RESEARCH ARTICLE

Clinical and Radiographic Success of Resin-bonded Strip Crowns in Primary Incisors with Varying Extents of Sound Tooth Structure Available for Bonding

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Abstract

Context: First-time dental treatment for children is often sought due to carious, malformed, fractured, and discolored teeth. The strip crown represents a highly esthetic and popular option for the restoration of primary anterior teeth. However, there are limited data on the clinical success of these crowns based on the extent of surface area used for adhesion.

Aims, settings and design: This *in vivo* study aimed to assess the clinical, radiographic, and photographic performance of 66 composite strip crown restorations on primary anterior teeth for up to 15 months and compare the outcome based on the extent and surface area of tooth structure available.

Materials and methods: The amount of surface area available in each group after removal of affected enamel was evaluated through 3D scanning of study casts and digital measurements. The teeth were thus grouped into three categories: group I with crown structure involvement up to the incisal one-third, group II with involvement up to the middle of the middle third, and group III with involvement up to the cervical one-third.

Statistical analysis used: Kruskal–Wallis *H* test and Mann–Whitney *U* test were used for computation of mean scores for intra- and intergroup comparison, respectively. Scoring was done as per FDI clinical criteria on a scale of 1 to 5.

Results: Group III showed the highest mean scores at different time intervals and also the highest failure rate (52.38%), followed by group II (12%) and group I (5%). The overall retention rate observed for the strip crowns was 77.28% at the end of 15 months.

Conclusion: Strip crowns should be considered for teeth that offer a minimum of half to two-thirds of the healthy tooth structure remaining. Further, longitudinal studies are required to add to the results of the final outcome of these restorations.

Key messages: A critical surface area value of <50 mm^2 or less than half of the available sound tooth structure was found to be detrimental to the retention rate of these crowns in this study. It could therefore be suggested to consider strip crowns for teeth that offer a minimum of half to two-thirds of healthy tooth structure remaining.

Keywords: Esthetic, Primary Incisors, Resin composite, Restorative dentistry, Strip crown, Tooth surface area.

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Introduction

Esthetics has been quoted to be the fourth dimension of dentistry in addition to biological, physiological, and mechanical dimensions.[1] With the ever-growing awareness pertaining to dental esthetics, there is greater emphasis by parents on obtaining satisfactory solutions to unsightly dental problems in their children. These problems include early childhood caries, malformed, and discolored teeth due to developmental defects and tooth fractures.[2]

From the perspective of the health of permanent teeth, proper intake of diet, phonetics, space maintenance, and esthetic appreciation, the significance of primary teeth cannot be ignored. It is, however, challenging to restore extensively destroyed anterior teeth with restorations that are durable, retentive, as well as esthetic owing to several factors such as -the small size of the teeth, close proximity of the pulp to the tooth surface, relatively thin enamel, etching ability of deciduous enamel due to its aprismatic nature, lack of surface area for bonding and issues related to child behavior. The options for treating decayed primary incisors depend upon the stage of decay, along with the age and cooperation of the child patient. Situations may vary and warrant either full-coverage crowns that are performed with metal, zirconia, and polycarbonate materials and held onto the tooth by a luting cement, or those that are bonded to the tooth with celluloid strip crowns.

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Conflict of interest: None

Currently known as the "strip crown" technique, this method produces a direct, mouth-formed, full-coverage restoration. A strip crown is essentially a crown form filled with a composite that is bonded onto the tooth.[3] Since these composite crowns provide superior esthetics than other forms of anterior coronal coverage restorative options and are easy to repair in case of subsequent chip or fracture, they are extremely popular for restoring primary anterior teeth. It remains the first choice among 46% of pediatric dentists for full coronal restoration of primary incisors.[4] Despite the

technique being used for over two decades, longitudinal clinical data on the longevity of these crowns are limited and there is a definite paucity of literature concerning the clinical success based on the extent of surface area used for adhesion. Furthermore, indications provided for strip crown treatment are not specific in clarifying the adequacy of the surface area for warranted outcomes. Hence, the durability of these crowns over extended periods of time continues to be a concern.

This randomized controlled prospective longitudinal study aimed to assess the clinical, radiographic, and photographic performance of resin-bonded composite strip crown restorations on primary anterior teeth until 15 months and compare the outcome based on the extent and surface area of tooth structure available.

