ORIGINAL RESEARCH

Comparative Evaluation of Polymethyl Methacrylate and Thermoforming Crowns as Semipermanent Crowns in Primary Molars: An *In Vivo* Study

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Abstract

Aim: The present randomized clinical trial is aimed at evaluating clinical efficiency of two different types of esthetic crowns—polymethyl methacrylate crowns and vacuum formed thermoformed crown as an alternative to full-coverage coronal restoration for deciduous molars.

Materials and methods: A total of 45 primary molars in pediatric patients were selected using randomization and split into three groups based on the technique used for preparation of crowns: group I—polymethyl methacrylate crowns; group II—thermoformed crown; and group III—stainless steel crowns (SSC). All crowns were clinically and radiographically evaluated at baseline, 1st month, and 3rd month for gingival health, retention, marginal integrity, proximal contacts, occlusion, alignment, and staining.

Statistical analysis: The data was tabulated and analyzed by Statistical Package for the Social Sciences (SPSS) Version 23.0 software. The intergroup comparison was done by Kruskal–Wallis test, analysis of variance (ANOVA), and Mann–Whitney *U* test for continuous data. The intragroup comparison was done by Friedman test and Wilcoxon signed-rank test for categorical data. All *p*-values < 0.05 were considered statistically significant.

Results: With regard to the parameters of plaque score, gingival index score, occlusion, interproximal contacts, retention, alignment, and marginal adaptation, no statistical significance was noted between the three groups. However, with regard to the discoloration (staining) when the polymethyl methacrylate acrylic (PMMA) group was compared with thermoforming group, statistical significance was noted in 1st month with *p*-values of 0.04 and 0.03, respectively. On intragroup comparison, statistically significant values were obtained in SSC group for plaque score and thermoforming group for gingival index score.

Clinical significance: The study concluded that the PMMA and thermoforming crowns can be used as an alternative to SSC for restoring the primary molars as they showed equivalent results to that of standard SSC.

Keywords: Polymethyl methacrylate, Stainless steel crown, Thermoformed crowns.

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Introduction

Primary posterior with extensive caries, cervical decalcification, developmental disturbances which are indicated for endodontic therapy may require full coverage coronal restorations.[1,2] Such endodontically treated primary teeth are restored using golden standard stainless steel crowns (SSCs).[3] However, due to their unesthetical metallic appearance, need for alternative esthetic crowns has been growing.

Polymethyl methacrylate acrylic (PMMA) is one of the highly used materials for the fabrication of provisional crown and bridge restorations which are available in various tooth shades manufactured using the computer-aided design/computer-aided manufacturing (CAD/CAM) technology.[4–6]

On the other side, Erkodur (A1, A2, A3), manufactured by Erkodent, Germany, are esthetic thermoforming sheets composed of polyethylene terephthalate glycol (PETG) material and can be used for the fabrication of semipermanent crowns.[7]

Materials and Methods

Study Design

The study was a randomized clinical trial undertaking the guidelines of Consolidated Standards of Reporting Trials (CONSORT) protocol.

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Conflict of interest: None

Sample Recruitment

The study was conducted from January to November 2021, and the children enrolled for the study were followed for a period of 3 months. The sample was selected from patients who underwent treatment in the Department of Pediatric and Preventive Dentistry, SVS Institute of Dental Sciences, Mahbubnagar, Telangana, India, based on the following criteria.

Inclusion Criteria

Clinical Criteria

Endodontically treated primary molar teeth (pulpotomy or pulpectomy).

Radiographic Criteria

At least two-thirds root should be present.

Exclusion Criteria

Children with special needs, debilitating diseases, malposition, morphologically variant tooth, and those with severe mobility were excluded from the study.

Radiographic Exclusion Criteria

- Presence of periapical and furcation radiolucency.
- Less than two-thirds of root structure.
- Absence of permanent tooth bud.

Prior to enrollment of sample in the study, the need of the study was explained and given to the child's parents or guardians in the form of written informed consent. Once the informed consent was signed, the children were short-listed and enrolled for sample of the study.

Size of the Sample

The sample size was calculated using G*Power 3.1.9 (Franz Faul, Universität Kiel), setting significance level at 0.05 and statistical power to be 80%. Final sample size was enhanced from 12 to 15 crowns to avoid over all attrition rate in each group of the study, respectively.

