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ORIGINAL ARTICLE

Comparison of Retention of Provisional Crowns Cemented with Temporary Cements Containing Stannous Fluoride and Sodium Fluoride—An In Vitro Study

Bhuvana Sachin

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Abstract The objective of this study was to evaluate the effect of the addition of stannous fluoride (SnF_2) and sodium fluoride (NaF) to luting cements on the retention of provisional crowns. Provisional crowns were fabricated using methyl methacrylate and bis-acryl composite resin for 32 chamfer prepared molars. For control group A, crowns were cemented with Freegenol and RelyX Temp NE non-eugenol cements. For test group B, crowns were cemented using the above cements with the addition of SnF_2. For test group C, crowns were cemented using the above cements with the addition of NaF. The specimens were thermocycled and retention test was conducted after 7 days. The addition of SnF_2 significantly increased the retentive strength of both the cements in the range of 27–48 %, whereas addition of NaF decreased the retentive strength of both the cements in the range of 14–23 %. SnF_2 can be mixed with non-eugenol luting cements to improve the retention of both methyl methacrylate and bis-acryl composite crowns. The different effects of NaF and SnF_2 on retention indicate that it may be useful to have two different types of provisional luting cements for short-term and long-term cementation, as appropriate.

Keywords Provisional crowns · Stannous fluoride · Sodium fluoride · Retentive strength

B. Sachin (✉)
Department of Prosthodontics, College of Dental Sciences, Davangere, India
e-mail: dr.bhuvana.sachin@gmail.com

Introduction

Biologically acceptable fixed prosthodontic treatment demands that the prepared teeth are to be protected and stabilized by a provisional restoration till the cementation of the final restoration. The restoration occasionally functions for extended periods while adjunctive treatments such as periodontics, endodontics, orthodontics, or oral surgery are being completed [1]. Long term provisional restoration are more susceptible to cement washout, marginal leakage, bacterial infiltration, and caries. So luting agents should have good mechanical, retentive, and antibacterial properties for the success of a long standing provisional crowns.

Because fluoride materials have antibacterial properties, many studies have been conducted by adding fluoride to luting cements. Levinstein et al. [1, 2] found that fluoride varnish (Duraphat) mixed with provisional luting agents improved the 1 h retention and 7 day retention of the provisional crowns by 69–145 %. In one more study, the addition of stannous fluoride had shown no effect on the retention of temporary acrylic crowns cemented with zinc oxide eugenol cement and increased the retention of those cemented with non-eugenol zinc oxide cement, after 7 days of cementation [3].

These above studies were conducted only on methyl methacrylate crowns, but not on bis-acryl composite crowns. Bis-acryl composite resin material exhibits superior microhardness and flexural strength over traditional methyl methacrylate [4]. So, it is also a suitable provisional restorative material for long term success. The comparison between the effect of stannous fluoride and sodium fluoride on retention of temporary crowns has not been done in any studies. Hence the present in vitro study was conducted to evaluate and compare the effect of addition of stannous fluoride and sodium fluoride to the luting cements on retention of provisional crowns.

Fig. 1 Prepared tooth using Aerotor handpiece clamped to Kavo milling apparatus

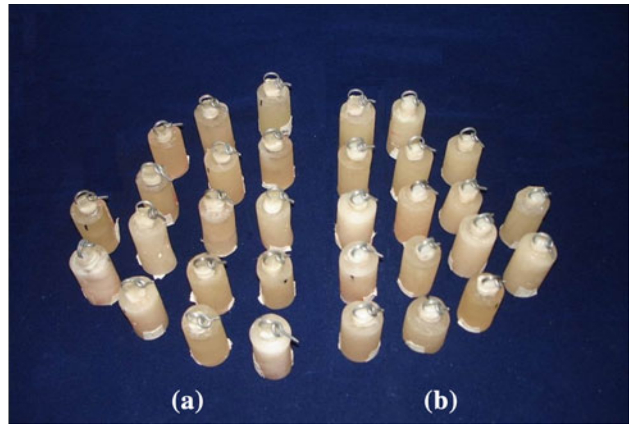

Fig. 2 Provisional crowns with metal rings seated on prepared teeth: **a** methyl methacrylate crowns, **b** bis-acryl composite crowns

Materials and Methods

Preparation of Specimen

Thirty-two human sound extracted molar teeth were obtained and stored in distilled water. The teeth were embedded in auto-polymerizing acrylic resin with copper mounting ring. Then, they were mounted on dental stone to provide firm base for all the specimens. Indices were made with polyvinyl siloxane (putty) material, which were used to check uniform reduction of prepared teeth and for the fabrication of the provisional crowns.