Materials and Methods

This trial was approved by the Ethical committee of Baba Farid University of Health Sciences. Random screening of children in the age-group of 2 to 5 years was carried out through school dental check-ups and outpatient Department of Pedodontics and Preventive Dentistry, for at least two carious/traumatized/discolored/malformed primary incisors showing different extents of tooth structure involvement.

The inclusion criteria for teeth in the study included:

- Presence of equivalent or more than one-third of the crown structure.
- Absence of physiological/pathological root resorption up to two-third or more of root length.

Teeth that were excluded from the study were:

- Grossly decayed teeth with less than one-third of tooth structure remaining.
- Teeth demonstrating poor prognosis with extensive root resorption or internal resorption.
- Impinging deep overbite.
- Periodontal disease.
- Parafunctional habits: bruxism/pencil/nail biting.

Informed written consent was obtained from the parents/guardian in the language best understood by them.

Patient demographic data were collected. Patient oral status, oral hygiene, and caries risk were evaluated by two investigators using the Oral Hygiene Index (OHIS-M),[5] and the American Academy of Pediatric Dentistry caries risk assessment form.[6]

A random, convenience sample of 115 teeth was selected. The final sample of teeth for each group requiring strip crowns was selected by measurements made using digital Vernier calipers before tooth preparation for restoration. Furthermore, specific sample grouping of teeth for each was determined via 3D laser scanning (3M-ESPE Lava Scan ST, St Paul, USA; Medit Identica Hybrid, Seoul, Korea) and digital measurements of casts prepared post tooth preparation. The accurate surface area available for each tooth was determined by AutoDesk Netfabb Standard 2018 Software. The specific, stratified sample that complied to enroll for the study comprised of 66 teeth with 23 subjects (10 males + 13 females) to keep the sample size significant for statistical analysis and to overcome the fall in sample size due to drop out cases.

The specific grouping was done as: group I with crown structure involvement up to the incisal one-third, or a minimum of 67% of healthy enamel and dentin available for bonding; group II with crown structure involvement up to the middle of middle third, or a minimum of 50% of healthy enamel and dentin available for bonding; group III with crown structure involvement up to the cervical one-third, or a minimum of 33% of healthy enamel and dentin available for bonding (Fig. 1 and Table 1).

Each restoration was done by a single operator previously calibrated in the procedure. The strip crowns were performed in accordance with the technique described by Kupietzky.[7] FDI World Dental Federation: clinical criteria for the evaluation of direct and indirect restorations[8,9] were used to evaluate the strip crowns clinically and radiographically (Fig. 2). Standardized photographs were taken soon after restoration for each restoration for photographic evaluation criteria. Esthetic, mechanical, and biological parameters were recorded immediately after placement and at 3, 6, 9, 12, and 15 months. Radiographic assessment of the restorations was done at baseline, 6 months, and 15 months in accordance with AAPD guidelines (2012).[10] Scoring was performed by the operator and also by two calibrated examiners and the mean of the scores obtained was taken as the final score for the restorations. The obtained data were subjected to statistical analysis and evaluation for significant outcomes.

Results

Kruskal–Wallis *H* test and Mann–Whitney *U* test were used for computation of mean scores for every group and intergroup comparison, respectively. Scoring was done as per FDI criteria on a scale of 1 to 5.