Clinical Procedure

An overall sample of 45 teeth from 42 children were randomly using chit method were allocated into the following three groups, that is, two experimental groups and one control group:

- Group I: Teeth restored with PMMA crown.
- Group II: Teeth crowned using thermoformed crown.
- Group III (control group): Teeth crowned using SSC.

One clinician completed all the pulp therapy procedures based on clinical and radiographic diagnosis, followed by postendodontic restoration using luting glass ionomer cement (Fuji IX, GC, Tokyo, Japan) (Fig. 1).

In all three groups, clinical photographs and intraoral periapical radiographs were taken.

Group I (Polymethyl Methacrylate Crowns)

The preparation of sample teeth was done using a round wheel bur to reduce the occlusal surface, with reference to the opposing tooth, leaving an interocclusal gap of 1.5 mm. Using a round-ended tapered diamond bur, preparation of 0.8–1.0 mm was done buccolingually and mesiodistally, followed by a circumferential chamfer margin preparation. The convergence angle was maintained at 6° by holding the burr 90° to the long axis of the tooth (Figs 2 and 3). An elastomeric impression was made for the prepared teeth, and then, casts poured using die stone. A crown was made using PMMA blocks using CAD/CAM system (Fig. 4).

Group II (Thermoformed Crowns)

Crown fabrication: Stainless steel crowns of various sizes were used as reference for the preparation of the thermoformed crowns. Putty material was used to obtain impressions of these SSCs, which were then stabilized on a metal plate using metal pins. An Erkodur A1 shade thermoforming sheet (1 mm thickness) was preheated and then placed in the Erkodent Erkoform 3D vacuum machine. This sheet was adjusted to be seated over the metal frame with impressions to obtain crowns of various sizes, which were trimmed, polished, and stored for later use (Figs 5 and 6).

The mesiodistal width of the tooth was measured using a caliper, and the crown of appropriate size was selected. Occlusal reduction was performed using a round wheel bur 1.5–2 mm. Then, circumferential reduction was done, about 0.5–1.2 mm, with a coarse diamond tapered flat bur buccolingually and mesiodistally. All line angles were rounded, and finishing was completed (Figs 7 and 8).

Group III (Stainless Steel Crown)

The crown was selected based on mesiodistal width of the tooth using a caliper and the crown of appropriate size was selected (Fig. 9). Occlusal reduction was performed using a round wheel bur 1–1.5 mm. Then, proximal reduction was carried out with a No. 69 L or 169 L bur. Buccal or lingual surfaces were not reduced. In some cases, such as prominent buccal bulge, particularly in primary 1st molars, reduction was performed. Line angles were rounded and smoothed. The selected crown was then seated, checking for a snug fit. If there was blanching of the gingiva, the crown was retrimmed, followed by crimping and polishing (Figs 10 and 11).

Crown cementation: The crowns trial was done and cemented under isolation using luting glass ionomer cement (GIC) (Fuji Type 1, GC, Tokyo, Japan). Digit pressure was applied on the crown and excess cement was removed using the explorer in buccolingual regions and with floss in interproximal areas.

Outcome measures: The crown was evaluated and assessed at the time of placement, 1st month, and 3rd month by an independent investigator for the rate of crown retention, graded as: normal, small crack/fracture, large crack/fracture, complete loss of the crown. Gingival health assessment was conducted using a periodontal probe, and marginal integrity assessment was done by a dental probe, graded as: no catch, catch/no crevice visible, catch/crevice visible, obvious crevice. The discoloration of the tooth was verified, graded as: clinically ideal, clinically acceptable, clinically unacceptable. The participants and the clinical evaluators were double-blinded to the type of crowns.

Results

The results were tabulated and statistical analysis was done.

Statistical test applied: Data was analyzed by Statistical Package for the Social Sciences (SPSS) Version 23.0 software. Data was summarized by mean ± standard deviation (SD) for continuous data and percentages for categorical data. The intergroup comparison between PMMA and thermoforming crown with the SSC was done by Kruskal–Wallis test, analysis of variance (ANOVA), and Mann–Whitney *U* test for continuous data. The intragroup comparison was done by Friedman test and Wilcoxon signed-rank test for


Diagnostic instruments


Aluminium bite wax


Local anesthesia


Tooth preparation instruments

Impression and restorative materials


Upper and lower impression trays

Putty materials

Light body impression materials

GIC luting materials

Fig. 1: Armamentarium required for the three groups

Fig. 2: Clinical images of PMMA crowns IRT tooth no. 84

categorical data. All *p*-values with values <0.05 were considered statistically significant.

