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INFLUENCE OF DESENSITIZING AGENTS ON THE RETENTION QUALITY OF COMPLETE CAST CROWNS CEMENTED WITH VARIOUS LUTING AGENTS – AN IN-VITRO STUDY

Medical Science

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ABSTRACT

AIM - To evaluate the effect of the various commercially available desensitizing agents on the retention of full metal crowns cemented with different luting agents like, Glass Ionomer Cement, Resin Modified Glass Ionomer Cement and Resin Cement.

MATERIALS AND METHODS- 420 extracted maxillary premolars were collected and prepared using a paralleling milling device. The prepared teeth were divided into 3 major groups: GIC, RMGIC and Resin cement and into 7 sub-groups: Systemp, Gluma, GC Tooth Mousse, Pro-Arginine, Novamin, Flouride and control group. The desensitizing agents were applied before impression making, provisional cementation and permanent cementation. Wax patterns were fabricated and casted with a loop using Ni-Cr alloy. After cementation, half of the samples were subjected to thermocycling and then under tensional force the crowns were removed using a universal testing machine.

RESULTS- In Group I (GIC), the thermocycled samples showed highest retention with Systemp and least with Pro-Arginine and non-thermocycled samples showed highest retention with GC Tooth Mousse and least with Control group. In Group II (RMGIC), thermocycled samples showed highest retention with Systemp and least with Flouride and non-thermocycled samples showed highest retention with Systemp and Novamin group and least with Pro-Arginine. In Group III (RC), the thermocycled samples showed highest retention with Systemp and least with Flouride and non-thermocycled samples showed highest retention with Systemp and least with Pro-Arginine group. The retention was improved with thermocycling and Resin cement showed the highest retentive strength, followed by RMGIC and then GIC in all groups.

CONCLUSION- Systemp, in all the subgroups showed the highest retention and Pro-Arginine showed the least retention. Resin cement showed the highest retentive strength. Also, thermocycling had increased the retention in all the samples irrespective of the type of cement used.

KEYWORDS

Dentinal Hypersensitivity, Desensitizing agents, Luting cements, Tensile bond strength, Thermocycling

INTRODUCTION

Fixed partial denture is considered to be a feasible treatment option. Even though being a permanent restoration, dislodgement might occur due to functional and para-functional forces, preparatory design, luting agent and also by the constant interaction of saliva. [1] The tooth preparation for FPD requires significant amount of tooth structure reduction leading to exposure of the dentinal tubules resulting in sensitivity. So it is necessary to seal these tubules for the patient's comfort which can be done by the application of desensitizing agents. [2]

Saliva in the oral cavity contaminates the prepared teeth. So, the application of desensitizer on the surfaces of prepared tooth is recommended, during interim stage and also before cementation, for reducing post cementation sensitivity. Sensitivity can result from, biomechanical preparation of tooth, action of both temporary and permanent luting agents and also the type of impression material used for impression making.[3]

Desensitizing agents act by occluding the tubules thereby reducing the flow of fluids, by intratubular blockage of fluid, by protein coagulation, mummification of the tubules and blocking the nerve stimulation. Hypersensitivity of dentin is best described as "a short, sharp pain arising from exposed dentin in response to stimuli typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other form of dental defect or pathology". [4] The application of desensitizing agents before the cementation of the prosthesis, reduces the risk of teeth sensitivity and preserves the health of pulpo-dentinal complex. Even though application of desensitizing agent is gaining popularity, unfortunately their effect on the retention of the crowns is questionable.[4]

Cement selection is also important for controlling the post-cementation sensitivity and to improve the success of the final prosthesis. [5] Cementation causes sensitivity by creating excessive hydrostatic pressure. The fluid in the dentin gets displaced causing irritation to the pulp. The initial pH of the cement and also the etching procedures done before the cementation procedure leads to the post cementation sensitivity. So, this sensitivity can be reduced by applying desensitizing agent on the exposed dentin.[6]

So, this study was done for evaluating the effect of the various desensitizers namely, Systemp, Gluma, GC Tooth Mousse, Pro-Arginine, Novamin and Flouride, on retention of full metal copings when cemented with different luting agents like, Glass Ionomer Cement, Resin Modified Glass Ionomer Cement and Resin Cement.

