Comparative Evaluation of the Fluoride Release and Recharge through Four Different Types of Pit and Fissure Sealants: An In Vitro Study

Dayanand Chole¹, Prathamesh Lokhande², K Shashank³, Srinivas Bakle³, Amarnath Devagirkar⁴, Praveen Dhore⁵

¹Professor and Head of Department, Department of Conservative Dentistry and Endodontics, Pandit Deendayal Upadhyay Dental College, Solapur, Maharashtra, India, ²PG Student, Department of Conservative and Endodontics, Pandit Deendayal Upadhyay Dental College, Solapur, Maharashtra, India, ³Reader, Department of Conservative and Endodontics, Pandit Deendayal Upadhyay Dental College, Solapur, Maharashtra, India, ⁴Senior Lecturer, Department of Conservative and Endodontics, Pandit Deendayal Upadhyay Dental College, Solapur, Maharashtra, India, ⁵Senior Lecturer, Department of Conservative and Endodontics, MIDSR Dental College, Latur, Maharashtra, India

ABSTRACT

Introduction: The property of pit and fissure sealant is crucial for inhibition of caries in high-risk individuals. Pit and fissure sealants with fluoride releasing ability have enhanced the anticariogenic effect. The aim of this study was to compare fluoride release and recharge property among four different pit and sealant materials.

Materials and Methods: The present in vitro study is a clinical study conducted by the Department of Conservative Dentistry and Endodontics of our institute for 9 days. The four pit and fissure sealants used were: (1) Aelite Flo - A flowable composite resin, (2) Fissurit Fx - A conventional resin-based sealant, (3) Beautisealant - Sealant with surface pre-reacted glass-ionomer fillers (Giomer), (4) Fuji VII - A glass ionomer based sealant. Ten cylindrical specimens of each material were prepared in a plastic mould (10 mm diameter and 1 mm thickness) and stored in plastic(polyethylene) tube containing 5 ml of ultrapure water. Fluoride analysis was done every 24 h from day 1 to day 6. On day 6, specimens were cleaned, dried and recharged with 0.2% NaF for 2 min. The concentration of fluoride released after recharge was measured from day 7 to day 9 in ppm. Fluoride release was measured using fluoride specific ion electrode connected to digital ion analyzer.

Results: The glass ionomer based sealant (Fuji VII) had a higher fluoride release than any other material tested at all times. Fluoride release also increased the following recharging with 0.2% NaF solution for all the materials.

Conclusion: Fuji VII had the highest fluoride release before and after recharge compared to other resin-based sealants.

Keywords: Fissure sealants, Fluoride release and recharge, Fluoride specific ion electrode, Sodium fluoride solution, Surface pre-reacted glass-ionomer fillers

Corresponding Author: Prathamesh Lokhande, Sanjeevan Hospital, A/P - Masur, Taluka - Karad, Satara - 415106, Maharashtra, India.
E-mail: prlokhande@gmail.com

INTRODUCTION

The most prevalent chronic disease of modern times is supposed to be dental caries.¹ Dental caries is defined as a progressive, irreversible, microbial disease affecting the hard parts of the tooth exposed to the oral environment, resulting in demineralization of the inorganic constituents, and dissolution of the organic constituents, thereby leading to cavity formation.² Caries occurs on smooth surfaces, as well as pits, and fissures of the tooth structure. In the case of children and young adults, 90% of carious lesions in permanent teeth and 44% in primary teeth are found in pits and fissures.³ There are various methods to prevent dental caries such as patient education, diet planning, conducting dental health education programs, pit and
Among various methods to prevent caries, pit and fissure sealants application is an effective method. Pit and Fissure sealants with the additional property of fluoride release have played a vital role in preventing initiation of caries and arresting its progression. There are various pit and fissure sealants with fluoride releasing ability like conventional glass ionomer cements, resin-modified glass ionomer cements, resin-based sealants, etc.

Glass ionomer used as a sealant has the property of fluoride release which is responsible for anticariogenic action. Glass ionomer based sealants showed a higher fluoride release than resin based sealants. However, Glass ionomer has poor mechanical properties which are inferior to resin based sealants. Resin-based sealants have high retention rates but are difficult to use in moist environment. A recently introduced resin-based fissure sealants containing surface reaction type prereacted glass ionomer (S-PRG) is also fluoride releasing. In case of pre-reacted glass ionomer S-PRG sealant, the advantages of glass ionomer cements along with the esthetic properties of resin-based sealants are retained.

