

Comparing Zirconia to Anterior Strip Crowns: A Randomized Clinical Trial

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Abstract

Background

Providing restorations to anterior teeth in children is a challenging task due to the need for high esthetics, strength, and durability.

Aim

this study was done to compare prefabricated primary zirconia with resin composite strip crowns on primary maxillary central and lateral incisors with regards to gingival health, plaque accumulation, recurrent caries, restoration failure, and opposing teeth wear over a period of 3, 6 and 12 months.

Methods

Children attending the King Abdulaziz University, Faculty of Dentistry (KAUFD) clinics who needed restorations were screened for inclusion criteria. A total of 120 teeth were treated; 60 with zirconia and 60 with strip crowns. Randomization was done by simple random allocation using SPSS software version 20.0 (Armonk, NY; IBM Corp.). A simple descriptive statistic was used for analysis by Wilcoxon Signed-Rank test and Chi-square test. Level of significance was set at ($\alpha = 0.05$) and level of confidence at (95%).

Results

Zirconia crowns showed significantly less gingival bleeding at the 3- and 6-months follow up periods ($p < 0.006$, $p < 0.001$; respectively), less plaque accumulation at all follow up visits ($p < 0.001$), no restoration failure ($p < 0.001$), but more wear to opposing teeth ($p < 0.02$). No significant difference was found between the two crowns with regards to recurrent caries ($p < 0.135$).

Conclusion

Based on our data we conclude that overtime teeth covered with zirconia crowns show better gingival health and less bleeding, plaque accumulation, recurrent caries as well as less loss of material. On the other hand, zirconia can cause more loss of opposing tooth structure.

Background:

Early childhood caries (ECC) is a chronic multifactorial disorder which continues to be dominant in children, especially in families of low socioeconomic status (1–7). Early childhood caries is defined as “the existence of one or more tooth decays (non-cavitated or cavitated lesions), missing (due to caries), or

filled tooth surfaces in any primary dentition of children under the age of six years” (1). Severe early childhood caries (S-ECC) is a progressive carious form in children, categorized in accordance to the number of affected teeth and the age of patient. The presence of smooth surface caries is considered to be an indication of S-ECC in patients below three years of age (8). In children between three to five, S-ECC is defined as “one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth or a decayed, missing, or filled score of greater than or equal to four (age three), greater than or equal to five (age four), or greater than or equal to six (age five) surfaces” (1).

Providing care to children who are considered to be at risk from ECC, can be achieved by a specialist who received adequate training and has experience in treating children as well as disease process (1). To perform treatment safely, effectively, and efficiently, the pediatric dentist can use behavior guidance techniques, protective stabilization and/or sedation or treatment under general anesthesia (1).

Despite their poor esthetics stainless steel crowns (SSC) are often the treatment of choice for multi-surface carious teeth and lesions with widespread white spots. Primary incisors with large or multi-surface caries can be restored with resin composite strip crowns if there is sufficient tooth structure after removing all carious tissues (9). When remaining tooth structure is minimal and not enough for bonding, pre-veneered aesthetic crowns is a favorable solution. Stainless steel crowns with cosmetic facing have good aesthetics and good retention even with minimal remaining tooth structure. Moisture and hemorrhage control are not critical with these restorations which need minimal chair time and offer full coverage and protection.

More recently, zirconia aesthetic crowns appeared in the market. Zirconia is a crystal-like dioxide of zirconium that possess a metal like mechanical properties and a tooth like color, and the ready to use zirconia crowns are available for primary teeth. Although there is high acceptance of zirconia crowns, the literature lacks solid proof for their clinical performance. There are limited clinical studies that are currently ongoing, however until the outcomes of adequate number of prospective clinical trials with enough long-term follow-up periods are available evidence to ensure clinical success and durability of these crowns are leftover uncertain.

This study was aimed at comparing prefabricated primary zirconia with resin composite strip crowns on primary maxillary central and lateral incisors with regards to gingival health, plaque accumulation, recurrent caries, restoration failure, and opposing teeth wear over a period of 3, 6 and 12 months.