Results have shown that with regard to the gingival status, plaque index and modified gingival index showed no statistical significance between the groups. However, statistically significant difference was noticed within the SSC group (Table 1). With regard to retention, there was no statistically significant difference between the groups at the end of 3rd month but two crowns in group I and only one crown in group II were dislodged (Table 2).

When crown alignment was taken into consideration, it was noticed that one case in groups I and II was rotated, whereas in group III, two crowns were rotated. However, still there was no statistically significant difference between both the groups (Table 2).

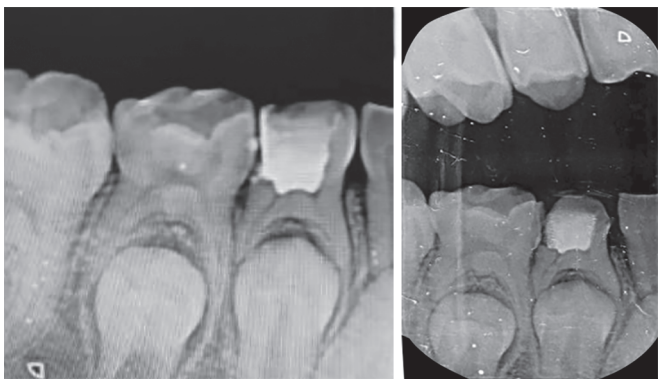

Fig. 3: Pre- and postoperative radiographs

Fig. 4: Armamentarium used for PMMA (group I) crowns

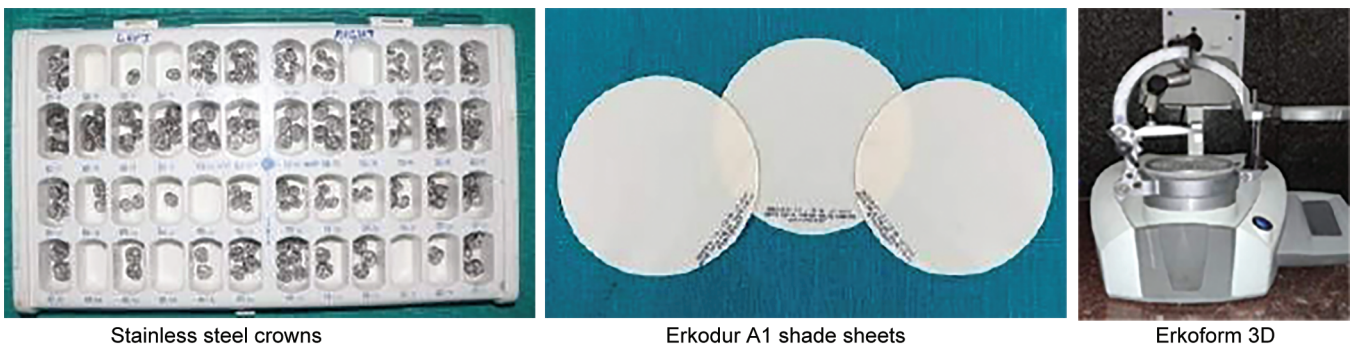

Fig. 5: Armamentarium used for thermoformed crowns

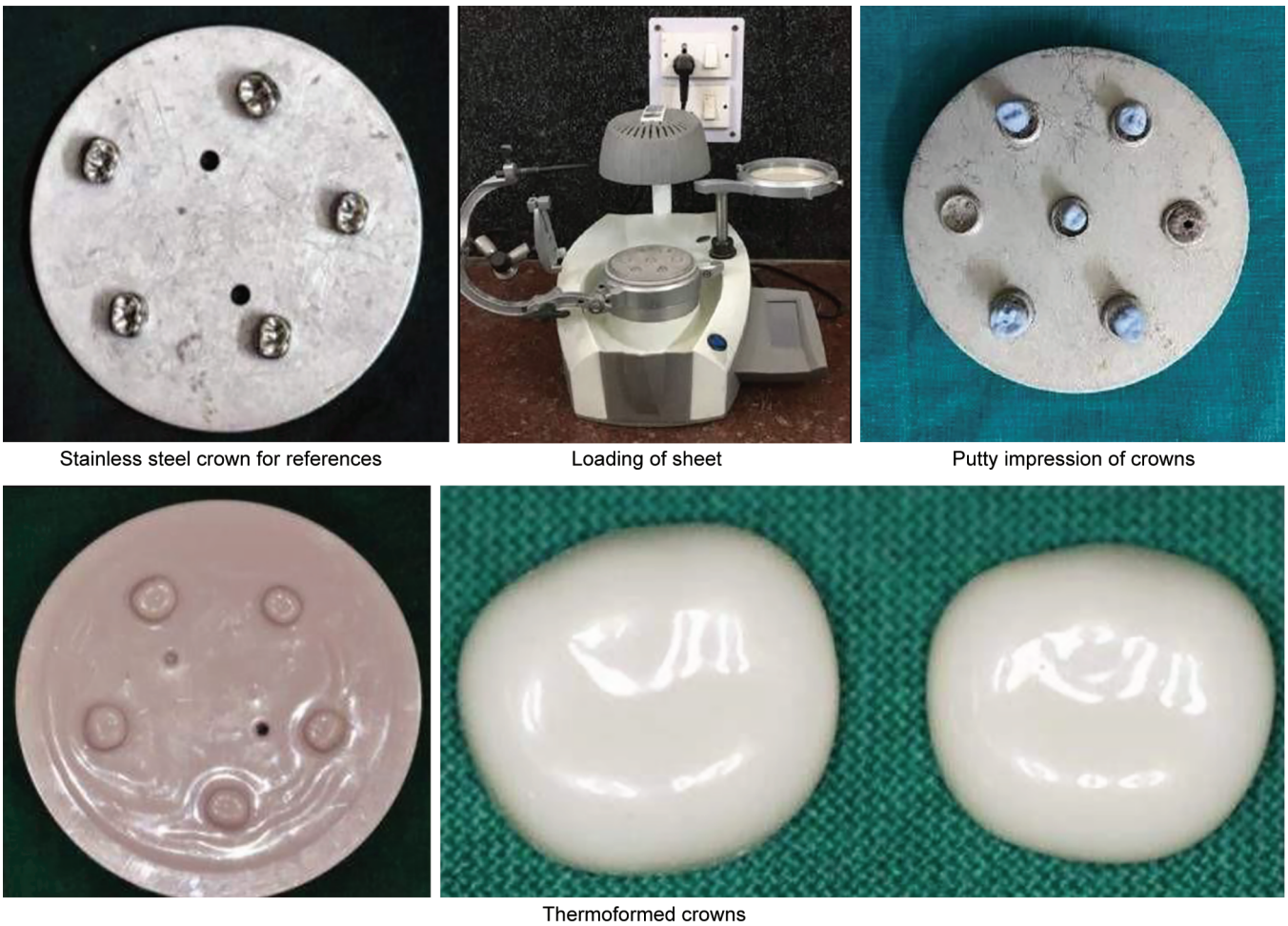

Fig. 6: Images for fabrication of thermoforming crown

There was no statistically significant difference between the groups with regard to the criteria of marginal adaptation (Table 2).

In the evaluation of interproximal contacts between the groups, there was no statistically significant difference between them. However, in group I, more number of samples have shown to have tight contacts (Table 1).

Discussion

Destruction of caries affected primary tooth structure in a child leads to various abnormal sequelae, which has an effect on aesthetics, self-esteem, mastication, speech, maintenance of arch length, and development of oral habits which in general causes disorientation of overall health.

The most common treatment option considered is extraction of the teeth, which results in unesthetical appearance and could interfere with the personality and behavior development of the child. Hence, the grossly affected primary teeth are restored to preserve the integrity of dentition to facilitate the eruption of permanent teeth.

Therapeutic treatment of primary teeth involves removal of necrotic tissue from the tooth root canal system to provide an bacteria-free environment conducive to healing.[8] Once obturated, it is necessary to prevent microleakage from saliva by sealing the disinfected root canals,[9] which is done by postendodontic restoration maintaining total coronal seal.

Traditionally, root canal treated teeth are weak and brittle. Rosen[10] described them as "desiccated and inelastic" due to an absence of blood supply causing the teeth to become dehydrated. Therefore, the role of the postendodontic definitive restoration beyond providing a coronal seal is to replace the lost tooth structure which helps in restoring function and supporting the remaining tooth structure allowing it to withstand occlusal and parafunctional stress.

