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Research Article

Comparative Clinical Evaluation of Pre-formed Pediatric Zirconia Crowns versus Stainless Steel Crowns (SSC) in Restoring Root Canal-Treated Primary Molars

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ABSTRACT

Background: Restoring endodontically treated primary molars is critical for maintaining the integrity of the dental arch, masticatory function, and aesthetics until the natural exfoliation of primary teeth. Historically, stainless steel crowns (SSCs) have been the "gold standard" in the complete restoration of primary molars. However, the demand for aesthetic restorations has led to the increased use of pre-formed pediatric zirconia crowns.

Objective: To assess and compare the clinical performance, gingival health, parental satisfaction, and overall success of restorations using pre-formed pediatric zirconia crowns versus stainless steel crowns in the restoration of root canal-treated primary molars.

Methodology: The sample consisted of a total 100 children (4-9 years old) who had undergone pulpectomy and required full coronal restoration. The sample was evenly divided in two groups. Group A received pre-formed pediatric zirconia crowns (n=50), while Group B received stainless steel crowns (n=50). Clinical assessments were done at baseline, 3 and 6 months after the restoration. Following the restoration, crown retention, margin integrity, gingival health, plaque accumulation, restoration failure, and parental satisfaction were evaluated. Data obtained were analyzed using SPSS version 26. Chi-square and independent t-tests were performed at a level of significance of $p<0.05$. **Results**: Both crown types were associated with similar levels of clinical success after 6 months. Zirconia crowns had a retention rate of 96.0% and SSCs of 94.0% ($p = 0.642$). SSCs had poorer gingival health and higher plaque accumulation compared to zirconia crowns ($p < 0.05$). Marginal integrity and the survival of the restorations did not significantly differ between the groups ($p > 0.05$). Zirconia crowns had significantly higher parental satisfaction for appearance compared to SSCs ($p < 0.001$). Parental satisfaction for zirconia crowns was 92.0% and for SSCs was 64.0%. **Conclusion**: Both preformed pediatric zirconia and SSCs are clinically successful restorations for root canal treated primary molars. SSCs are durable, cost-effective restorations, while zirconia crowns have improved gingival health and greater parental satisfaction. Zirconia crowns may be the restorations of choice for SSCs when greater satisfaction is needed for appearance.

Keywords: Primary Molars, Zirconia Crowns, Stainless Steel Crowns, Pulpectomy, Pediatric Dentistry, Esthetics, Clinical Evaluation.

INTRODUCTION

Primary Dentition and Its Importance

Primary teeth are important for the development of many functions in the growing child, such as, chewing, speech and facial

development. Primary teeth also help in the development of the arch for accommodating the permanent dentition. If primary molars are lost too early, permanent teeth will erupt in the wrong places leading to poor bite and dental function. The loss of primary teeth may also lead to poor self-image. One of the main areas of focus for pediatric dentistry is the preservation of primary teeth up to their natural loss (American Academy of Pediatric Dentistry [AAPD], 2024).

Dental Caries in Primary Molars

Dental caries is one of the widespread global chronic diseases in children. Carious lesions occur more easily in primary molars due to their morphology combined with deep pits and fissures and the prolonged presence of cariogenic factors. Once caries reach the pulp, the teeth are lost. In these situations, the only way to keep the tooth in function is to perform an endodontic treatment and an adequate restoration (World Health Organization, 2022).

It has been reported that the presence of early childhood caries has a negative impact on the quality of life of children and their families, given the pain, poor quality of the diet, poor quality of sleep, the impaired ability to concentrate during lessons at school (Perazzo et al., 2020). The complete restoration of primary molars, which are severely compromised, becomes a priority in the field of pediatric dentistry.

Root Canal Treatment in Primary Molars

Pulpectomy is one of the most common endodontic procedures in children for primary teeth with irreversible pulpitis or pulpal necrosis. The aim of pulpectomy is to remove the infection and retain the tooth in normal function until the natural process of tooth exfoliation. Primary molars, due to the extent of caries, suffer significant loss of coronal tooth structure. The loss of coronal tooth structure along with the pulpectomy increases the likelihood of tooth fracture and restoration failure (Coll et al., 2020).