MATERIALS AND METHODOLOGY

420 recently extracted, caries free, maxillary 1st and 2nd premolars were collected and mounted with its surface upto 2mm below the CEJ [Figure 1]. For improving the mechanical interlocking, notches were made on the roots. Teeth were placed on the platform of the surveyor to which customized jig was attached. Functional cusp was reduced to 1mm and 0.5mm for the non-functional cusp and 4mm overall axial wall with a 12° taper. 1mm shoulder finish line was prepared using the end cutting bur and the entire preparation was finished using a finishing bur.

Desensitizing agents were applied onto the tooth surface, before impression making, before cementation of temporary crowns and before final cementation. Teeth were divided into 7 subgroups depending upon the type of desensitizing agent used. **Novamin, Pro-Arginine and Flouride pastes:** A rotary rubber cup was used to burnish the paste into each tooth for 3 sec at a moderate speed. This procedure was carried out three times and then rinsed with water. **GC Tooth Mousse:** A pea sized amount was taken and was applied evenly on the surface of the prepared tooth using the gloved finger and was left undisturbed for 3 minutes. **Gluma:** Gluma was applied using cotton pellets and left undisturbed for 30 - 60 seconds. A stream of air was then sprayed gently until the film of the fluid disappeared and then was rinsed thoroughly with water. **Systemp** desensitizer was applied by brushing onto the tooth structure for 10 seconds on each surface using the applicator tip. A stream of compressed air was then sprayed till the fluid film disappeared completely [Figure 2].

Poly vinyl siloxane impression material (Aqausil, Denstply, India) material was used for impression making using a dual stage impression technique. A hollow aluminium pipe was used as tray for making impressions. Provisional crowns fabricated were cemented using eugenol free provisional cement after application of desensitizing agents.

Dies were made using type IV dental stone (FUJI ROCK) and were numbered from 1-140 depending upon the type of cements used are GIC, RMGIC and RC. Wax patterns were prepared with Type II inlay wax (Rolex, casting wax), a loop was attached onto the occlusal surface and casting was done using the induction casting machine.

The provisional restoration was removed and the teeth were again treated with desensitizers prior to cementation using the 3 cements, GIC, RMGIC and RC [Figure 3]. A static axial load of 5kgs for 10 minutes was applied and the samples were stored in an incubator at 37°C for 24 hours. 10 samples of each subgroup were subjected to thermocycling. The retention test for all the samples was done using automated universal testing machine [Figure 4] and vertical tensional force was applied on the crown and the tooth.

Raw data was collected and tabulated and statistical analysis was done between the major groups i.e. between the Group I (GIC), Group II (RMGIC) and Group III (Resin cement) and within each individual subgroup.

FIGURE 1: MOUNTED SAMPLES

FIGURE 2: DESENSITIZING AGENTS

FIGURE 3: LUTING AGENTS

FIGURE 4: UNIVERSAL TESTING MACHINE

RESULTS

A significant difference (p<0.01%) was seen in the samples subjected to thermocycling and also in the samples not subjected to thermocycling in Group I **[Table 1, Graph 1]**. Thermocycled samples showed highest retention with Systemp and least with Pro-Arginine; non-thermocycled samples showed highest retention with GC Tooth Mousse and least with Control group. Thermocycled samples: Systemp > Gluma > GC Tooth Mousse > Control group > Flouride > Novamin > Pro-Arginine. Non-thermocycled samples: GC Tooth Mousse > Pro-Arginine > Systemp = Flouride > Novamin > Gluma > Control group.