Methods:

Sample size calculation

G*Power 3.1.9.2 software (Franz Faul, Universität Kiel, Germany, 2014) performed for power analysis, indicated that we needed a total 120 teeth (corresponding to around 60 children to achieve 80% power with 95% confidence assuming medium effect size in the mean change in gingival health 6 months after

crown application in the zirconia and composite groups with the assumption of non-normal distribution. The number of crowns in each arm will be 60.

Sample selection

A sample of 120 primary upper anterior incisors were treated in the Pediatric Dental Clinics, King Abdulaziz University, Faculty of Dentistry (KAUFD), at Jeddah, Saudi Arabia. All children visiting the clinics between November 1, 2015 to January 31, 2016 with the following criteria were included in the study

1. Healthy four to six years old children.
2. Those having opposed anterior teeth.
3. No history of systemic illness or dental developmental anomalies which can affect dietary patterns, caries susceptibility or the selection of restorative materials to the best of current knowledge.
4. Minimal of two surfaces of caries in the targeted teeth.
5. Patient with Early Childhood Caries as defined by AAPD, 2016.
6. Cooperative patients who had behavioral rating "positive" or "definitely positive" followed the Frankl behavior classification scale (10).

Written consents were obtained from the parents/guardians after explaining the full details of the treatment procedure and its possible outcomes, discomfort, risks, and benefits.

No patient was excluded based on gender, race, social or economic background.

Exclusion Criteria

Children having the following criteria were excluded from this research

1. Teeth with proximity to exfoliation and resorption of the root passed its half.
2. Presence of single surface caries not involving the proximal surfaces.
3. Teeth that have been subjected to trauma.
4. Anxiety and lack of cooperation which required treatment under general anesthesia.
5. Bruxism.
6. Special health needs.
7. Presence of teeth wear on the opposing teeth, or absence of opposing.

Study design

The present study was a randomized controlled clinical trial that followed the guidelines published by Consolidated Standards of Reporting Trials (CONSORT) (11). This research has been ethically accepted by the Committee of Research Scientific Unit at King Abdulaziz University with reference no. 076 - 16. Before enrolment, every patient's parent/ guardian signed an informed consent sheet. Also, the presented research was registered at ClinicalTrials.gov under registration number NCT03184012.

Randomization

Concealment was applied for randomization of children in each group to either resin composite strip crown or zirconia crowns. Randomization was done using SPSS software version 20.0 (IBM Corp., Armonk, NY) Allocation concealment was assured by handling sequentially numbered opaque sealed envelopes to the attending candidate. At the time of crown application, an envelope was opened and allocate the child to the written restoration material inside that envelop.

Examiner calibration

To test the reliability of the examiner and evaluate the restoration performance, sixteen teeth were treated by full coronal restorations then examined. The examiner evaluated those teeth based on the standard evaluation criteria of the study. The results produced by the examiner were analyzed using Cohen's kappa to test intra-examiner reliability.

Statistical Analysis

This study was analyzed using IBM SPSS version 23 (IBM Corp., Armonk, NY). Simple descriptive statistics were applied to characterize the variables of the study via tally and percentages for the definitive and nominal variables, whereas mean and standard deviations were used to represent the constant variable. In comparing the distributions of two variables, a two-related-sample tests with *chi-square test* were used. These tests were assumed to be observing normal distribution.

Results:

Correlation between examiners

The intra-rater agreement and correlation of the examiner was calculated using Cohen's Kappa Co-efficient and the clinical calibration results produced by the examiner were found to be at an excellent agreement range (0.97).