Each tooth was prepared for complete crown with the following standard dimensions: (1) Convergence angle of 20° (each axial wall with 10°) [5], (2) Chamfer finish line, and (3) One mm occlusal reduction. Axial wall reduction was done using Kavo milling apparatus. An Aerotor hand piece was clamped to the milling apparatus with 10° angulation. The teeth with firm base were rotated against the outer surface of the bur for the axial wall reduction (Fig. 1). The prepared teeth were distributed into four groups. Two groups were used for bis-acryl composite and two groups for methyl methacrylate resin.

Forty-eight bis-acryl composite (Protemp2, 3M, ESPE, Germany) and 48 methyl methacrylate (Self cure tooth molding resin, Dental Products India, Mumbai, India) provisional crowns were fabricated. A thin layer of petrolatum was applied on prepared tooth surface. Then, the material was mixed and loaded into the putty index and placed on to the prepared tooth. The index was held undisturbed till the mix became rubbery i.e., around 3–5 min for methyl methacrylate and 1–2 min for bis-acryl composite resins. The index was removed and placed thrice along the path of insertion. Once the material became stiff and hard, excess material was trimmed and crowns were polished. Steel rings of 8 mm diameter were attached to the center of the occlusal surface with the same provisional crown material. They served as connectors to the tensile testing machine (Fig. 2). Non-eugenol cements were used for cementation.

Four groups were made with 24 crowns: group I—Bis-acryl composite crowns cemented with Freegenol (GC America, USA), group II—Bis-acryl composite crowns cemented with RelyX Temp NE (3M, ESPE, Germany), group III—Methyl methacrylate crowns cemented with Freegenol, group IV—Methyl methacrylate crowns cemented with RelyX Temp NE.

Each group was divided into three subgroups and each subgroup comprised of eight crowns ($n = 8$). Subgroups: A (control group)—crowns were cemented with pure form of luting cements. B (test group)—crowns luted with cement mixed with SnF_2 0.4 % by weight (stannous fluoride; Fluka, Sigma-Aldrich, USA), [3]. C (test group)—crowns luted with cement mixed with NaF 2.26 % by weight (sodium fluoride; Qualigens Fine Chemicals, Mumbai, India) [1, 2]. An electronic balance was used to weigh the materials.

Thermocycling

After cementation, all the specimens were stored in 100 % humidity at 37 °C for 1 h in the incubator and thermocycled 100 times (5/55 °C) with 1 min dwell time using thermocycling apparatus. Then, they were stored in the incubator in 100 % humidity at 37 °C for 7 days to simulate aging [6].

Retention Test

The specimens were mounted on Hounsfield Universal Testing machine (Fig. 3) and the cemented crowns were subjected to tensile dislodgment forces using a cross-head

Fig. 3 Sample was mounted on Hounsfield universal testing machine and subjected to retentive test

speed of 1 mm/min. The maximum force required for crown removal was considered as retentive strength and various groups were compared.

Statistical Analysis

One way ANOVA was used for multiple group comparisons followed by Post hoc Tukey's test for pair-wise comparisons. Results on retentive strengths were presented as Mean ± SD and range values. A P value of 0.05 or less was considered for statistical significance.

Results

Table 1 and Fig. 4 show comparative mean retentive strength of different groups of provisional crowns. The mean retentive strength (N) of pure form of Freegenol and Relyx Temp NE ranged from 41 to 46 N for methyl methacrylate and bis-acryl composite crowns.

The addition of SnF_2 increased the retentive strength of Freegenol and Relyx Temp NE by 48 and 27 %, respectively, for bis-acryl composite crowns and by 46 and 27 %, respectively, for methyl methacrylate crowns. The addition of NaF decreased the retentive strength of Freegenol by 23 and 17 % for bis-acryl composite and methyl methacrylate crowns, respectively. NaF mixed with Relyx Temp NE showed significant decrease in the retentive strength by 14 and 15 % for bis-acryl composite and methyl methacrylate crowns, respectively. The mean retentive strengths for the groups IC, IIC, III C, IV C ranged from 34 to 36 N with no significant difference.