Fig. 1: The three types of crown involvement

FDI criterion	Clinically acceptable			Clinically unacceptable	
	1: Clinically excellent	2: Clinically good	3: Clinically sufficient/ satisfactory	4: Clinically unsatisfactory (but reparable)	5: Clinically poor (replacement necessary)
1) Esthetic 1.1) Surface gloss, luster and roughness	Comparable to enamel	Slightly dull, not noticeable from speaking distance; some isolation pores	Dull surface but acceptable if covered with film of saliva; multiple pores on ≥⅓ of the surface	Rough surface, cannot be masked by saliva film, simple polishing is not sufficient; voids	Quite rough, unacceptable plaque retentive surface
1.2) Surface and marginal staining	No staining	Minor staining, easily removable	Moderate staining that may also present on other teeth, not esthetically unacceptable	Unacceptable pronounced staining; major intervention necessary for improvement	Severe staining; not accessible for intervention
1.3) Color match and translucency	Good color match, no difference in shade and/or translucency	Minor deviations	Distinct deviation but acceptable; does not affect esthetics	(Localized) clinical deviation that can be corrected by repair	Unacceptable; replacement necessary
1.4) Esthetic anatomical form	Form is ideal	Form deviates only slightly from the norm	Form deviates from the norm but esthetically acceptable	Form is affected and unacceptable esthetically	Form is completely unsatisfactory and/ or lost
2) Function 2.1) Fracture and retention	Restoration retained, no fractures, cracks, or chipping	Small hairline crack	Two or more or larger hair-line cracks and/or chipping (not affecting the marginal integrity or proximal contact)	Material chip fractures which damage marginal quality or approximal contacts; bulk fractures with partial loss (<½ of the restoration)	(Partial or complete) loss of the restoration or multiple fractures
2.2) Marginal adaptation	Harmonious outline, no gaps, no white or discolored lines	Small marginal fracture removable by polishing; slight ditching, slight step/flashes, minor irregularities	Several small marginal fractures; major irregularities, ditching, flash or steps	Severe ditching or marginal fractures; larger irregularities or steps (repair necessary)	Restoration (complete or partial) is loose but in situ; generalized major gaps or irregularities
3) Biological 3.1) Secondary caries	No secondary or primary caries	Small and localized demineralization	Larger areas of demineralization, dentin not exposed	Caries with cavitation and suspected undermined caries	Deep secondary caries or exposed dentin that is not accessible for repair
3.2) Periodontal response	No plaque, no inflammation	Little plaque, no inflammation (gingivitis)	Plaque accumulation at acceptable level; gingival bleeding acceptable	Plaque accumulation or gingival bleeding not acceptable	Severe/acute gingivitis or periodontitis

Fig. 2: FDI World Dental Federation criteria used to assess esthetic, functional, and biological properties of resin strip crowns

Table 1: Distribution of surface area and number of decayed surfaces in three groups

		N	*Mean*	*Minimum*	*Maximum*
Surface area (mm^2)	I	20	80.95	62	102
	II	25	56.10	43	78
	III	21	38.29	28	55
	Total	66	56.78	36	133
No. of decayed surfaces	I	20	2.75	1	4
	II	25	3.20	2	4
	III	21	3.57	2	4
	Total	66	3.18	1	4

Table 2: Intergroup comparison of color match

	Gp I vs II	*Gp I vs III*	*Gp II vs III*
Time	*p value*	*p value*	*p value*
Baseline	1.000	1.000	1.000
3 months	0.371	0.038*	0.090
6 months	0.020*	0.000**	0.055
9 months	0.039*	0.001*	0.164
12 months	0.564	0.223	0.459
15 months	0.851	0.485	0.521

*Significant
±Highly significant

Table 3: Intergroup comparison of partial and complete loss of restorations

	Gp I vs II	*Gp I vs III*	*Gp II vs III*
Time	*p value*	*p value*	*p value*
Baseline	1.000	1.000	1.000
3 months	1.000	0.162	0.119
6 months	1.000	0.043*	0.024*
9 months	1.000	0.006*	0.002*
12 months	0.742	0.089	0.117
15 months	0.846	0.025*	0.009*

*Significant
±Highly significant

Fig. 3: Photographic assessment of esthetic and functional parameters

Esthetic Parameters

The surface of restorations in group III was significantly rougher than group I and group II at 6 and 9 months. Significantly more staining was also seen in group III restorations at all time intervals. Comparison of the color match at different time intervals showed that mismatch in color and translucency was found to be significantly higher between group I and III and group I and II at 3, 6, and 9 months (Table 2). Clinical crown contour showed no significant difference between the three groups.

Functional Parameters

Table 3 shows the intergroup variation in the loss of restorations. At baseline, the mean score was evaluated as clinically excellent (FDI Score 1) for all groups. At 3 months, two restorations belonging to group III were completely lost (FDI Score 5). At 6 months, one restoration belonging to group III was completely lost (FDI Score 5) and one restoration was partially lost without compromising the margins or contact (FDI Score 3). At 9 months, three restorations, all belonging to group III were lost. Two of these restorations were completely lost (FDI Score 5) while one restoration was partially lost (FDI Score 3). None of the restorations belonging to group I and group II were lost till 9 months. At 12 months, one restoration belonging to group I was completely lost (FDI Score 5) due to trauma, and there was also a concurrent fracture of the tooth. Two restorations belonging to group II were also lost (FDI Score 3 and FDI Score 5). Two restorations belonging to group III were partially lost (FDI Score 3). At 15 months, one restoration belonging to group II was completely lost (FDI Score 5), along with two restorations from group III (FDI Score 5) (Fig. 3).