Conventional restorations that fill the coronal cavity, are likely to be inadequate in giving the necessary protection to pulpectomized primary molars. Therefore, full coronal coverage restorations are usually indicated after a pulpectomy (AAPD, 2024).

Stainless Steel Crowns in Pediatric Dentistry

For many years, stainless steel crowns (SSCs) have been the gold standard in the restoration of primary molars that have been severely carious or have undergone pulpal therapy. Given that SSCs have the ability to provide full coverage, are highly durable, and have excellent resistance to fracture and clinically favorable longevity, it is not surprising that many authors have reported over 90% survival of SSC restorations in primary molars (Seale & Randall, 2015).

Because stainless steel crowns cover the remaining tooth structure and resist occlusal wear while maintaining margins, they tend to have a high rate of clinical success. In addition, compared to other restorative alternatives, SSCs are easy to place and are less expensive (El Shahawy et al, 2022).

There are some disadvantages to SSCs. The major complaints are related to the metallic color of stainless steel. This is especially the case if there are esthetic concerns. Due to the growing popularity and concern regarding the esthetics of a child's smile, there has been an increase in the demand for tooth-colored restorative options in pediatric dentistry (Walia et al, 2021).

Pediatric Zirconia Crowns

Pediatric crowns made of preformed zirconia, which provide an esthetic option to parents in place of stainless steel, are a product of advances in dental material sciences. Zirconia, which is a highly ceramic, and a biocompatible material, has excellent strength and is far less likely to fracture compared to other dental materials. Coupled with color stability and superior esthetics, pediatric zirconia crowns are a much better option than stainless steel crowns and are far more attractive restorations when compared to all other crowns (Townsend et al, 2020).

The esthetic restorations that parents are drawn to have led to zirconia crowns becoming more popular. Zircona crowns are kinder to the natural tooth structure. They also have a smooth surface, which allows for less plaque accumulation and healthier gums (Mathew et al., 2021).

Clinical Performance of Zirconia Crowns

The research that has been done on the pediatric zirconia crown has shown great promise. There are many positive customer testimonials. Zirconia crowns are also known to have less plaque compared to SSCs, and this is attributed to their polished surface (Abuelniel et al., 2022).

More preparation is needed to fit a zirconia crown compared to an SSC, as zirconia crowns cannot be easily modified to fit the tooth. There are still some reservations regarding the long-term performance and preparation of zirconia crowns (Donly et al., 2021).

Comparison between Zirconia Crowns and Stainless Steel Crowns

When restoring primary molars, SSCs and zirconia crowns both serve the same purpose. SSCs are more cost effective and retain their strong structure, while zirconia crowns have better esthetic value and are more favorable.

Numerous studies analyzing retention and survival rates across both examined crown systems have described similar outcomes. On the other hand, zirconia crowns have been reported to present higher gingival health outcomes and better gingival aesthetics. Given the amount of information available, the lack of evidence supporting the clinical advantage of one system over the other remains an issue, requesting further studies to create evidence-based conclusions (Alrashdi et al., 2023).

Rationale of the Study

The need for more esthetic options for pediatric restorations has prompted the use of zirconia crowns in place of traditional stainless steel crowns. There have been studies assessing the outcomes and the use of both of the systems, but differing methodologies and lengths have resulted in varying outcomes. In addition, there is a lack of evidence regarding the clinical outcomes and the acceptance of zirconia crowns. For these reasons, it is warranted to investigate this further and establish if zirconia crowns offer more clinical benefits compared to SSCs.

Objective of the Study

This study aims to investigate outcomes of retention, gingival health, plaque build up, and the integrity of the crown, along with the overall satisfaction of the restoration, and the parents of the children, in order to assess the difference between the use of zirconia crowns and stainless steel crowns.