1. Proportion distribution of demographic data

Full coronal restorations were placed on 120 primary maxillary anterior teeth (64 central incisors, 56 lateral incisors) on 32 patients, (44 males and 76 female). The mean age of patients at the base line was 4.43 years, with no drop out until the 12 months follow up. (Table 2)

Table 1
The Description of the Criteria Used to Record the Clinical Parameters

Criteria	Score	Description
Gingival Health	Alpha	No gingival bleeding
	Bravo	Bleeding with probe
	Charlie	Spontaneous bleeding
Plaque index	0	No plaque
	1	A film of plaque adhering to the free gingival margin cannot be seen with the naked eye. But only by using disclosing solution or by using probe.
	2	Moderate accumulation of deposits within the gingival pocket, on the gingival margin and/ or adjacent tooth surface, seen by naked eye.
	3	Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin.
Secondary caries*	Alpha	No caries present
	Charlie	Caries present
Restoration failure*	Alpha	Crown appears normal, no cracks, chips, or fracture
	Bravo	Small but noticeable area of loss of material
	Charlie	Large loss of crown material
	Delta	Complete loss of crown
Proximal contact*	Alpha	Resistance met when passing floss
	Bravo	Floss passed without resistance but contact present
	Charlie	No contact with adjacent tooth
Marginal integrity*	Alpha	Close marginal adaptation
	Bravo	No detectable margin
	Charlie	Detectable margin
Occlusion*	Alpha	Normal occlusion
	Charlie	Faulty occlusion
	Alpha	Normal occlusion
Tooth wear of opposing	0	No loss of enamel surface characteristics, no loss of contour
* US Public Health Service "USPHS", Alpha criteria rating system (Ryge, 1980) Teeth**		
** Smith and Knight Tooth Wear Index (Bardsley, 2008; Smith and Knight, 1984).		

Criteria	Score	Description
	1	Loss of enamel surface characteristics, minimal loss of contour
	2	Loss of enamel exposing dentine for less than one third of surface, loss of enamel just exposing dentin, defect less than 1 mm deep
	3	Loss of enamel exposing dentin for more than one third of surface, loss of enamel and substantial loss of dentin, defect less than 1–2 mm deep
	4	Complete enamel loss, pulp exposure, secondary dentin exposure, pulp exposure or exposure of secondary dentin, defect more than 2 mm deep, pulp exposure, secondary dentin exposure

* US Public Health Service “USPHS”, Alpha criteria rating system (Ryge, 1980)

** Smith and Knight Tooth Wear Index (Bardsley, 2008; Smith and Knight, 1984).

Table 2
Proportion Distribution of Demographic Data

Demographics	N	Min	Max	Mean	SD
Age	120	3.0	5.5	4.43	0.7
		Count		%	
Total		120		100.0	
Nationality	Saudi	88		73.3	
	Non-Saudi	32		26.7	
Gender	Male	44		36.7	
	Female	76		63.3	
Restoration type	Zirconia Crown	60		50.0	
	Strip Crown	60		50.0	

2. Gingival health evaluation:

Gingival health as measured by bleeding with probing is depicted in Table 3. It can be seen that at the 3-months follow-up significantly more teeth in the strip crown group were bleeding compared to the zirconia groups ($p < 0.006$). At the 6-months follow-up also more teeth in the strip crown group were bleeding ($p < 0.001$). However, at the last follow-up visit at 12 months both groups showed no bleeding.

Table 3
Gingival Health Evaluation

Gingival Health (assessed as bleeding on probing)	Zirconia Crowns	Strip Crowns	<i>p</i> -value
At 3 months	24 (40.0%)	40 (66.7%)	0.006 ^a
At 6 months	0 (0.0%)	28 (46.7%)	< 0.001 ^a
At 12 months	0 (100%)	0 (100%)	N/A ^b
<i>^a-significant using Chi-Square Test @<0.05 level.</i>			
<i>^b-No statistics are computed because variable is a constant</i>			

3. Plaque index evaluation:

Both groups were examined for plaque indices and scored according to Silness and L oe criteria. at the beginning of the study dental prophylaxis was provided to all patients and oral hygiene instructions were given to patients and their parents as well. Table 4 shows plaque indices at the follow-up visits. During the 3-months follow up more zirconia covered teeth showed either no plaque, or less plaque accumulation compared to teeth covered with strip crowns ($p < 0.001$). At the 6-months follow-up also more zirconia covered teeth showed less plaque accumulation ($p < 0.001$). At the end of the study all teeth covered with zirconia were free of plaque while only 80% of those covered with strip crowns were free of plaque and 20% had a film of plaque at the gingival margin ($p < 0.001$)