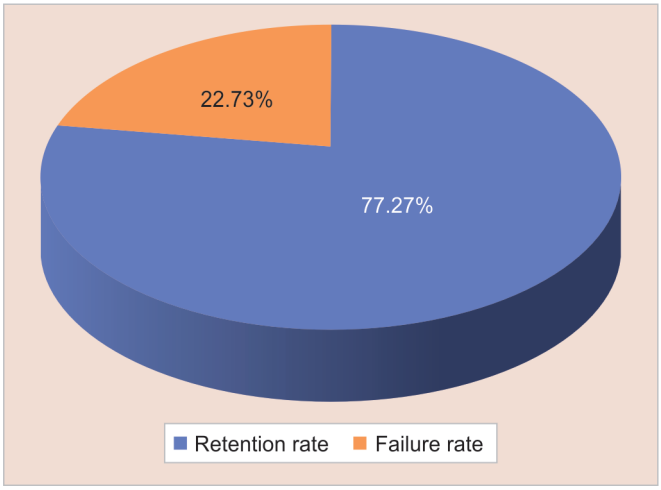

Fig. 4: Retention and failure rate of strip crowns

The overall retention rate observed for resin bonded strip crowns in this study was 77.27% (Fig. 4). Group III showed the highest failure rate at 52.38%, followed by group II at 12% and group I at 5%.

Table 4: Intergroup variation in caries risk

			Group			
			A	*B*	*C*	*Total*
Caries risk	High	Count	9	12	14	35
		% within group	45.0	48.0	67.0	53.03
	Low	Count	4	3	0	7
		% within group	20.0	12.0	0.0	10.60
	Moderate	Count	7	10	3	20
		% within group	35.0	4.0	14.3	30.30
Total		Count	20	25	21	66
		% within group	100.0	100.0	100.0	100.0

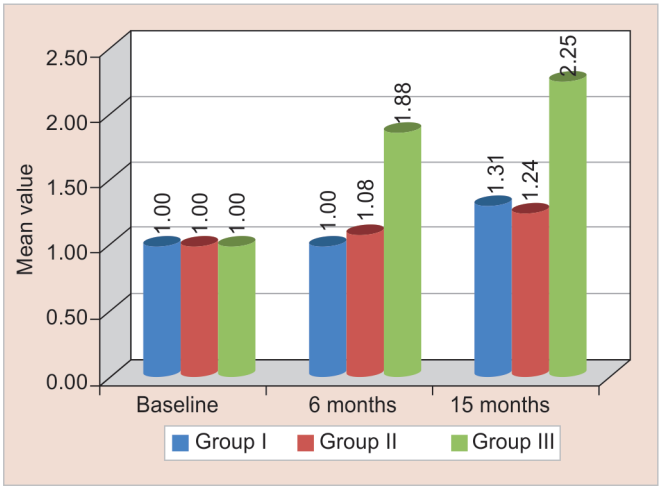

Fig. 5: Intergroup comparison of radiographic assessment

The intergroup comparison of marginal adaptation at different time intervals showed significant differences between the groups at 6 and 9 months, with group III demonstrating consistently higher scores.

Biological Parameters

Comparison of recurrent caries at margins of the restorations at different time intervals showed consistently higher scores for group III at all time intervals. This finding may be correlated with the intergroup variation in caries risk, where 67% of teeth in group III belonged to the high-risk category (Table 4).

The intergroup comparison of periodontal response at different time intervals showed significant differences between group I and group III and also between group II and group III at 15 months. Although the scores in group I and group III were found to be equivocal up to 6 months, the scores for group III were consistently higher thereafter. At 15 months, 25% of the teeth in group III, 12.5% in group II, and 10% in group I were scored at FDI Grade 2. Clinically visible gingivitis (FDI Grade 3) was seen in 25% of the teeth in group III and 10% of the teeth in group II.