Full coverage coronal restoration for endodontically treated primary dentition includes several options, with each approach having their own advantages and pit falls. Conventionally used full coverage crowns include the golden standard SSCs. These conventional SSCs are extremely durable, relatively inexpensive, and has minimal technique sensitivity during placement.[11] Despite the favorable qualities, major drawback affecting their usage is the poor esthetic appearance.

However, the alternative crowns (PMMA and thermoforming crowns), at the end of 3rd month showed success rate of 86 and 93.3% success rates, respectively (Figs 12 and 13). Among the

Fig. 7: Clinical images of thermoforming crowns IRT tooth no. 64

two crowns that failed in group I, one showed chipping of the crown surface and other showed complete dislodgement. The reason behind chipping of one crown in group I was due to higher placement in the occlusion. The other sample in this group showed loss of crown due to failure of cementation. In this case, the crown was cemented again. On the other hand, in group II loss of crown was noticed due to the parafunctional habit of the child which was replaced by an SSC (Fig. 14). Our use of a GIC type 1 material in cementation of crowns displayed significant clinical stability of the crowns.

Evaluation of gingival health parameter shows lowered gingival inflammation arising during the baseline to 1st-month follow-up visit and moderate with no statistical differences at the 3rd-month follow-up in both the groups. The increase in plaque score in the PMMA group can be attributed to the fact of increased adhesion of *Candida albicans* to the epithelial cells of the mouth and acrylic resin surfaces. Gingival response was better in thermoforming crowns compared to PMMA group due to its smooth surface and modified surface free energy by the thermoforming process. Taking into consideration of the low-to-moderate gingival response in both groups, routine oral hygiene maintenance teaching is suggested to be added to the treatment plan.

The restoration replacing the teeth must provide maximum interdigitation in function and working contacts. At the same time, they must allow free range of motion provided by the reduction of interferences in excursive movements. Thus, the restorations must require minimal occlusal adjustments.

The other parameters evaluated were interproximal contact and marginal integrity. These three were evaluated using the scoring criteria used by Donly et al.,[12] which is as follows:

Criteria	*Occlusion*	*Interproximal contact*	*Marginal integrity*
Alpha	Clinically ideal	Clinically ideal, with the contact area having acceptable resistance to the passage of floss	Clinically ideal
Bravo	Clinically acceptable	Clinically acceptable, with the contact area too tight or loose to the passage of floss	Clinically acceptable
Charlie	Clinically unacceptable	Clinically unacceptable, with no contact with the adjacent tooth	Clinically unacceptable

In terms of occlusion, interproximal contacts, and marginal integrity, there was no statistically significant difference between the groups. The reason behind tight contacts in group II could be due to lack of possibility to modify the thermoformed crowns. Whereas, the SSC can be modified based on available space.

The proper alignment of the teeth results in the ability to brush and floss all surfaces of the teeth more easily and thoroughly, reducing harmful bacteria that cause dental caries and gingival diseases. This leads to fewer oral health problems will be encountered and will need less restorative dentistry over lifetime. The results of the present study demonstrated only one case in groups I and II and two cases of the crowns in group III were rotated mesiodistally with no statistically significance among and within the groups.

The quality of a restoration is considered from both functional and esthetic point of view.

In terms of color stability, it was observed that five crowns in group I and four crowns in group II exhibited stains that could be polished away, with significant differences between PMMA and thermoforming crowns. The accumulation of debris on the surface of the crown, especially on the buccal and lingual cervical thirds, was identified as the reason behind this. This parameter was not applicable to the SSC as it has a metallic appearance.

Thus, the growing patients demands for esthetics requires a comprehensive selection of dental materials. Here, in the present study, the thermoforming crowns were considered better than the PMMA crowns as it had smooth surface and were preformed which reduced the chair side time. Hence, the two new materials in the

