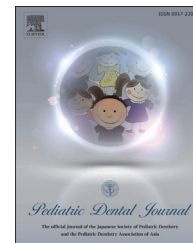


Available online at www.sciencedirect.com**Pediatric Dental Journal**journal homepage: www.elsevier.com/locate/pdj**Research Paper****Evaluation and comparison of strip crowns and primary anterior zirconia crowns in 3–5 years old children at one year****Mayank Sharma, Amit Khatri*, Namita Kalra, Rishi Tyagi***Department of Pedodontics and Preventive Dentistry, University College of Medical Sciences and Guru Teg Bahadur Hospital, Delhi, 110095, India***ARTICLE INFO****Article history:**

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ABSTRACT

Background: Preservation of the decayed primary anterior teeth is important until their natural exfoliation time as it acts as natural space maintainer. Two most common anterior aesthetic full coronal restorations, the strip crowns and the preformed zirconia crowns, are available options.

Objective: To evaluate and compare the clinical outcomes (gingival health, plaque accumulation, teeth wear of opposing dentition, color match and restoration failure) of strip crowns and preformed primary anterior zirconia crowns at one year follow up in 3–5 years old children.

Material and methods: Forty maxillary primary incisors were restored by either strip crown or zirconia crown. Permuted block randomisation method was used for allocation of participants. Gingival health, plaque accumulation, teeth wear of the opposing dentition, color match and restoration failure for crowns were assessed at one-year follow-up. Data was analysed using McNemar- Bowker test and Chi-Square test.

Results: At one-year follow-up, gingival inflammation, plaque accumulation, restoration failure were significantly higher for the strip crowns (level of significance = 0.012, 0.013 and 0.0001, respectively) and, no statistically significant difference was found between the strip crowns and zirconia crowns for teeth wear of opposing dentition and color match evaluation (level of significance = 0.435 and 0.168, respectively).

Conclusion: Overall, zirconia crowns were found more successful than strip crowns for the rehabilitation of caries affected primary incisors.

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1. Introduction

Dental caries is the public health problem around the globe and shown the significant impact on the children's wellbeing [1]. American Academy of Paediatric Dentistry defined Early childhood caries as "the presence of one or more decayed (non-cavitated or cavitated lesion), missing (due to caries) or filled tooth surface in any primary tooth in children less than 71 months of age or younger [2]. Early childhood caries (ECC) most commonly seen in the children which affects the physical appearance of the children by mutilating the primary anterior teeth [3,4]. This destruction not only affects the aesthetics but also develop the parafunctional habits like improper speech, tongue thrusting, reduction in the masticatory efficacy, psychological issues and reduction in the vertical dimension of occlusion [5]. Primary teeth with two or more decayed surfaces should be restored with full coronal restorations [6]. So, it is important to preserve the decayed primary anterior teeth until their natural exfoliation time as it acts as natural space maintainer [7].

Nowadays, children as well as their guardians are involved in the selection of the restoration for caries affected teeth, and aesthetic demand by children and acceptance for tooth-coloured restorations by guardians has been increased [8,9]. Two most common anterior aesthetic full coronal restorations, the resin composite strip crowns and the preformed primary anterior zirconia crowns, are available [2,10].

Resin composite strip crowns are used for the rehabilitation of the primary anterior teeth using the celluloid forms of the crowns and resin composite [11]. For many years, Strip crowns had been considered as the most aesthetic option for the mutilated primary anterior teeth until the preformed paediatric zirconia crowns were introduced [12]. Strip crowns are highly technique sensitive, which require proper moisture control during bonding and the placement of the crowns [12]. This isolation is difficult to obtain in children's oral cavity not only due to fewer technique and materials are available for isolation in children but also because children who require these belong to the younger age group and most difficult to manage in operatory [13].