Radiographic Assessment

Radiographic assessment was performed at baseline, 6 months, and 15 months in accordance with AAPD guidelines (2012) for dental radiographs in children (Fig. 5). This was done to assess the marginal contour and adaptation of the resin bonded strip crown restorations. The radiographic performance of the teeth in group III was significantly poorer than those of group I and group II at 6 months and than those of group II at 15 months. In the present study, no tooth was observed to show any evidence of pulpal or periapical pathosis. However, the marginal contour assessment score was consistently higher for group III and the difference was found to be highly significant. At the 6-month follow-up, all the teeth in group I (100%) showed excellent margins (FDI Score 1), whereas 92% in group II and 52.4% in group III showed excellent margins. The remaining teeth in group III and 8% in group II demonstrated a clinically acceptable score (FDI Score 2). 9.5% of teeth in group III showed a clinically sufficient score (FDI Score 3) and 9.5% showed loss of restoration (FDI Score 5). At 15 months, 86.4% of teeth in group I showed a harmonious transition between the restoration and tooth along with no concurrent pathology (FDI Score 1), whereas 74.9% of teeth in group II and 40% of the teeth in group III showed the same. 13.4% of the teeth in group I, 11.8% of teeth in group II, and 25.0% of teeth in group III showed acceptable material excess and/or marginal step of <150 µm (FDI Score 2). Marginal gap and step of <250 µm were seen in 3.9% of teeth in group I, 9.7% of teeth in group II, and 10% of teeth in group III (FDI Score 3). FDI Score 5 showing loss of restoration was seen in 25% of the teeth in group III. Therefore, a break in radiographic margins was seen in 35% of teeth in group III, 21.5% in group III, and 17.3% in group I.

Discussion

Dental caries continues to be the most prevalent chronic disease of childhood. Children experiencing caries as infants or toddlers are at high risk for subsequent caries in both the primary and permanent dentition. The teeth most often involved are the maxillary central and lateral incisors and the maxillary and mandibular primary first molars, while the mandibular primary incisors are relatively unaffected.[11,12] Maxillary incisors are the most severely involved, and such carious lesions rapidly and progressively destroy the incisors after an eruption and give rise to low masticatory efficiency, loss of vertical dimension, parafunctional habit formation, speech disturbances, and psychological and behavioral complications. Therefore, preserving the integrity of the primary dentition is critically important until they exfoliate normally.

Lee[13] presented a literature review regarding the restoration of primary anterior teeth and stated that despite numerous articles being published over the years, very little data exist on the longevity of these restorations in a clinical setting. This lack of long-term, controlled clinical data prevents the validation or endorsement of any of the restorative options for repairing carious or traumatized anterior primary teeth. For over three decades, the most esthetic

restorative option for carious primary incisors has been the bonded strip crown.[14] However, there is a definite dearth of literature concerning clinical success based on the extent of surface area used for adhesion. This study attempted to assess the clinical, radiographic, and photographic performance of resin bonded composite strip crown restorations on primary anterior teeth based on the extent and surface area of tooth structure available.

Clinical and Photographic Assessment

The surface of restorations in group III was found to be significantly rougher than group I and group II at 6 and 9 months. Since the restorative material used was the same in all groups, this change can be attributed to the caries risk assessment done at various intervals showing 81% of the group III sample with a baseline history of intake of beverages. Also, 67% of high caries risk group teeth belonged to group III, 48% belonged to group II, and 45% belonged to group I (Table 4). It has been documented that the presence of weak acids present in different beverages consumed daily can influence the hardness and surface roughness or degradation of the nano-filled composite material. The same findings may be extrapolated to an intergroup comparison of staining where significantly more staining was seen in group III restorations at all time intervals. In addition to acidic beverages, consumption of tea and milk beverages with added Bournvita, Horlicks, etc., was also found to favor staining of the restorations. Similar susceptibility of nanohybrid composite resin staining by tea was reported by Poggio et al.[15]

The difference in the color match can be attributed to the fact that group I had just 15% of endodontically treated teeth compared with group II (44%) and group III (71.4%). Although pulpally treated teeth were sealed with RMGIC baseliner, the translucent nature of the resin bonded strip crown restorations allowed the discolored tooth surface to show through the restoration.[16]

Ram and Fuks[17] reported similar unacceptable esthetic results with resin strip crowns in teeth that had been endodontically treated. It was suggested that the discoloration seen with pulpectomy-treated teeth could be minimized by using an opaquing agent on the facial aspect of the preparation before strip crown placement or using a glass ionomer in the coronal one-third of the pulp canal to prevent coronal discoloration by the endodontic paste.