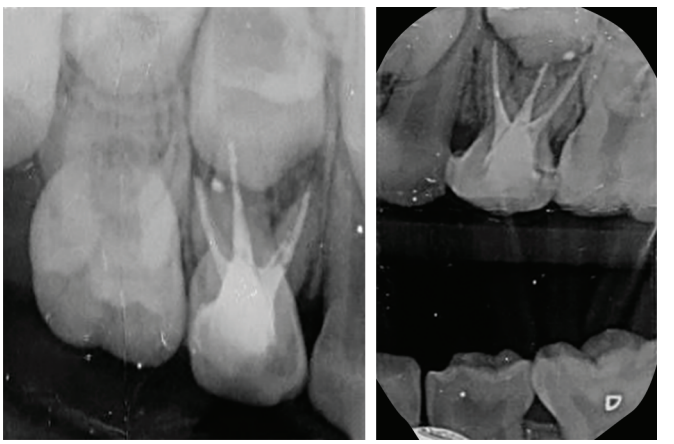

Fig. 8: Pre- and postoperative radiographs

Stainless steel crowns

Fig. 9: Armamentarium used for SSC

Fig. 10: Clinical images of SSC IRT tooth no. 85

present study showed results equivalent to the traditional SSC along with an added advantage of esthetical appearance which suggests its use as an alternative to the traditional SSC.

Merits of the Study

- In the present study, two different materials for the fabrication of primary molar crowns were assessed and compared with SSC.
- These materials are esthetic and cause very little soft tissue inflammation.
- The parameters assessed show equivalent results to that of standard SSCs.
- The cost and effectiveness for use in the primary dentition was also assessed.

Demerits of the Study

- Sample size was smaller when compared to other studies.
- Postoperative radiographs during the follow-up period were not included in the study.
- Shorter duration of the study might have an influence on the results.

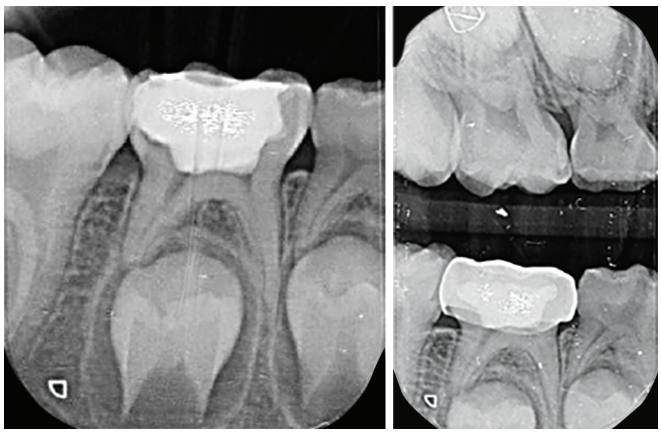

Fig. 11: Pre- and postoperative radiograph

Table 1: Comparison between groups I, II, III for all the parameters—plaque score, gingival score, occlusion, and interproximal contacts

			p-values		
Variables	*Group vs groups*		*0 month*	*1 month*	*3 months*
Plaque score	PMMA	Thermoforming	0.36	0.28	0.71
		Stainless steel (SS)	0.53	0.53	0.77
	Thermoforming	SS	1	0.71	1
Gingival score	PMMA	Thermoforming	0.29	0.27	0.71
		SS	0.77	0.36	1
	Thermoforming	SS	0.55	1	0.71
Occlusion	PMMA	Thermoforming	1	1	0.65
		SS	0.53	0.53	0.45
	Thermoforming	SS	0.41	0.41	0.64
Interproximal contact	PMMA	Thermoforming	0.24	0.1	0.16
		SS	0.21	0.21	0.48
	Thermoforming	SS	0.63	1	0.32

Table 2: Comparison between groups I, II, and III for all the parameters—retention, alignment, marginal adaptation, and staining

			p-values		
Variables	*Intergroup comparison*		*0 month*	*1 month*	*3 months*
Retention	PMMA	Thermoforming	0.55	0.14	0.40
		SS	0.53	0.53	0.32
	Thermoforming	SS	0.31	0.55	0.58
Alignment	PMMA	Thermoforming	1	1	1
		SS	0.77	0.77	0.77
	Thermoforming	SS	0.5	0.5	0.5
Marginal adaptation	PMMA	Thermoforming	0.7	0.5	0.64
		SS	1	1	0.81
	Thermoforming	SS	0.5	0.5	0.32
Staining	PMMA	Thermoforming	1	0.04 S	0.81
		SS	1	0.03 S	0.36
	Thermoforming	SS	1	1	0.07