Recently introduced zirconia crown in paediatric dentistry earned the maximum popularity, out of all the aesthetic options available, due to its natural appearance and higher durability [14]. Zirconia is a crystalline dioxide of zirconium provides a natural appearance to the restored teeth [15]. Zirconia has also been considered as an ideal material for the fabrication of the naturally contoured crowns due to its higher fracture and mechanical strength, and superior volume and chemical stability than previously available dental ceramics [6]. Few *in vivo* and *in vitro* researches recommend the zirconia as an accepted material for the restoration of the primary teeth [10,16,17]. Most importantly, zirconia crowns cementation is less technique sensitive as compared to that of the strip crowns. Some disadvantages include the no crimping ability, limitation in trimming of the crowns or alterations in the shape, comparatively more tooth reduction and also more expensive as compared to other restorations [18]. So, our study aimed to evaluate and compare the clinical outcomes (gingival health, plaque accumulation, teeth wear of opposing

dentition, color match and restoration failure) of the strip crowns and preformed primary anterior zirconia crowns at one year follow up in 3–5 years old children.

2. Material and methods

2.1. Trial design

The randomised controlled clinical trial design of this study followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines [19]. The study was approved by the Research Ethics Committee of the University college of medical sciences and GTB hospital, Delhi, India (no. IEC-HR/2018/36/132). This research was partially funded with Intra-mural Research Grant (IMRG) from University College of Medical Sciences, Delhi, India. Every child's parent/guardian explained and signed an informed consent form before the enrolment.

2.2. Sample size calculation

Considering the Standard deviation of 0.44 in strip crown and 0.60 in zirconia crown at 6 months ($\alpha = 5\%$ and $\text{power} = 80\%$) [10], to estimate a difference of 0.62 in Mean Gingival Health, a minimum sample of 11 crowns are required in each group, total 22 crowns. The sample size was calculated using G*Power v3.1 software. Giving the availability of time and resources and possibility of 25% attrition in subsequent follow-ups, an additional 18 crowns were included in study, ensuring 20 crowns in each group. The effect size was found to be 0.80. Therefore, a total sample of 40 crowns were included. The subjects were allocated into two groups, Group 1: Resin composite strip crowns (3 M® St. Paul MN, USA) and Group 2: Pre-fabricated primary anterior zirconia crowns (Kids - e - Crown™, MH, India). Initially, 34 children/52 teeth examined and 24 children/40 teeth then selected who satisfied the inclusion/exclusion criteria (Fig. 1).

2.3. Participants

The participants included in the study had good general health and with dmft of ≥ 3 (WHO Index, Federation Dentaire Internationale, WHO, 2006) [10], mandibular primary incisors present, carious primary maxillary incisors with involvement of minimum two surfaces, out of which one must be palatal caries and at least 2/3 crown remains after caries removal (Figs. 2 and 3), require full coronal restoration in the primary incisor involving enamel or enamel and dentin only, managed by behavioural management techniques only and with firm tooth with adequate root support.

2.4. Randomisation

Permuted block randomisation method was used for the allocation of the participants in the groups [10]. Randomisation was done on children in place of individual tooth. Two individuals block size were included. Each block comprised of children who needed similar number of crowns. Hence, a child who needed crowns was only registered in the study