Table 2 shows comparison of retentive strengths of crowns luted with cements mixed with SnF_2. Group IB showed highest retentive strength (68 N), followed by group IIIB (60 N), group IIB (54 N), and lastly group IVB (52 N).

In case of crowns cemented with pure form of luting cements, cement covering inner surface of crown was observed with small remnants on prepared tooth surface. But, when SnF_2 or NaF was mixed with luting cements, more than 50–60 % of cement layer remained on the tooth surface after the retention test, confirming adhesive failure

Table 1 Retentive strength (N) of Bis-acryl composite crowns and methyl methacrylate resin crowns after 7 days and pair-wise comparisons

Subgroups		Bis-acryl composite resin crowns		Methyl methacrylate resin crowns	
		Group I Freegenol cement	Group II Relyx temp NE cement	Group III Freegenol cement	Group IV Relyx temp NE cement
A (Pure form)	Mean ± SD	46.07 ± 8.25	42.15 ± 8.0	41.09 ± 4.16	41.70 ± 7.96
	Range	31.49–57.49	33.65–77.40	37.28–50.03	31.88–57.88
B (+SnF_2)	Mean ± SD	68.07 ± 6.26	54.30 ± 10.80	60.06 ± 6.26	52.77 ± 12.92
	Range	58.09–82.53	40.22–71.61	52.18–67.88	39.24- 68.67
C (+NaF)	Mean ± SD	35.34 ± 7.56	36.47 ± 7.80	34.21 ± 5.85	35.56 ± 6.27
	Range	27.47–50.23	28.35–51.70	28.45–45.13	29.43–47.09
ANOVA	F	40.80	8.23	47.6	6.77
	P	<0.01, S	<0.5, S	<0.01, S	<0.01, S
Difference between agents	A−B	22 (48 %)	12.15 (27 %)	19.03 (46 %)	11.06 (27 %)
		$P < 0.01$, S	$P > 0.05$, NS	$P < 0.01$, S	$P > 0.01$, S
	A−C	10.73 (23 %)	5.68 (14 %)	6.90 (17 %)	6.15 (15 %)
		$P < 0.05$, S	$P > 0.05$, NS	$P < 0.01$	$P > 0.05$, NS
	B−C	32.8 (48 %)	17.83 (33 %)	25.91 (43 %)	17.21 (33 %)
		$P > 0.05$, NS	$P < 0.05$, S	$P > 0.01$, S	$P < 0.05$, S

NS Non significant, *S* Significant

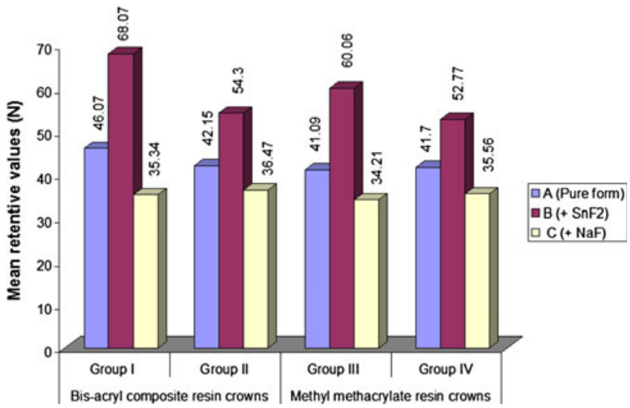

Fig. 4 Graphical representation of mean retentive strength (Newton) of provisional crowns after 7 days

Table 2 Comparison of retentive strength (Newton) of provisional crowns cemented with two luting cements mixed with SnF_2

Groups compared	Mean difference	Change in percentage	*P* value
IB–IIB	13.77	0.20	<0.05, S
IB–IIIB	7.95	0.12	NS
IB–IVB	15.37	0.23	<0.05, S
IIB–IIIB	5.76	0.11	NS
IIB–IVB	1.53	0.03	NS
IIIB–IVB	7.29	0.12	NS

NS Non significant, *S* Significant

between provisional crown and luting cement (Fig. 5). This showed that the fluoridated cements enhanced the adherence of cement to the tooth structure rather than to the provisional crown.

