dental hospital, oral hygiene was emphasized. While 55% of the children brush autonomously without supervision, this aspect should be improved by insisting on brushing under adult supervision.

Periodontal health indicators between primary molars restored with SSCs were compared to intact natural control molar teeth. We found that SSCs were associated with more gingivitis surrounding than contralateral control teeth, as measured by Löe and Silness gingival index (0.5 *vs.* 1.5), probing depth

TABLE 1. Comparison between molar samples.

	Healthy molar	Molar with SSC	*p*. overall
Löe and Silness gingival index	0.50 (0.00; 1.00)	1.50 (1.00; 2.00)	<0.001
Probing depth	2.00 mm (2.00; 2.50)	2.75 mm (2.50; 3.25)	<0.001
Bleeding on probing	0.00 (0.00; 0.00)	0.50 (0.25; 0.75)	<0.001
Plaque accumulation			
0	15 (45.50%)	0 (0.00%)	<0.001
1	7 (21.20%)	9 (27.30%)	<0.001
2	8 (24.20%)	21 (63.30%)	<0.001
3	3 (9.09%)	3 (9.09%)	<0.001

Statistical analysis: shapiro.test and wilcox.test from the R stats package, and the friedman_test function from the rstatix package. SSC: stainless-steel crowns.

(2 *vs.* 2.75) and bleeding (0 *vs.* 0.5). Statistically significant differences were also found in clinically detectable plaque (healthy teeth—45.5% level 0 *vs.* SSC—63% level 2).

Belduz Kara and Yılmaz [9] compared the oral hygiene and gingival health of restored teeth with SSCs or aesthetic crowns and antagonist teeth for 18 months Based on our results, they found that control teeth had better periodontal health than restored teeth.. However, their study found that clinically detectable plaque on the restored teeth was comparable to that on the control teeth. They also found that periodontal health deteriorated with time regardless of the type of crown used. Their results were attributed to oral hygiene compliance. Similarly, Prabhu *et al.* [10], found worsening gingival status of molar teeth restored with SSCs over time compared to control teeth. However, Prabhu *et al.* [10], observed less plaque and debris accumulation in SSCs due to decreased plaque adherence to the smooth surface. Aggarwal *et al.* [18] evaluated the effect of different crown materials on the interleukinone beta (IL-1β) content of the gingival creviccular fluid and the inflammation of the marginal gingiva. Preformed zirconia crowns resulted in better periodontal health than SSCs, but neither group had significant periodontal complications.

Ayesha *et al.* [18] studied the impact of prosthetic devices (SSC and a Stainless-Steel Bands) on gingival health in pediatric patients. Despite the similar gingival health in both groups, there were noticeable changes over the first six months, with worse gingival health in the first month and gradually improving over time. Heidari *et al.* [4] found that gingival color improved and inflammation parameters significantly decreased after SSC placement at 6 months. Further, they found that improper fitting causes adverse effects on the gingiva.

SSC-restored teeth accumulated more supragingival plaque than natural teeth in our study. SCC-restored teeth may suffer from inadequate hygiene due to children and parents' reluctance to properly clean them. Supragingival plaque accumulation could also be influenced by SSC surface characteristics. Restorative materials behave differently in terms of plaque retention based on their surface texture, surface area, surface smoothness, and microstructure [6]. Additionally, the correct marginal adaptation is key to reducing gingival inflammation risk. Hamza *et al.* [19] concluded in their study that stainless steel crowns showed significantly less biofilm formation in the first 72 hours than all other restorative materials tested. For proving SSC's effectiveness on the gingival health of children, additional *in-vitro* studies will be needed with prolonged incubation times and *in-vivo* studies in the real oral environment.

Additionally, the control molars had significantly better periodontal health than the restored ones. The gingival index, pocket depth and the bleeding on probing of restored teeth were always higher than control teeth. Gingivitis levels were found to be higher in the study group than in the control group.

Different factors influence periodontal health: marginal integrity of the crown (without defects, roughness or cement remains), periodontal status, oral hygiene, biotype and intrinsic resistance to disease. Therefore, dentists should minimize manipulating the margin of SSCs to avoid irregular and rough margins as well as length discrepancies to get an adaptation that decreases the risk of soft tissue inflammation [20].

Ideally, the margin should be placed within the gingival sulcus keeping it above the insertion zone of the supracrestal connective tissue. However, subgingival margins are associated with greater bleeding on probing than supragingival margins in long-term periodontal health [21, 22]. Also, it is crucial to avoid iatrogenic soft tissue damage from subgingival preparations, since they potentially invade biological width. Over-contoured restorations are more likely to accumulate residual cement and biofilm. SSCs may increase gingival inflammation in part because of this fact [22].

The study has limitations. We did not perform a radiological evaluation of the molars, which could have provided substantial information regarding the extent of root resorption and its correlation with periodontal status. Diet and saliva pH were not assessed, which could have provided more information. Future studies may include a larger sample size. A prospective randomized case-control study with crown placement by the same clinician and a 12-month follow-up should also be considered for future studies.

For minimum mechanical defects, stainless-steel crown margins should be adapted to the tooth as closely as possible. Therefore, it minimizes gingival irritation and diminishes subgingival plaque adhesion, maintaining gingival health. Periodontal health should be maintained by giving parents more oral hygiene instructions after their child's teeth were restored with SSCs.

5. Conclusions

In the study population, molars restored with SSCs showed poorer gingival health and greater gingival inflammation than

healthy control molars. Providing families with information about maintaining more thorough oral hygiene should be a priority.

Therefore, gingivitis from SSCs may be caused by the subgingival margin invading the gingival sulcus and biological space.

A larger sample size and longer observation time are necessary to evaluate the periodontal status of SSC-restored molars.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

JRB and TV—designed the research study. AR—was responsible of collecting, analyze and reviewing data, and writing the manuscript. TP—was in charge of analyzing and reviewing data. GP—was responsible of statistical analysis. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was authorized by the Ethics Committee of Dental Hospital of the University of Barcelona (Reference No. 40/2021). The questionnaires were explained in the beginning to their legal guardians for their consent and they had the right to request withdrawal from the study at any stage.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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