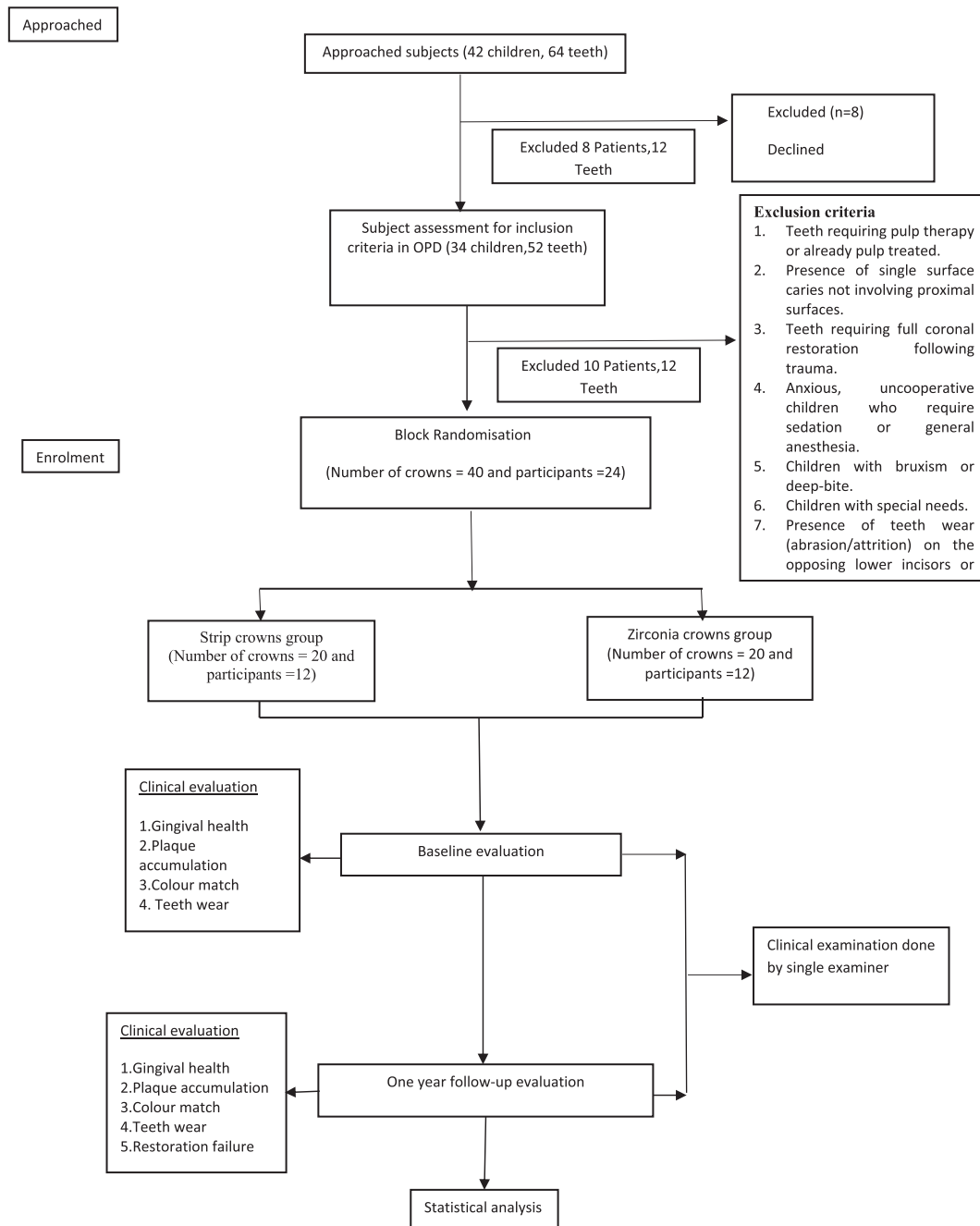


Fig. 1 – Randomized controlled trial flow diagram.



Fig. 2 – Preoperative - strip crowns.



Fig. 3 – Preoperative - zirconia crowns.

when other child who required a same number of crowns was available. Randomly assigned children were twenty in accordance with each group permutation as shown (Table 1) and (Fig. 1).

2.5. Standardization

Subjects assessment for the inclusion and exclusion criteria, and all the procedures were done by single dentist to ensure the standardization. Only one dentist completed all clinical procedures and, all the clinical outcomes were evaluated by the same dentist at one year after the calibration with the senior faculty member for consistency.

2.6. Calibration of dentist for consistency

Calibration of dentist was done in the first three clinical procedures and crown evaluation sessions with one senior faculty member for consistency. The dentist and faculty member each evaluated the patients independently and reviewed their scoring after the examination was complete to confirm the consistency. The examiner and faculty member agreed 100% with each other in all three sessions. This single dentist was then approved to do all the procedures throughout the study, and clinical outcomes evaluations of the crowns at one year follow up.

2.7. Procedure

After the crown size selection, local anaesthesia and good isolation with rubber dam were achieved. Caries excavation was done and the cases with very deep lesions, resin modified GIC liner/base (Viterbond, 3M-ESPE Dental products, St.Paul, Minn®) was used for protection of pulp. The tooth preparation was done. Incisal edge was reduced using no. 330 carbide bur by approximately 1.5 mm and the interproximally contact opened. Both labial and palatal surface were prepared by a coarse tapered round diamond bur by 1–1.5 mm, further the preparation was smoothened and 1 mm subgingival preparation was done a fine tapered round-end diamond bur. In both the groups, principles followed for the tooth preparation were similar [7,10].