A significant difference was seen in the samples subjected to thermocycling (p<0.01%) and also in the samples not subjected to thermocycling (0.04%) in Group II **[Table 2, Graph 2]**. Thermocycled samples showed highest retention with Systemp and least with Flouride; Non-thermocycled samples showed highest retention with Systemp and Novamin group and least with Pro-Arginine. Thermocycled samples: Systemp > Control group > Pro-Arginine > Gluma > Novamin > GC Tooth Mousse > Flouride. Non-thermocycled samples: Systemp = Novamin >Gluma > GC Tooth Mousse > Flouride > Control group > Pro-Arginine.

A significant difference (p<0.01%) is seen in the samples subjected to thermocycling and a non-significant difference (0.21) is seen in the samples not subjected to thermocycling in Group III **[Table 3, Graph 3]**. Thermocycled samples showed highest retention with Systemp and least with Flouride; Non-thermocycled samples showed highest retention with Systemp and least with Pro-Arginine group. Thermocycled samples: Systemp > Gluma > GC Tooth Mousse > Control group > Pro-Arginine > Novamin > Flouride. Non-thermocycled samples: Systemp > Control group > Gluma > GC Tooth Mousse > Novamin > Flouride > Pro-Arginine.

Table 1: Comparison of thermocycled samples in-between the sub-groups and non-thermocycled samples in-between the sub-groups cemented with GIC (Group-I) by using ANOVA test

Group I	Groups	Minimum	Maximum	Mean	SD	P-value
Thermocycling	Control group	5.40	7.84	6.79	0.74	<0.01*
	Systemp	6.74	8.83	7.75	0.67	
	Gluma	5.89	7.67	6.89	0.66	
	G C Tooth mousse	5.86	7.80	6.88	0.65	
	Pro-Arginine	5.29	7.67	6.40	0.86	
	Novamin	5.89	7.01	6.39	0.36	
	Flouride	4.53	7.98	6.59	1.32	
Non-Thermocycling	Control group	3.37	6.72	5.41	1.02	<0.01*
	Systemp	5.27	6.68	6.15	0.49	
	Gluma	4.18	6.67	5.61	0.89	
	G C Tooth mousse	5.92	7.98	6.85	0.71	
	Pro-Arginine	5.74	7.19	6.29	0.43	
	Novamin	5.16	6.74	5.86	0.49	
	Flouride	4.10	7.65	6.15	1.10	

Graph 1: Schematic representation of tensile bond strengths of thermocycled and non-thermocycled samples in sub-groups, cemented with GIC (Group I).

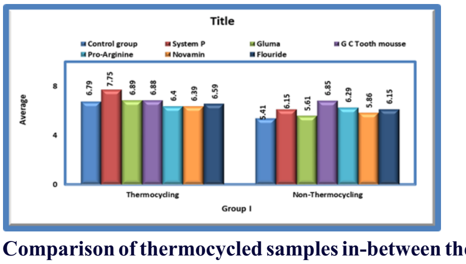


Table 2: Comparison of thermocycled samples in-between the sub-groups and non-thermocycled samples in-between the sub-groups cemented with RMGIC (Group II) by using ANOVA test.

Group II	Groups	Minimum	Maximum	Mean	SD	P-value
Thermocycling	Control group	7.22	9.07	8.26	0.64	0.04*
	Systemp	7.82	9.11	8.44	0.51	
	Gluma	7.33	8.80	8.13	0.49	
	G C Tooth mousse	6.52	8.17	7.80	0.59	
	Pro-Arginine	6.36	9.34	8.15	0.96	
	Novamin	7.43	8.59	8.05	0.42	
	Flouride	6.51	9.88	7.37	1.10	
Non-Thermocycling	Control group	4.08	8.33	6.58	1.32	<0.01*
	Systemp	6.43	8.78	7.54	0.77	
	Gluma	6.37	8.85	7.47	0.98	
	G C Tooth mousse	5.61	8.85	7.35	1.10	
	Pro-Arginine	5.46	7.85	6.54	0.89	
	Novamin	6.95	8.02	7.54	0.34	
	Flouride	6.19	7.87	6.97	0.61	

GRAPH 2: Schematic representation of tensile bond strengths of thermocycled and non-thermocycled samples in sub-groups, cemented with RMGIC (Group II).