Discussion

In this study, only non-eugenol cements were used because many studies reported that zinc oxide eugenol cement had a significant softening effect on provisional crowns and eugenol decreased the retention of crowns [7–10]. One study reported that non-eugenol cements had higher retentive values than eugenol containing cements [11].

The concentration of SnF_2(0.4 % by weight) was selected from a previous pilot study in which the release of fluoride over 3 months and the setting properties of the cements were tested [3]. The concentration of NaF (2.26 % by weight) was selected from two studies in which Duraphat NaF varnish of same concentration was used to improve the retention of provisional crowns [1, 2].

The addition of SnF_2 increased the retentive strength of both the cements. The results are in accordance with the results reported by Lewinstein [3]. The probable reasons

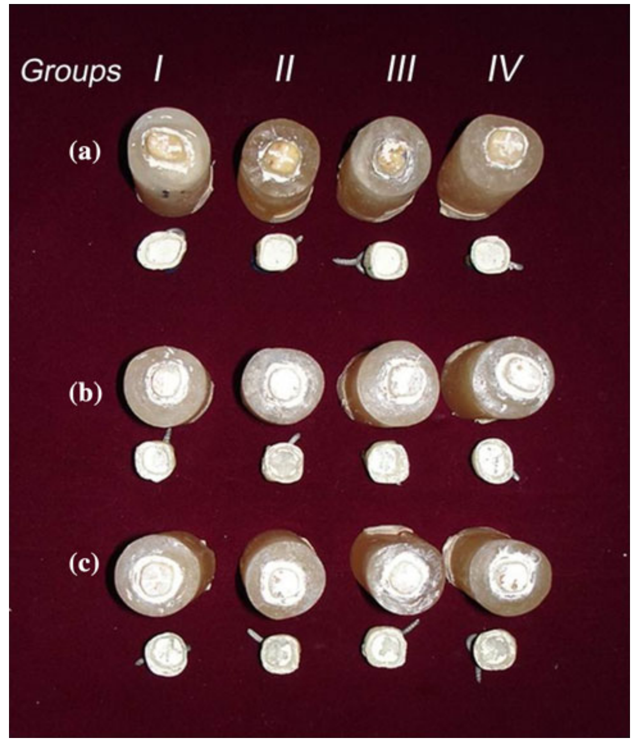

Fig. 5 Cemented crowns and prepared teeth with cement remnant after retention tests. **a** crowns luted with pure form of luting cements, most of cement covering inner surface of crown was observed. **b** and **c** crowns luted with luting cements mixed with SnF_2/NaF, most of cement layer remained on the tooth surface

for these results are: (1) Since these non-eugenol cements are acid base-oxide cements, SnF_2 may react with these cements to create antisoluble layer, (2) SnF_2 may improve adhesive property of the luting cement to tooth structure.

The addition of NaF significantly decreased the retentive strength of both the cements. This observation was in correlation with the two studies which had shown that the addition of Duraphat varnish (2.26 % of NaF) to the cements showed a decrease in retentive strength with Freegenol after 7 days [2]. The probable reason is NaF may have altered the retentive characteristics of the luting cement.

The other benefits of fluoridated cements are: (1) SnF_2 has got anti-solubility property which provides significant protection against acid demineralization [12], (2) It can serve as a reliable source of fluoride release to prevent caries and control micro-leakage between the cement and the prepared tooth surface [3], (3) Fluoride compound may improve micro-hardness and the fluoride content of dentin due to liberated fluoride ions [13].

Tests in vitro cannot accurately reproduce clinical factors such as oral temperature changes, occlusal forces, and saliva of varying pH and abrasion resistance of the cement. Further studies with regard to physical properties of fluoridated cements are required.

Conclusion

- Bis-acryl composite crowns were slightly more retentive than methyl methacrylate crowns but there was no statistically significant difference among them.
- SnF_2 can be mixed with non-eugenol luting cements to improve the retention of both methyl methacrylate and bis-acryl composite crowns.
- The addition of sodium fluoride decreased the retentive strength of both the cements.

The different effects of NaF and SnF_2 on retention indicate that these may be useful to have two types of provisional luting cements for short and long-term cementation as appropriate. Fluoridated luting cements may improve the retention and clinical conditions of long standing provisional restorations.

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