S, statistically significant

Fig. 12: Clinical images of PMMA crowns IRT tooth no. 84

Fig. 13: Clinical images of thermoforming crowns IRT tooth no. 64

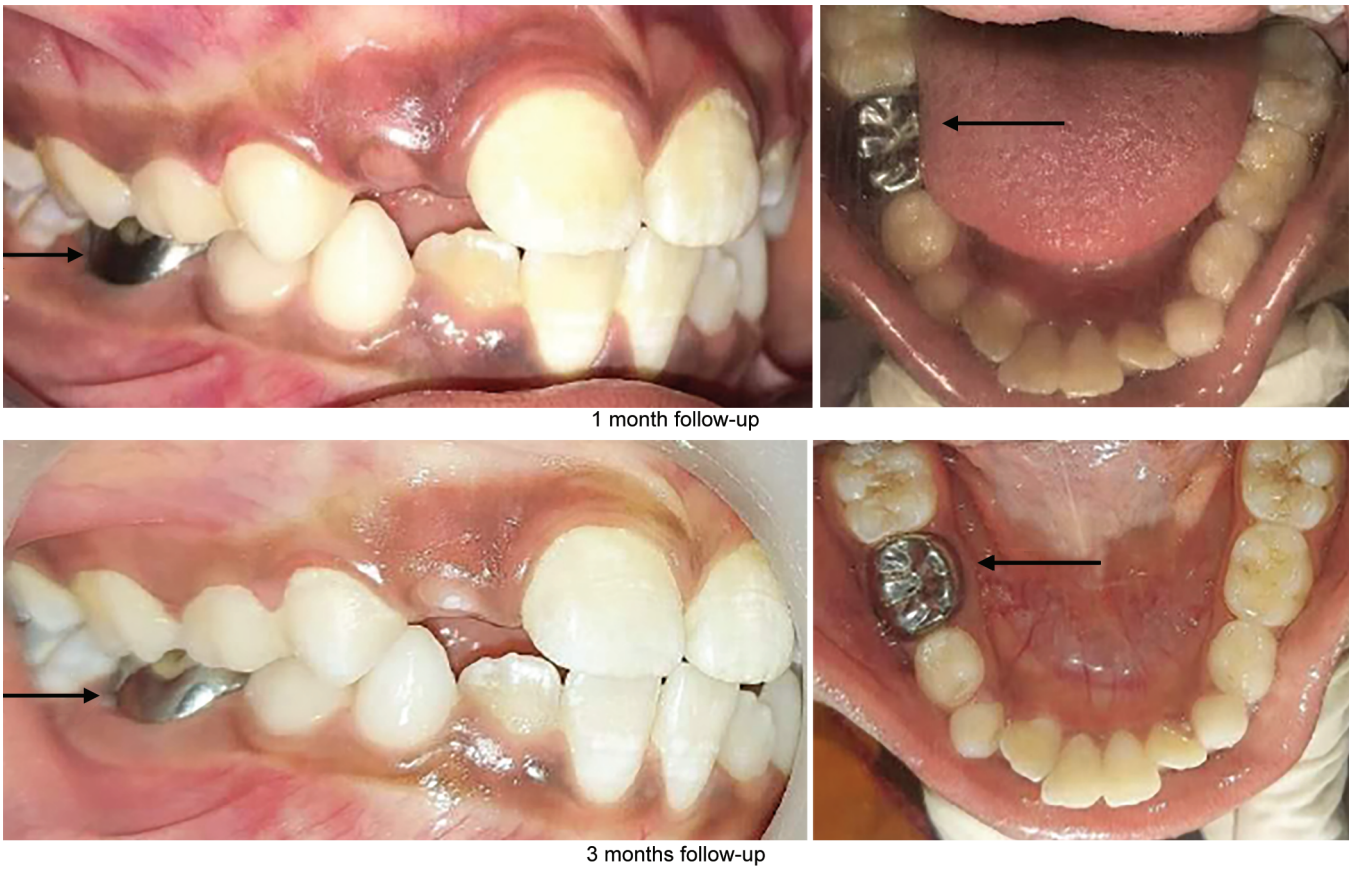

Fig. 14: Clinical images of SSC IRT tooth no. 85

Conclusion

Pertaining to the limitations of the study, following conclusions could be drawn:

- The two new materials are esthetical and cause very little soft tissue inflammation.
- These crowns can be used as an alternative to SSC for primary molars as the parameters assessed show equivalent results to that of SSC.
- Whenever parental concerns and cost are considered, the dentist can opt for these crowns when compared to other expensive options.

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