Resin composite strip crown placement procedures: First the gingival margin of the strip crown was cut to get a good adaptation, then shade selection of the resin composite (3 M, Filtek™ Z250 Universal Restorative®) was done and celluloid crown form was filled. 37% phosphoric acid solution (3 M™ ESPE™ Etching Liquid®) was used for etching the tooth



Fig. 4 – Strip crowns - clinical evaluation at 1 year.

surfaces for 20 s, and then the light cure bonding adhesive (3 M, Scotchbond-UniversalAdhesive-Refill-Vial-41258®) was applied onto the etched surfaces. The strip crown then inserted and extra resin was swiped and polymerised with curing light, followed by celluloid form removal. Occlusal adjustments and finishing were done, if needed, using polishing discs (3 M ESPE, Sof-Lex® Polishing-Strip) [2,10].

Pre-fabricated primary zirconia crown placement procedure: After a trial for the selection of the crown, labial and lingual borders adjustments were done only if needed, using high-speed fine diamond bur under water irrigation because excess heat may lead to micro-fractures in the zirconia. Final passive fit was checked and cemented with type II GIC (Shofu Version 2 Glass Ionomer Restorative cement) [7,10].

Standard postoperative directives, including oral hygiene guidelines and dietary requirements, such as avoiding sticky foods that could cause restorations to debond, were given to all patients.

2.8. Evaluation and outcomes

Assessment criteria included the evaluation of gingival health and plaque accumulation using a blunt periodontal probe (Double ended probe Williams 1-2-3-5-7-8-910 Goldman Fox Flat) (Figs. 4 and 5), tooth wear on opposing teeth using Bardsley and Smith and Knight Tooth Wear Index (Figs. 6 and 7). Both the incisal and labial surfaces of the opposing teeth to the crowns were clinically evaluated for any sign of tooth wear, evaluation of color match and restoration failure was done by visual assessment of the restoration, according to the US Public Health Service “USPHS”, Alpha criteria rating system (Figs. 4 and 5). Color match was scored by comparing each crown to the color of adjacent teeth (Figs. 4 and 5). Clinical

Table 1 – Distribution of 20 teeth in each group at baseline.

No. of teeth restored per child*	No. of children in strip crowns group (Total = 12 children)	No. of children in zirconia crowns group (Total = 12 children)	Total crowns in strip crowns group (20 crowns)	Total crowns in zirconia crowns group (20 crowns)
1	7	7	7 (7×1)	7 (7×1)
2	3	3	6 (2×3)	6 (2×3)
3	1	1	3 (3×1)	3 (3×1)
4	1	1	4 (4×1)	4 (4×1)

* Randomisation using permuted block randomisation technique



Fig. 5 – Zirconia crowns - clinical evaluation at 1 year.



Fig. 6 – Teeth wear evaluation - strip crowns at 1 year.



Fig. 7 – Teeth wear evaluation - zirconia crowns at 1 year.

evaluations criteria were based on some previous researches [3,10,11,13]. At baseline, only gingival health, plaque accumulation, teeth wear of the opposing dentition and color match were measured, while at the one-year follow-up, all five outcome measures were evaluated (Figs. 4–7). The description of the criteria used to record the clinical parameters (Table 2).

2.9. Statistical analysis

The mean of scores of gingival health, plaque accumulation, teeth wear of opposing dentition, color match and restoration failure, and distribution of crowns at baseline and one year were compared between strip crowns group and zirconia crowns group using the chi-square test. The mean of gingival health score was compared within the groups between baseline and one year using the McNemar- Bowker test. Analyses

were performed using the Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, Versions 20.0. Armonk, NY: IBM Corp).

3. Results

3.1. Demographic details

In our study, total 40 full coverage restorations were placed on primary maxillary incisors, out of which 29 were in central incisors and 11 in lateral incisors in 24 children (12 male, 12 female) (Table 3). There was a dropout of one child patient with one strip crown at one year follow up who belonged to the strip crowns group. Mean age of patients at the baseline was 3.87 years. Maximum frequency of children (70.83%) was found to be 4 years old and least (8.3%) in 5 years old age group.