Table 4
Plaque Index Evaluation

Plaque index		Zirconia Crowns	Strip Crowns	<i>p</i> - value
At 3 months	No plaque	20 (33.3%)	4 (6.7%)	< 0.001 ^a
	A film of plaque adhering to the free gingival margin, cannot be seen with the naked eye	36 (60.0%)	44 (73.3%)	
	Moderate accumulation of deposits in the gingival pocket, on gingival margin and/or adjacent tooth surface, can be seen by the naked eye	4 (6.7%)	12 (20.0%)	
At 6 months	No plaque	47 (79.7%)	24 (40.0%)	< 0.001 ^a
	A film of plaque adhering to free gingival margin, cannot be seen by naked eye	12 (20.3%)	36 (60.0%)	
At 12 months	No plaque	58 (100.0%)	48 (80.0%)	0.001 ^a
	Film of plaque adhering to the free gingival margin, cannot be seen with naked eye	0 (0.0%)	12 (20.0%)	

^a-significant using Chi-Square Test @<0.05 level.

4. Secondary caries evaluation

Evaluation of recurrent caries was done by visual inspection according to modified United States Public Health Service (USPHS) criteria.(12) The results showed that none of the teeth covered with zirconia crowns developed caries during the entire period of follow up. On the other hand, teeth that received strip crowns restorations had no recurrent lesions in the 3- and 6-months follow up but when it reached the 12-months follow up, 6.7% presented with recurrent caries. This finding, however, was not significant by applying *Chi-Square Test* ($p < 0.135$) (Table 5).

Table 5
Secondary Caries Evaluation

Recurrent caries		Zirconia Crowns	Strip Crowns	<i>p</i> -value
At 3 months	No caries present	60 (100.0%)	60 (100.0%)	N/A ^b
At 6 months	No caries present	59 (100.0%)	60 (100.0%)	N/A ^b
At 12 months	No caries present	58 (100.0%)	56 (93.3%)	0.135
	Caries present	0 (0.0%)	4 (6.7%)	
<i>^b-No statistics are computed because variable is a constant.</i>				

5. Restoration failure evaluation

Crown failure during follow up intervals (Table 6) was clinically evaluated by visual assessment according to the US Public Health Service "USPHS", Alpha criteria rating system (12). From base line until the three months follow up, no failures was noticed in both groups. In the zirconia crown group, two crowns were lost completely in 6 and 12 months follow up due to trauma caused by falling of patients and hitting hard objects.

Table 6
Restoration Failure Evaluation

Restoration failure		Zirconia Crowns	Strip Crowns	p-value
At 3 months	Crowns appear normal, no cracks, chips, or fractures	60 (100.0%)	60 (100.0%)	N/A ^b
At 6 months	Crowns appears normal, no cracks, chips, or fractures	59 (98.3%)	52 (86.7%)	0.024 ^a
	Small but noticeable area of loss of material	0 (0.0%)	7 (11.7%)	
	Large loss of crown	0 (0.0%)	1 (1.7%)	
	Complete loss of crown	1(1.7%)	0 (0.0%)	
At 12 months	Crowns appears normal no cracks, chips, or fractures	58 (98.3%)	37 (61.7%)	< 0.001 ^a
	Small but noticeable area of loss of material	0 (0.0%)	18 (30.0%)	
	Large loss of crown	0 (0.0%)	5 (8.3%)	
	Complete loss of crown	1 (1.7%)	0 (0.0%)	
<i>^a-significant using Chi-Square Test @<0.05 level.</i>				
<i>^b-No statistics are computed because variable is a constant.</i>				

On the other hand, failure was more in the strip crown group as 11.7% showed small but noticeable area of material marginal loss and 1.7% presented with large loss of crown during the 6 months follow up ($p < 0.024$). Moreover, this loss increased with time to reach 30% small but noticeable area of loss of material and 8.3% large loss of crown by the 12 months follow up ($p < 0.001$).

6. Tooth wear evaluation

Tooth wear was evaluated (Table 7) according to Smith and Knight Tooth Wear Index (13, 14). The incisal and labial surfaces of the teeth opposing the full-coronal restorations were clinically observed for any sign of abrasion. Seven teeth (11.7%) opposing to zirconia crowns showed loss of enamel surface characteristics and minimal loss of contour ($p < 0.02$).