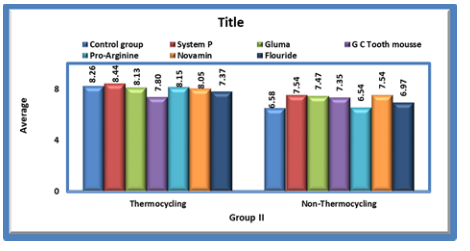
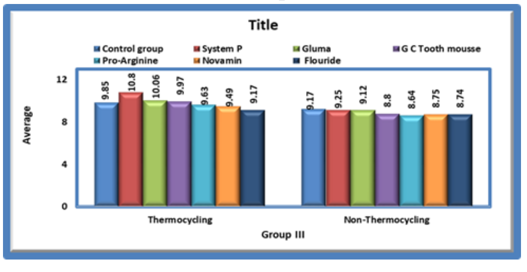


Table 3: Comparison of thermocycled samples in-between the sub-groups and non-thermocycled samples in-between the sub-groups cemented with resin cement (Group III) by using ANOVA test.

Group III	Groups	Minimum	Maximum	Mean	SD	P-value
Thermocycling	Control group	8.82	11.54	9.85	0.85	<0.01*
	Systemp	9.79	12.48	10.80	0.91	
	Gluma	9.12	11.44	10.06	0.77	
	G C Tooth mousse	9.32	11.99	9.97	0.82	
	Pro-Arginine	8.24	10.87	9.63	0.80	
	Novamin	8.15	10.98	9.49	0.87	
	Flouride	8.22	10.14	9.17	0.64	
Non-Thermocycling	Control group	8.54	10.18	9.17	0.52	0.21
	Systemp	7.82	10.19	9.25	0.78	
	Gluma	7.99	9.56	9.12	0.59	
	G C Tooth mousse	7.32	9.79	8.80	0.78	
	Pro-Arginine	7.49	9.51	8.64	0.60	
	Novamin	7.33	9.49	8.75	0.58	
	Flouride	7.81	9.80	8.74	0.64	

GRAPH 3: Schematic representation of tensile bond strengths of thermocycled and non-thermocycled samples in sub-groups, cemented with Resin cement (Group III).



DISCUSSION

Tooth hypersensitivity is the most common complaint that causes discomfort to the patient. The tooth hypersensitivity can occur due to the exposure of the dentin and also due to the acidic nature of the luting cement. To overcome this hypersensitivity, desensitizing agents are being applied onto the tooth surfaces at various steps of the fixed prosthesis fabrication. [7]

The tubular structure and fluid content are the important morphological features of a dentin, which connects the dentino-enamel junction to the pulp. [8] Because of this structural pattern, the dentin becomes permeable. The diameter of the dentinal tubules increase as more amount of the dentin gets exposed and comes closer to the pulp, thereby increasing its permeability. [9]Desensitizing agents prevents the fluid flow by occluding the dentinal tubules, thereby reducing the pain sensation by countering the hydrodynamic mechanism and also by blocking the open dentin tubules, preventing chemical assault. [10]

The tensile bond strength is preferred because it is easier to obtain pure tensile strength of luting agents bonded to various materials. It is the most significant property of the luting agent for determining its success. [11]

The desensitizers reduce the flow of the fluid in the tubules of dentin by acting on the sensitive area which is exposed and by decreasing the diameter or reducing the number of tubules of dentin which are open.[12] However, the retention might get compromised due to the application of desensitizing agents as they might cause alteration in the properties of the luting agents.[13]

So this study was done to evaluate the effect of the various commercially available desensitizing agents namely, Systemp, Gluma, GC Tooth Mousse, Pro-Arginine, Novamin and Flouride, on retention of complete cast crowns when cemented with luting agents like, GIC, RMGIC and RC.