3.2. Baseline data

At baseline, no statistically significant difference in scores of gingival health, plaque accumulation, teeth wear of the opposing dentition and color match was found between the groups ($p = 1.000$).

3.3. Gingival health and plaque accumulation

Comparing the gingival health at one year from baseline within each group, there was decrease in the mean gingival health score in strip crowns (mean difference = 0.05) and zirconia crowns (mean difference = 0.61) (Table 4). Thus, the improvement in the gingival health was found to be more in the zirconia crowns group than strip crowns group over a period of one year. On intergroup comparison, the gingival health improvement was significantly more in the zirconia crowns group than in the strip crowns group (level of significance = 0.012) (Table 5). On plaque accumulation evaluation at baseline, no plaque was assessed in both the groups as the treatment was started after prophylaxis of all the teeth. At one year, on intergroup comparison, the plaque accumulation was significantly more in the strip crowns group (level of significance = 0.013) (Table 5).

3.4. Teeth wear of opposing dentition

Considering the teeth wear of opposing dentition, at baseline, there was no wear of any tooth of opposing dentition in strip crowns group and zirconia crowns group was found. On intergroup comparison, there was no significant difference in teeth wear of the opposing dentition was found between strip crowns group and zirconia crowns group at one year (level of significance = 0.435) (Table 5).

3.5. Color match

On the color match evaluation at one year, there was no significant difference in the color match was found between the strip crowns group and zirconia crowns group on intergroup comparison (level of significance = 0.168) (Table 5).

Table 2 – Evaluation criteria for strip crowns and zirconia crowns.

Clinical outcomes	Grades	Description
Gingival health	0	No obvious signs of inflammation
	1	Mild marginal gingivitis, tissue slightly reddened and edematous
	2	Moderate marginal gingivitis, tissue obviously reddened and swollen
	3	Severe gingivitis, tissue is very swollen: spontaneous bleeding
Plaque accumulation	0	No plaque
	1	A film of plaque adhering to the free gingival margin and adjacent area of the tooth. The plaque may be seen in situ only after application of disclosing solution or by using the probe on the tooth surface
	2	Moderate accumulation of soft deposits within the gingival pocket, or the tooth and gingival margin which can be seen with the naked eye
	3	Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin
Teeth wear of opposing dentition	0	No loss of enamel surface characteristics, no loss of contour
	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
Color match	0	No noticeable difference from adjacent teeth
	1	Slight shade mismatch
	2	Obvious shade mismatch
Restoration failure	0	Crown appears normal: no cracks, chips, or fractures of material
	1	Small but noticeable area of loss
	2	Large loss of crown material
	3	Complete loss of crown

Table 3 – Baseline data of the teeth restored.

Primary maxillary incisors (Tooth number- FDI system)	Count (%)
Right lateral (52)	4 (10)
Right central (51)	14 (35)
Left central (61)	15 (37.5)
Left lateral (62)	7 (17.5)

3.6. Restoration failure

Restoration failure was evaluated at one year. In strip crowns group, 5 crowns were normal with no cracks, chips, or fractures of material, 11 crowns showed small but noticeable area of loss, 2 crowns showed large loss of the crown material and 1 crown completely lost out of 19 restored teeth examined as shown in Table 6. In zirconia crowns group, only 1 crown lost

Table 4 – Mean gingival health score of strip crowns group and zirconia crowns group at baseline & after one year.

Gingival health	Strip crowns group				Zirconia crowns group			
	Mean	Standard Deviation	Mean difference	Level of significance	Mean	Standard Deviation	Mean difference	Level of significance
Baseline	1.40	0.50	–0.05	0.549	1.45	0.51	–0.61	0.246
1 year	1.35	0.60			0.84	0.37		

Table 5 – Intergroup comparison of Gingival health, Plaque Accumulation, Teeth wear, Color match and Restoration failure results at the one year follow up.