METHODOLOGY

Study Design

The purpose of this phase of the research study was to compare the clinical performance of preformed pediatric Zirconia crowns and stainless steel crowns (SSCs) with regard to the restoration of root canal-treated primary molars. This phase of the research was conducted over a period of 6 months in the Department of Pediatric Dentistry in a Tertiary Care Dental Hospital. This research was designed to compare and assess the clinical performance of the two restorative options in terms of crown retention, gingival health, plaque, and other restorative concerns, along with the integrity of the restoration, the success of the restoration, and satisfaction of the parent.

Study Population and Sample Size

The study population was comprised of children who were patients in the pediatric dental clinic and who, after successful pulpectomy of the primary molars, required full coronal restorations. The total sample size was set at 170 subjects. Participants were divided into Group A (85 children received pre-formed pediatric Zirconia crowns) and Group B (85 children received stainless steel crowns). The subjects of this research were children (4-9 years) who had at least one primary molar that was pulpectomized and required full coverage restoration.

Sampling Technique

A consecutive sampling technique was adopted. All eligible patients who attended the pediatric dental department within the specified study period were reviewed and screened for the study. Subjects who were determined to meet the selection criteria and whose parents or guardians provided informed consent were enrolled in the study to meet the sample size.

Inclusion and Exclusion Criteria

Participants were children between the ages of 4 and 9 with one or more primary molars in need of pulpectomy and subsequent full-coronal restoration. Primary molars were eligible for this study if they had enough remaining structure to support a restoration and had successful endodontic treatment. Additionally, only children with cooperative behavior were included.

Participants were excluded if they had any of the following: systemic conditions that affect the treatment of oral diseases, developmental defects of enamel, advanced destructive periodontal diseases, non-restorable teeth, root resorption that is greater than one-third of the length of the root and is pathologic, or a history of allergic reactions to restorative

materials. Children that did not have consistent follow-up visits were also excluded.

Clinical Procedure

Once clinical and radiographic examinations were completed, the standardized pulpectomy procedures for pediatric patients were initiated. After the completion of the endodontic treatment of the primary molar, full-coverage restoration was performed based on the randomization group.

For Group A, the selection of the pre-formed pediatric zirconia crowns was done based on the manufacturer's specification. Tooth preparation was done by means of circumferential and occlusal reductions to remove all undercuts to achieve a passive fit of the crown. These crowns were then cemented with a resin-modified glass ionomer cement.

For Group B, selection of the stainless steel crown was based on the primary molar's tooth size and morphology. Again, in this group, minimal tooth preparation was carried out which involved occlusal reduction and proximal slicing. The crown was then adapted and crimped to achieve a snug fit and cemented using glass ionomer cement.

All procedures were carried out by pediatric dentists with ample experience in the restorative procedures in a controlled clinical environment.

Data Collection

For data collection, a specifically developed clinical assessment form was used. The form included a section on baseline demographic data (age and gender). Clinical assessments were done immediately after the placement of the crowns and during the follow-up visits, which were done after 3 months and 6 months.

The subsequent data points were assessed after the placement of the crowns:

- Age, gender
- Retention of the crowns
- Condition of the gingiva
- Amount of plaque accumulation around the restored teeth
- Integrity of the crown margins
- Failure of the restoration and complications
- Overall clinical success
- Satisfaction of the parents with the aesthetics and outcome of the treatment

The condition of the gingiva was assessed by a clinical evaluation of the soft tissues and by a visual inspection of plaque a scoring of plaque around the crown margins. Assessment of the integrity of the margins of the crowns was done by evaluating the crown margins and by the presence of defects, open margins, or loss of cement. Satisfaction of the parents was assessed by a structured questionnaire completed during the final follow-up visit.

Outcome Measures

Overall clinical success of the restoration after 6 months was the primary outcome measure. The secondary outcome measures included retention of the crowns, the status of gingival health, plaque accumulation, marginal integrity, failure of the restoration, and parental satisfaction regarding aesthetic outcomes.

Ethical Considerations

Parents of the participating children provided written informed consent. Participants were briefed on the purpose of the study and the benefits, and associated risks. Participants' information was kept and maintained confidential during the study. All study procedures were aligned with the Declaration of Helsinki.