Table 7
Tooth Wear Evaluation

Tooth wear of opposing		Zirconia Crowns	Strip Crowns	<i>p</i> - value
At 3 months	No loss of enamel surface characteristics, no loss of contour	60(100.0%)	60(100.0%)	N/A ^b
At 6 months	No loss of enamel surface characteristics, no loss of contour	60(100.0%)	60(100.0%)	N/A ^b
At 12 months	No loss of enamel surface characteristics, no loss of contour	53(88.3%)	60(100.0%)	0.020 ^a
	Loss of enamel surface characteristics, minimal loss of contour	7(11.7%)	0(0.0%)	
<i>a-significant using Chi-Square Test @<0.05 level.</i>				
<i>b-No statistics are computed because variable is a constant.</i>				

Discussion:

Despite the continuing prevalence of dental caries in primary maxillary anterior teeth in children, the esthetic management of these teeth remains problematic. Esthetic restoration of primary anterior teeth can be especially challenging due to: small teeth size, close proximity of dental caries to the pulp, relatively thin enamel, lack of surface area for bonding, and issues related to child behavior (15).

In evaluation of gingival health, this study shows better gingival response in zirconia crowns which can be explained by the fact that zirconia is biocompatible and possesses a polished and smooth surface leading to less plaque accumulation and hence less gingival irritation (16–18). This is in accord with results reported in 2014 by Walia et al. (19) who evaluated anterior primary crowns for 129 patients (aged 3 to 5 years old). Their study revealed that zirconia crowns showed improved gingival health, while the other crowns (Composite strip crowns and pre-veneered SSCs) displayed more gingival inflammation. Another recent retrospective study by Holsinger et al. (20) assessing 57 primary anterior teeth treated with zirconia showed significant healthy gingiva in relation to these crowns.

A retrospective study done in 2003 by Kupietzky et al. (9) included 112 composite resin strip crowns found that 43% of the restored teeth showed gingival irritations around the crowns. These findings could be explained as the gingival health of teeth restored with composite strip crowns can be affected by tooth preparation and finishing (21, 22). Unfortunately, upon reviewing the literature there were no sufficient data with regards to gingival response related to primary teeth restored by composite resin strip crowns. Padbury in 2003 (23), suggested placement of the strip crown margin supra gingivally to reduce gingival inflammation. Despite this recommendation being clinically logical, it is considered not applicable in most cases as it will result in poor aesthetics and appearance.

In agreement with our study, Walia et al. (19) who assessed anterior primary crowns for 129 patients (aged between 3 to 5 years old) also reported that zirconia crowns showed improved gingival health due to less plaque accumulation when compared to composite strip crowns and pre-veneered SSCs.

Our data showed that none of the teeth covered with zirconia crowns showed recurrent caries during the entire follow up. In contrast, teeth restored with composite resin strip crowns showed that 6.7% developed recurrent caries in the 12-months follow up. The lack of adequate preventive measures could have contributed in caries recurrence in our community. Important factors that influence development of caries are poor oral hygiene and high cariogenic diet consumed by the patients included in our study.

A recent study by Holsinger et al. (20) reported results similar to our study's in their evaluation of 57 crowns treated with zirconia for primary anterior teeth in 18 patients. Their study showed no recurrent caries after a follow-up period of 24 months. Talebi et al. (24) evaluated the drawbacks of anterior primary crown restorations in 38 primary anterior teeth of 12 patients aged 3–5 years diagnosed with early childhood caries (ECC). Their results showed recurrent carious lesions at three and 12 months. One case displayed recurrent carious lesions around the margins of the restoration at the 3-months follow-up. While in eight teeth, the secondary caries occurred at the 12-month follow up over the boundaries of the restoration. Johnsen et al. (25) stated that patients diagnosed with ECC had higher tendency to develop recurrent caries after treatment. Another study done in 2000 by Almeida et al., found that young patients having ECC who were managed under general anesthesia to receive resin composite strip crown restorations exhibited significantly higher caries rates versus the control group who were caries free originally.