	Strip crowns group		Zirconia crowns group		Level of significance
	Mean	Standard Deviation	Mean	Standard Deviation	
Gingival health	1.35	0.60	0.84	0.37	0.012 ^a
Plaque accumulation	1.35	0.60	0.89	0.31	0.013 ^a
Teeth wear	0.12	0.33	0.21	0.41	0.435
Color match	0.76	0.66	0.37	0.59	0.168
Restoration failure	1.00	0.88	0.15	0.67	0.0001 ^a

^a Statistically significant value.

Table 6 – Gingival health, Plaque Accumulation, Teeth wear, Color match and Restoration failure results at the one year follow up.

Outcome measures	Grades	Strip crowns group	Zirconia crowns group
		n (%) = number of crowns (percentage)	n (%) = number of crowns (percentage)
Gingival health	0	1 (5.8)	3 (15.7)
	1	9 (52.9)	16 (84.2)
	2	7 (41.1)	0 (0)
Plaque Accumulation	0	1 (5.8)	2 (10.5)
	1	9 (52.9)	17 (89.4)
	2	7 (41.1)	0 (0)
Teeth wear	0	15 (88.2)	15 (78.9)
	1	2 (11.7)	4 (21)
Color match	0	6 (35.2)	13 (68.4)
	1	9 (52.9)	5 (26.3)
	2	2 (11.7)	1 (5.2)
Restoration failure	0	5 (26.3)	19 (95)
	1	11 (57.8)	0 (0)
	2	1 (5.2)	0 (0)
	3	2 (10.5)	1 (5)

completely and 18 crowns were normal with no cracks, chips, or fractures of material, out of 20 restored teeth examined. On intergroup comparison, there was significant difference in restoration failure between the strip crowns group and zirconia crowns group (level of significance = 0.0001) was found (Table 5).

4. Discussion

This randomised controlled trial research compared the clinical outcomes of aesthetic strip crowns and zirconia crowns in 3-5-year-old children over a period of one year. Randomised controlled trial is considered as most reliable for clinical interventional research [19]. Based on the results of this study, clinical outcomes were found better with the zirconia crowns than strip crowns.

In our study, gingival health for the zirconia crowns was found significantly better with zirconia crowns than strip crowns at one year follow up. According to Hackmyer and Donly (2010), preparation of the tooth and its finishing are aspects that may influence the gingival health of the crowns [20]. The extent of gingival inflammation is closely related to the position of the crown margin and location of margins coronal to the free margin of gingiva are desirable [10]. Related finding from a retrospective analysis of Kupietzky et al. (2003) included 112 resin composite strip crowns showed that 43% of the restored teeth had gingival inflammation all around the crowns [21]. In this study, in zirconia crowns group, also significant decrease in the mean gingival health from baseline was observed. Zirconia is extremely biocompatible when used as a tooth material and has a smooth and polished surface contributing to less plaque formation and therefore less gingival irritation. Another recent retrospective study for the zirconia crowns by Holsinger et al. (2016) [14] assessing 57 primary anterior teeth treated with zirconia crowns showed significant healthy gingiva in relation to these crowns and an intergroup study by Walia T et al. (2014) [10] who assessed anterior primary crowns for 129 teeth reported that zirconia

crowns showed improved gingival health due to less plaque accumulation when compared to composite strip crowns, supported the results of our study. Abdulhadi et al. (2017) [3] found lower tendency of plaque build-up lead to less gingival inflammation which was also in favour of our study. So, these results may be the explained as zirconia, used for the fabrication of full coronal crowns, not only exhibits remarkable biocompatibility and also a smooth plus polished surface that contributes to a lower propensity of plaque build-up and hence a lower risk of gingival inflammation as compared to the strip crowns [3].

The wear of the opposing dentition could be defined as the removal of surface layer material (e.g. enamel) by opposite teeth surface during function [6]. In this study, when the teeth were assessed for the wear of the opposing dentition, minimal loss of contour indicative of a loss of enamel surface of the opposing teeth was found in the 11.7% strip crowns and 21% zirconia crowns which was statistically insignificant at one year. Walia et al. (2014) [10] found 10% crowns of the 38 zirconia primary crowns showed minimal loss of contour indicative of a loss of enamel surface and no wear in the strip crowns group at 6 months. In contrast to our study, Holsinger et al. (2016) [14] found no wear of the opposing dentition in zirconia crowns at about 20.8 months. The wear of enamel associated with various composite resins and ceramics is also a multi - factorial phenomenon. In zirconia crowns, antagonistic tooth wear is consistent with the surface and physical properties of zirconia, including bending strength, hardness, density and fracture toughness [6]. Latest study by the University of Zurich has also shown that only glazed and poorly polished can be harmful to the opposite teeth structure [10].