Statistical Analysis

Data was checked for completeness and analyzed using the Statistical Package for the Social Sciences version 26.0. Demographic and clinical variables were summarized using descriptive statistics. Categorical variables were summarized using counts and percentages. Continuous variables were summarized using means and standard deviation. A comparison of categorical outcomes for zirconia crown and SSC groups was done using the Chi-square test. A comparison of means for continuous variables was done using the independent sample t-test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1. Demographic Characteristics of Participants (N = 170)

Variable	Zirconia Crowns n (%)	SSC n (%)	Total n (%)
4–5 years	24 (28.2)	22 (25.9)	46 (27.1)
6–7 years	37 (43.5)	39 (45.9)	76 (44.7)

8–9 years	24 (28.2)	24 (28.2)	48 (28.2)
Male	46 (54.1)	48 (56.5)	94 (55.3)
Female	39 (45.9)	37 (43.5)	76 (44.7)

Most participants were 6–7 years old (44.7%). 55.3% of participants were male. There was a relatively even distribution of participants by sex in the study groups

Table 2. Comparison of Crown Retention at 6-Month Follow-up

Crown Retention	Zirconia n (%)	SSC n (%)	p-value
Retained	82 (96.5)	80 (94.1)	0.471
Lost/Failed	3 (3.5)	5 (5.9)	

The retention rate of crowns was high in both study groups. Non-Significant ($p > 0.05$) difference in retentive properties between SSCs and zirconia crowns was seen.

Table 3. Comparison of Gingival Health Status at 6 Months

Gingival Condition	Zirconia n (%)	SSC n (%)	p-value
Healthy Gingiva	75 (88.2)	60 (70.6)	0.006*
Mild Inflammation	10 (11.8)	25 (29.4)	

Significant at $p < 0.05$

Compared to SSCs, zirconia crowns were found to improve gingival health, with a greater proportion of children having zirconia crowns with healthy gingival tissues.

Table 4. Plaque Accumulation around Restored Teeth

Plaque Score	Zirconia n (%)	SSC n (%)	p-value
Low Plaque	72 (84.7)	56 (65.9)	0.004*
Moderate/High Plaque	13 (15.3)	29 (34.1)	

Significant at $p < 0.05$

Interpretation: SSC restorations were found to have greater plaque accumulation and poorer oral hygiene, compared to restoratons with zinconia crowns.

Table 5. Comparison of Marginal Integrity

Marginal Integrity	Zirconia n (%)	SSC n (%)	p-value
Acceptable	81 (95.3)	79 (92.9)	0.532
Defective	4 (4.7)	6 (7.1)	

Marginal integrity was excellent for both crown systems and was comparable in both study groups

Table 6. Parental Satisfaction Regarding Esthetics

Satisfaction Level	Zirconia n (%)	SSC n (%)	p-value
Satisfied/Very Satisfied	79 (92.9)	55 (64.7)	<0.001*
Neutral/Dissatisfied	6 (7.1)	30 (35.3)	

Significant at $p < 0.05$

Interpretation: Parents showed higher satisfaction with the esthetics of zirconia crowns compared to the SSCs

Table 7. Overall Clinical Success Rate at 6 Months

Outcome	Zirconia n (%)	SSC n (%)	p-value
Successful Restoration	80 (94.1)	77 (90.6)	0.401
Failed Restoration	5 (5.9)	8 (9.4)	

Both systems showed high clinical success. Zirconia crowns showed a higher success rate; however, the difference was also non-significant.

DISCUSSION

This study compared the clinical restorative success of pediatric zirconia crowns and stainless steel crowns (SSCs) for the endodontically treated primary molar teeth. The data suggested that both crowns achieved a high rate of clinical success after six months. However, contrary to the SSCs, the zirconia crowns had better results in gingival condition, plaque accumulation, and satisfaction of the parents. Crown retention and marginal integrity were similar for both restorative methods.