This study was completed within a period of 6 months, as according to the ISO technical specification 11405 [14]. Immediately after the extraction the bond strength is measured for better results, which is not possible and teeth which have been extracted and stored for more than 6 months might undergo degenerative changes in the dentinal protein.[15]

GICs are very commonly used and accepted material for restoration as they have the ability to adhere to the tooth with a chemical bond and there is a constant release of fluoride [16].GIC bond by chemico-mechanical bonding that occurs by exchange of ions and penetration of dentin micro-mechanically and also it reacts with the oxide layer of the metal. [17]

The main reason for using Resin Modified Glass Ionomer cement is because of its antibacterial property and low micro leakage as reported by Herrara M et al due to release of fluoride slowly and also in studies by Rosential SF. [3]

When compared to Glass Ionomer cement, Resin cements have lower solubility and their pH at placement is also higher as compared to Glass Ionomer cements because of their hydrophilic nature. Rohit Mohan Shetty et al, compared the postoperative sensitivity of abutment teeth restored with full coverage restorations cemented with either GIC or Resin cement and concluded that in the presence of post-cementation of sensitivity, Resin cement can be used for cementation.[5]

The desensitizing agents used in this study include: Systemp, Gluma, GC Tooth Mousse, Pro-Arginine, Novamin and Flouride paste.

Systemp desensitizer is an aqueous solution which is composed of Gluteraldehyde and polyethylene glycol dimethacrylate. Glutaraldehyde is a biologic fixative, which causes occlusion of the tubules of dentin by coagulating the plasmatic protein superficially. So, upon excitation, it prevents the liquid displacement in the tubules of dentin thereby achieving desensitization. [10]

Gluma desensitizer is composed of 35% hydroxyethyl methacrylate and 5% gluteraldehyde. The occlusion of the tubules of dentin occurs immediately, due to the action of gluteraldehyde on the proteins present in the fluid in the dentin. The formation of barrier occurs when the aldehyde groups which are there in the gluteraldehyde interlace with the amino groups of the collagen of dentin, resulting in fixation of proteins.[18]

Tooth Mousse desensitizer is composed of an active ingredient Recaldent CPP-ACP, which has the ability of remineralization of hard tissues along with desnsitization of the tooth. Moreover, the effectiveness of CPP-ACP is enhanced by the saliva. It acts by binding onto the bacterial, biofilm, surrounding soft tissue and hydroxyapatites thereby causing localization of the bioavailable calcium and phosphate.[10]

The essential components of Colgate Sensitive Pro-Relief Desensitizing Paste are arginine, bicarbonate and calcium carbonate. It acts by forming 2-µm plugs, which primarily comprise calcium and phosphate. Previous studies have shown that the in-office Colgate Sensitive Pro-Relief Desensitizing Paste containing 8% arginine and calcium carbonate prevents sensitivity without having significant effect on the shear bond strength of composite to enamel or dentin. [19]

Fluoride when applied, precipitates calcium fluoride or apatite's containing calcium fluoride. It was seen that high amount of calcium ions were still present on the dentin surface after demineralization. It was considered that the deposition of apatites occurred not only on the dentin surface but also within the demineralized dentin layer. The precipitation of microcrystals in the exposed collagen layer of the demineralized dentin might partially restore dentin structure. [20]

Novamin (calcium sodium phosphosilicate), which when exposed to water/body fluids (saliva), reacts instantly by releasing billions of mineral ions that become available to the natural remineralization process in the mouth. It deposits hydroxycarbonate apatite and reduces the possibility of reopening the dentinal tubules. This causes the physical occlusion of dentinal tubules, relieving hypersensitivity. [21]

From the results obtained it was seen that, when cemented with GIC

[Table 1, Graph 1], the highest bond strength in the thermocycled samples was seen with Systemp and the least with Pro-Arginine. In non-thermocycled samples, the highest bond strength was seen with GC Tooth Mousse and the least with control group. A significant difference (p<0.01%) was seen in the samples subjected to thermocycling and also in the samples not subjected to thermocycling in Group I.