The intergroup comparison of partial and complete loss of restorations at different time intervals showed maximum loss (52.3%) of restorations in group III, which was highly significant. Therefore, an overall retention rate of the strip crown restorations showed a failure rate of 22.73% and a clinical success rate of 77.27% (Figs 4 and 6). This is in accordance with the retention rates reported in previous studies (Table 5).

It was also noted by Ram and Fuks[17] that the more the surfaces that were cariously involved, the greater the likelihood of failure of the crown. The present study, however, correlated the above results to the surface area required for longevity and retention. Since the grouping of the sample in the present study was based on the measured overall surface area for adhesion of restorative material, 60% of the restorations were lost in the groups showing <50 mm^2 of surface area or less than half of available sound tooth structure (Fig. 7).

According to the results obtained, group III showed a maximum partial (29%) and complete (38.1%) loss of restorations, followed by group II with 8% complete loss and 4% partial loss, and by group I with 5% partial loss and no complete loss of restoration (Fig. 8).

Marginal adaptation at different time intervals showed significant differences between the groups at 6 and 9 months, with group III demonstrating consistently higher scores. This can be attributed to the more bulk of the material and less surface area available for adhesion in the teeth in group III which are known to jeopardize the margins of composite restorations.[26]

Group III showed consistently high scores for recurrent caries at all time intervals. This finding may be correlated with the intergroup variation in caries risk where 67% of teeth in group III belonged to the high-risk category. Kuper et al.[27] showed that composite restorations with margins having a greater apical extension were at a greater risk of failure and subsequent development of dental

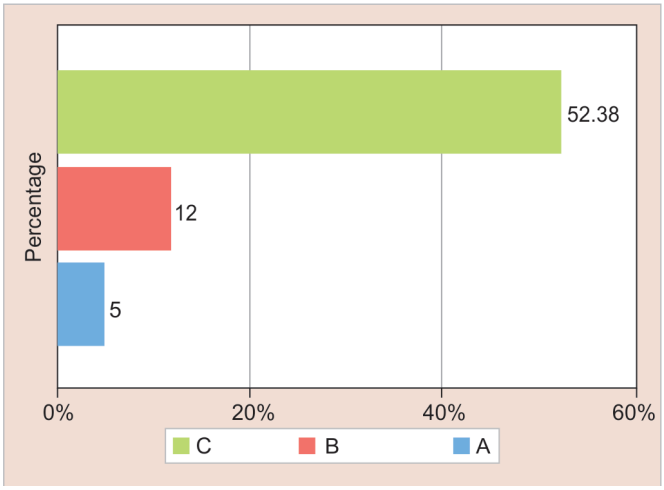

Fig. 6: Failure rates in three groups

Table 5: Retention rates of resin-bonded strip crowns reported in literature

Authors	*Year*	*Study design*	*Reported retention rate*	*Follow-up period*
Tate et al.[18]	2002	Retrospective	49%	6–48 months
Al-Eheideb and Herman[19]	2003	Retrospective	70%	6–27 months
Kupietzky et al.[16]	2003	Retrospective	88%	18 months
Kupietzky et al.[20]	2005	Retrospective	78%	3 years
Ram and Fuks[17]	2006	Retrospective	80%	24–74 months
Walia et al.[21]	2014	Clinical trial	78%	6 months
Dhillon et al.[22]	2015	Retrospective	80.8%	1 year
Lin and Lin[23]	2015	Retrospective	71.7%	24 months
Radu et al.[24]	2016	Clinical trial	82.77%	20 months
Manmontri et al.[25]	2018	Retrospective	86.9%	12–33 months