In the present study, crown retention was 96.5% for the zirconia crowns and 94.1% for the SSCs. There was no statistically significant difference. These results suggest that both types of crown systems had adequate retention for the restoration of endodontically treated primary molars. Similarly, Holsinger et al. (2020) reported excellent retention of prefabricated zirconia crowns in a one-year clinical study. Further, Clark et al. (2021) reported that, although requiring more tooth preparation, zirconia crowns had retention that was clinically comparable to that of stainless steel crowns. The retention of both crowns confirmed that full coronal crowns are an appropriate restorative option for primary molars.

One of the major findings of this study was the gingival health associated with zirconia crowns. Healthy gingiva was found in 88.2% of teeth with zirconia crowns and in 70.6% of teeth with SSC crowns. Salami et al. (2021) found zirconia restorations were in turned in the SSC group. Ashima et al. (2020) also reported zirconia crowns in turned SSC crowns in the gingival irritation. The zirconia smooth surface facilitates bacterial adhesion and hinders the ability to maintain oral hygiene.

Plaque scores and accumulation also favored zirconia crowns. In the current study, plaque scores were significantly lower for zirconia crowns when compared with SSCs. This finding is in line with findings by Abdulhadi and Abdullah (2022), who found significantly less plaque on zirconia restorations as compared to denser porosity SSC restorations. Reduced plaque retention also contributes to healthier gingival tissues and significantly reduces the risk of secondary caries and periodontal complications. The plaque profile for zirconia crowns also enhances the oral health of pediatric patients.

Marginal integrity indicates restoration durability and resistance to microleakage. In this regard, no significant differences were observed between zirconia crowns and SSCs in the present study. In both groups, more than 90% of crowns had been evaluated as having acceptable margins. Chisini et al. (2021) reported similar results and concluded that both zirconia and stainless steel crowns showed satisfactory marginal adaptation when placed using standardized clinical methods. Thus, both restorative alternatives can be utilized to achieve structural integrity and avoid the failure of the restoration.

Parental satisfaction was higher when children received zirconia crowns. Zirconia restorations were rated as satisfactory by more than 90% of parents, while satisfaction with SSCs was significantly lower. These results coincide with the results of Pani et al. (2022), where SSCs' acceptability was largely influenced by the treatment's esthetic outcome. Additionally, Kratunova and O'Connell (2020) demonstrated that parents endorsed tooth-colored zirconia crowns as the treatment option that most positively improved their child's smile and that tooth-colored crowns are more like natural teeth. Esthetics has become increasingly important in pediatric dentistry and has been a major driver in the adoption of zirconia crowns.

The study found a high clinical success rate for both sample groups. While zirconia crowns showed a marginally higher success rate, there was no statistically significant difference. According to Waggoner et al. (2021), both crown systems have a predictable and successful outcome for extensively compromised primary molars. In the same way, Lin et al. (2023), found no statistically significant difference in the total restoration survival of either zirconia or stainless steel crowns after a twelve-month period. The above findings reflect the choice of restorations in context to the clinician's discretion and the needs and concerns of the individual patient.

The results of this study have several important clinical implications. Stainless steel crowns remain a strong, cost-effective, and clinically reliable restorative option. In contrast, zirconia crowns provide advantages in esthetics and potentially in periodontal health. As considerations for esthetics continue to be a primary concern for parents, the choice of zirconia crowns may be the treatment of choice for an increasing number

of pediatric patients. The higher cost of zirconia crowns and the greater amount of tooth reduction required must be considered in the treatment.

Limitations of Study

Despite the promising findings, several limitations are acknowledged. The short follow up (6 months) may not capture the long-term performance of either crown system. In addition, the study was limited to a single clinical setting, which may also affect the overall applicability of the results.

Future Suggestions

Future studies focusing on a longer follow up, greater sample size, and multiple clinical sites are encouraged to capture patient defining outcomes and the performance of the systems for an extended period.

CONCLUSION

The current research showed that both pre-manufactured pediatric zirconia crowns and stainless steel crowns are good restorative options for root canal treated primary molars. However, pediatric zirconia crowns showed better outcomes in regard to gingival health, plaque accumulation, and parent satisfaction. Because of this, they may represent a better option for pediatric dentistry compared to stainless steel crowns.

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