In our study, color matching and restoration failure were assessed using Ryge's direct (USPHS) evaluation criteria. In strip crowns group, 52.9% crowns found slight shade mismatch and 11.7% crowns showed obvious shade mismatch at one year follow up. Kupietzky et al. (2003) [21] who had done the retrospective study of only strip crowns found 21% teeth with slight shade mismatch at an average 18 months which is comparatively more in our study. Ram et al. (2006) [22] found

that the color was “acceptable” for the strip crowns in 96% of central incisors and 98% of the lateral incisors at 24 months follow up where “acceptable color” was defined as perfect match with the adjacent teeth and “unacceptable color” as slight or more difference with the adjacent teeth, which was also in contrast to our study. In this study, in zirconia crowns group, only 26.3% crowns showed the slide shade mismatch and 5.2% showed the obvious shade mismatch at one year follow up, and Holsinger et al. (2016) [14], in his retrospective study for zirconia crowns, also found the almost similar results where only 32% crowns showed the slide shade mismatch for zirconia crowns at an average 20.8 months. In our study, comparatively more shade mismatch for strip crowns than zirconia crowns may be related to alterations in composite restoration that could be caused by the development of color deterioration products, variations in surface topography due to wear and external staining [13].

In the strip crowns group, we had significantly higher success rate for the zirconia crowns as compared to the strip crowns at one year follow up. In zirconia crowns group, we had 95% normal crowns with no cracks, chips or fracture of the material at one year follow up. In the randomized controlled trial, Walia et al. (2014) [10] reported the 100% normal crown with no cracks, chips or fracture of the material and more success rate for zirconia crowns at 6 months follow up and, in a retrospective study for the zirconia crowns by Holsinger et al. (2016) [14] had 96% crowns intact at an average 20.8 months follow up for the zirconia crowns. Tate et al. (2002) [23] had 51% failure rate for the strip crowns given under the general anaesthesia for the patients who came for the follow up for at least 6 months supported the results of our study.

In contrast to our study, success rate between 80% and 88% were found for strip crowns in the studies done by Kupietzky et al. (2005) [24]; Ram and Fuks (2006) [22] and Kupietzky et al. (2003) [21].

Strip crowns are extremely technique sensitive and require proper haemostasis and composite curing [14]. In our research, only behavioural management approaches have been used to treat kids. However, they remained uncooperative, agitated and anxious during treatment, rendering moisture management ineffective for this highly sensitive technique procedure [10].

Zirconia crowns are comparatively less technique sensitive and more moisture-resistant than strip crowns, although it is cement-dependent, and different manufacturers suggest different cements; some manufacturers offer glass ionomer cement, such as one used in this study, while some others recommend bioactive cement [14]. Flexural strength of zirconia oxide materials has also been stated to be between 900 and 1100 MPa. So, it may be the justification for the high success rate of zirconia crowns in our study.

5. Conclusion

This research contributes considerable importance to the literature as regards the clinical efficiency of zirconia crowns in primary incisors as these crowns were found more successful over strip crowns. While zirconia crowns are more

costly than the strip crowns but the high failure rate of strip crowns and the need to revisit dental care and re-treatment of broken strip crowns should be taken into account. This research showed that zirconia crowns are cost competitive because they have a high success rate and a limited need for retreatment.

Contribution

Dr. Mayank Sharma – Clinical work and evaluation done, collected and analysed the data.

Dr. Amit Khatri – Conceived the idea, supervised the clinical work and clinical evaluation, and led the writing.

Dr. Namita Kalra – Supervised the clinical evaluation and led the writing.

Dr. Rishi Tyagi - Supervised the clinical evaluation and led the writing.

Declaration of competing interest

There is no conflict of interest.

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