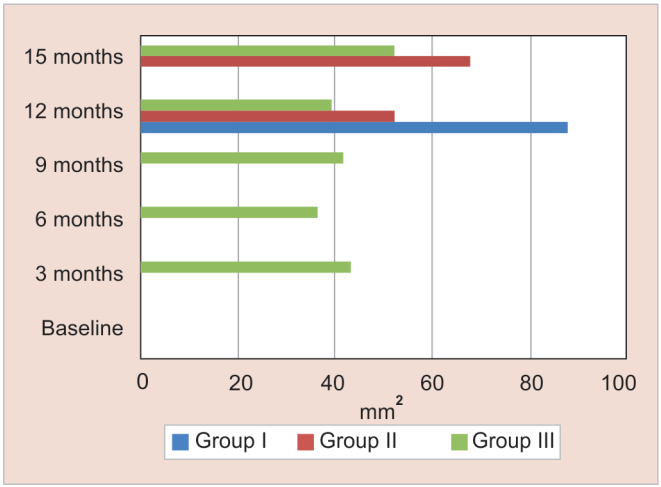

Fig. 7: Surface area comparison of lost restorations

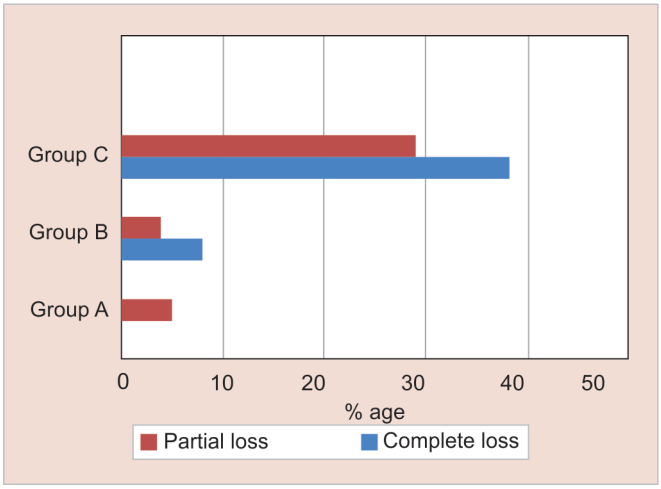

Fig. 8: Comparison of complete and partial loss of restorations

Fig. 9: Periodontal response score 3 at 9 months wrt 51 and 61

caries compared with restorations with more sound, supragingival margins.

Kupietzky et al.[16] stated that the health of the labial gingival tissue may be evaluated as an indication for the integrity of the cervical margins of the restoration. The authors assumed that healthy gingivae are indicative of well-adapted crown margins. Possible explanations regarding the health of the gingiva surrounding the resin strip crowns being slightly more inflamed than around teeth without crowns include (a) Crowns may lead to more cervical plaque accumulation and hence, more inflammation, (b) The radiographic finding of less than ideal crown margins may also contribute to more inflammation. Therefore, the poor marginal adaptation and gingival health seen in teeth in group III can be attributed to the higher amount of destruction and poor margins seen in this group (Fig. 9). Similar findings were seen in the intergroup comparison of adjacent mucosa at different time intervals which showed a significant difference between group II and group III at 15 months. The presence of local irritant factors such as plaque and poor oral hygiene were the main contributing factors for this difference, as was seen while recording the OHIS-M.

Radiographic Assessment

Kupietzky et al.[20] observed that during the radiographic assessment of marginal contour of resin strip crowns was not as good as what was seen clinically. Thirty-five percent of the teeth in the study demonstrated less-than-ideal crown margins. In contrast, Ram and Fuks[17] noted good marginal adaptation of the resin and a healthy periodontal ligament without any pulpal or periapical pathosis in 96% of the teeth with a minimal follow-up period of 24 months. In the present study, a break in radiographic margins was seen in 35% of teeth in group III, 21.5% in group II, and 17.3% in group I. These findings can also be correlated with the poor gingival health seen in teeth in group III as described above.

Conclusion

Resin strip crowns represent an excellent and esthetic option for the restoration of decayed primary incisors. However, adequate case selection and optimum moisture and hemorrhage control are of vital importance for the longevity of these restorations. The outcome of this study showed that resin strip crowns belonging to group I and II performed significantly better clinically and radiographically than group III, which had the least amount of available tooth surface area. A critical surface area value of <50 mm^2 or less than half of the available sound tooth structure was found to be detrimental to the retention rate of these crowns in this study. It could therefore be suggested to consider strip crowns for teeth that offer a minimum of half to two-thirds of healthy tooth structure remaining. Furthermore, longitudinal studies are required to establish this value and add to the results of the functional performance and final outcome of these restorations.

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