Systemp forms covalent bond with the proteins, forming the protein pulg that binds with the calcium, phosphate and fluoride minerals released from GIC, thereby improving the bond strength which were similar to studies done by Chauhan et al [13] and Sharma et al [1]. But in studies by Yim et al, Mansner et al, retention with Systemp was decreased by 23% when cemented with GIC [13]. GC Tooth Mousse smoothens the surface by filling the irregularities on the application and GIC bonds chemico-mechanically, which bonds better on a smoother surface, thereby improving the retention when used with GC Tooth mousse [7] which was similar to studies by Jalandar et al [7], Chandrasekharan et al [4], Mazzoui et al, Burnwell and Chandavarkar et al [18]. Least retention was seen with Pro-Arginine because it forms very delicate plug which might interfere with the bonding of the luting agent and also may be because of the reason that it is effective only for few hours.

The samples cemented with RMGIC **[Table 2, Graph 2]**, showed the highest bond strength with Systemp group and lowest with Fluoride group in thermocycled samples and in non thermocycled samples, the highest was seen with Systemp and Novamin group and lowest with Pro-Arginine group. A non-significant difference is seen in the samples subjected to thermocycling and a significant difference (p<0.01%) is seen in the samples not subjected to thermocycling in Group II.

Systemp is composed of gluteraldehyde and polyethylene glycol, which form covalent bonds with proteins when combined together, which leads to the formation of protein plugs, aiding in the retention with RMGIC, which binds with the resin tags present [22] which was similar to a study by Rupkumar et al [22]. Novamin releases calcium and phosphorous ions in exchange for the sodium and hydrogen ions released before. These calcium and phosphorous ions together form Ca-P layer, which crystallizes into hydroxyl-apatite crystals that help in the tubular occlusion forming a hybrid layer. [21] This hybrid layer helps in improving the retention by bonding chemically with the ions released thereby improving the retention. [23] This supports the results obtained in the present study.

Least retention was seen the Flouride group in thermocycled group, because, according to Sarac et al [6], Fluoride has a low bond strength and these crystals are acid-resistant and may prevent chemico-physical bond preventing complete penetration of resin components of RMGIC and Resin cement.

The samples cemented with Resin cement **[Table 3, Graph 3]**, showed the highest bond strength with Systemp group and lowest with Flouride group in thermocycled samples and in non thermocycled samples, the highest was seen with Systemp group and lowest with Pro-Arginine group. A significant difference (p<0.01%) is seen in the samples subjected to thermocycling and a non-significant difference is seen in the samples not subjected to thermocycling in Group III.

It has been stated in the literature that Systemp form the protein plugs by forming covalent bond with the proteins, which helps in improving the micro-mechanical bond with the resin tags, thereby increasing the retention with the tooth tissue and also the tensile bond strength of the Resin cement. [24]

Thermocycling aims at thermally stressing the adhesive joint at the tooth/restoration interface by subjecting the restored teeth to extreme temperatures compatible with temperatures encountered intraorally. This process highlight the mismatch in thermal expansion and contraction between the restoration and tooth structure and interfacing cement resulting in different volumetric changes during temperature changes. [25] The retention might also increase because of release stresses within the cement due to compressive stresses incorporated in the cement as the metal expands and contract due to temperature changes. It can be seen that thermocycling in retention tests have some influence on the performance and lifespan of restorations and that thermocycling should hence be included in any in-vitro microleakage study. Few studies have shown that, if the cycles exceed this frequency, bond strength was reduced in majority of the studies. [26] Hence, in this in-vitro study the following protocol was followed for thermocycling (500 cycles).

CONCLUSION

Within the limitations of the study the following conclusions were drawn:

1) In thermocycled and non-thermocycled samples in all the sub-groups, the highest retention was seen with Resin cement (Group III), followed by RMGIC (Group II) and then GIC (Group I).
2) Systemp, when compared to other subgroups showed the highest retentive strength with GIC, RMGIC and Resin cement.
3) Pro-Arginine, when compared to other subgroups showed the least retentive strength with GIC, RMGIC and Resin cement.
4) Thermocycling improved the bond strength irrespective of the type of cement or desensitizer used.

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