The greater restoration failure of the composite strip crowns in this study may be explained by the fact that treatment was done under nitrous oxide sedation and physical restrains to manage the children behavior. Eidelman et al. (26) reported that improved results for strip crowns were found in cases done under general anesthesia than those done under sedation. General anesthesia allows treatment to be rendered under theoretically optimal conditions; implying outcomes would be more successful. Success rate between 80% – 88% were found in the studies done by Kupietzky et al. (9); Waggoner et al. (22); Ram and Fuks (27). High failure rate of 51% over a period of two years was seen in a study by Tate et al. (28) where strip crowns were placed under general anesthesia and endodontically treated teeth were included as well. Endodontic treatment can also affect the overall retention as these teeth are usually more damaged as mentioned by Kupietzky et al (29).

Regarding the zirconia crowns, the success rate in this study was 98.3% by the end of the 12 months follow up. Only two crowns failed due to trauma. Current research on the clinical success of prefabricated primary zirconia crowns for primary incisors is still limited. Walia et al. (19) reported the retention rate of zirconia crowns as 100% after 6 months. These crowns have no facial upper structure, as they are made up of solid zirconia leading to no chance of facial veneer fracture as stated by Manicone et al (30). The flexural strength of zirconia oxide materials has been reported to be in the range of 900 to 1,100 MPa. This is approximately twice as strong as alumina oxide ceramics currently in the market and five times

greater than standard glass ceramics (30). Another important property is their fracture toughness making them perdurable and a highly strong restoration (31).

Tooth wear in this study was evaluated according to the Smith and Knight Tooth Wear Index (13, 14). Seven teeth accounting for 11.7% of teeth opposing to zirconia crowns showed loss of enamel surface, minimal loss of contour compared to 100% no loss of enamel surface characteristics in strip crown group. This results is in agreement with Walia et al. (19) who found four opposing primary teeth out of 38 zirconia crowns having loss of enamel surface characteristics and minimal loss of contour.

This study adds significant value to the literature with regards to the clinical performance of zirconia crowns in anterior primary molars. Although the zirconia crowns are considered expensive in comparison to strip crowns, we should take into consideration the high failure rate of strip crowns and the need to repeat dental visits and re-treatment of failed strip crowns. This fact may make the zirconia crowns cost effective after all as it has high success rate and minimal need for re-treatment.

Conclusions:

Based on our data we can conclude that overtime teeth covered with zirconia crowns show better gingival health and less bleeding, plaque accumulation, and recurrent caries as well as less loss of material. On the other hand, zirconia can cause more loss of opposing tooth structure.

Recommendations:

We recommend longer follow-up studies on zirconia crowns with inclusion of more evaluation parameters such as patients' satisfaction especially with high cost of zirconia crowns, ease of handling, as well as other variables.

Abbreviations

KAUFD

King Abdulaziz University, Faculty of Dentistry

ECC

Early childhood caries

S-ECC

Severe early childhood caries

SSC

stainless steel crowns

Declarations

Ethics approval and consent to participate:

Prior to the beginning of this study the investigators obtained ethical approval from the Ethical Approval Committee at the Faculty of Dentistry, King Abdulaziz University. Detailed explanation was given to all recruited patients including possible risks and benefits and all included patients signed an official consent.

Consent for publication:

Consent for publication obtained from the participant's parents or legal guardians prior to the study.

Availability of data and materials:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests.

Funding:

This research is self-funded.

Author's contribution:

SA and MA were the project supervisors and BA was the principle investigator for this study. NA coordinated the study and contributed to the design of this study. All authors shared writing and reviewing the manuscript and approved the final paper.

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Figures

Zirconia Crowns Vs Strip Crowns Follow-up



3-month follow-up



6-month follow-up



12-month follow-up

Figure 1

Intra-oral photographs showing the treatment of teeth no. 52, 51, 61, 62 by zirconia crowns (on the right), and teeth no. 52, 51, 61, 62 by Strip crowns (on the left) at different follow up intervals (baseline, 3 months, 6 months and 12 months).

Supplementary Files

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