Various in vitro studies of the past have showed that fluoride containing materials can be recharged by fluoride-containing agents such as dentifrices and mouthwashes. The majority of studies carried out in the past concentrated on restorative materials with a very few studies looking at pit and fissure sealants. Studies in the past did not compare the fluoride releasing ability of glass ionomer sealant to the resin-based sealant with S-PRG fillers. Hence, the need to conduct such a study.

Therefore, this in vitro study was carried out to compare the ability of fluoride release before and after recharging from glass ionomer sealant, conventional resin-based sealants and resin based sealants with S-PRG fillers. Fluoride analysis was done using fluoride specific ion electrode connected to digital ion analyzer.

**MATERIALS AND METHODS**

The present in vitro study is a clinical study conducted by the Department of Conservative Dentistry and Endodontics of our institute for duration of 9 days.

Four recent and commonly used pit and fissure sealants were selected.

1. Aelite Flo- A Flowable Composite Resin, Bisco Inc. Schaumburg, USA
2. Fissurit Fx - A Conventional Resin-based sealant, Voco GmbH, Cuxhaven, Germany
3. Beautisealant - Sealant with S-PRG Fillers (Giomer), Shofu Inc, Kyoto, Japan
4. Fuji VII - a Glass Ionomer-Based sealant, GC Corp Tokyo, Japan.

For every material used, ten disc-shaped specimens (Figures 1-4) were prepared using plastic moulds. The
moulds were 10 mm in diameter and 1 mm in depth. Nylon thread was embedded into each specimen for suspension. The specimens were covered with glass slides to obtain a smooth surface. For the resin-based sealants, all specimens were light cured using an LED curing unit or 20 s. For GIC, the specimen was prepared according to manufacturer’s instructions. Specimens were dry ground with silicon carbide abrasive paper. The total surface area of each specimen was 157 mm\(^2\). The specimens were allowed to set at 37°C for 24 h.

The specimens were dipped in a clean plastic tube containing 5 ml of ultrapure water. During the entire period of study a constant temperature of 37±2°C was maintained using an incubator (Figure 5). The first fluoride concentration was measured at 24 h. After every measurement, the specimens were washed with 1 ml of deionized water and placed in a new plastic tube containing 5 ml of ultrapure water.

On day 6 after fluoride measurement was done, specimens were dried and immersed in 0.2% NaF (Figure 6) for 2 min. After this refluoridation program, specimens were again rinsed with ultrapure water, dried, and placed in a clean polyethylene tube until analysis. Fluoride release was measured before recharging at 1-6 days and after recharging at 7th, 8th, and 9th day.
Fluoride concentration measurement was done using fluoride specific ion electrode (Orion, Thermo Electron Corp) which is connected to a digital ion analyzer (Figure 7). Electrode was calibrated using standard fluoride solutions of 0.1, 1, 10, 100 ppm fluoride.16

All the measurements were done by pipetting 5 ml of the sample solution and adding 5 ml of total ionic strength adjustment buffer II in a clean polyethylene (plastic) tube (Figure 8). The solutions were stirred before measurements. Fluoride concentrations were displayed on the digital analyzer in parts per million.

Statistical Analysis

The difference in fluoride measurements at different materials were analyzed using two-way Repeated measures ANOVA and comparison between the means.

The difference in amount of initial fluoride release and fluoride release after recharge were analyzed using paired t-tests.

The difference in the amount of fluoride released from the four materials studied was analyzed using post-hoc multiple comparison tests.

Table 1: Fluoride release from test materials (ppm) [mean & SD]

<table>
<thead>
<tr>
<th>Days</th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
<th>Group IV</th>
<th>F value</th>
<th>P value</th>
<th>Post-hoc multiple comparison test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20±0.002</td>
<td>2.73±0.38</td>
<td>5.82±0.53</td>
<td>15.66±0.68</td>
<td>2041.9</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.001 I versus III: P&lt;0.001</td>
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<td></td>
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<td></td>
<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
</tr>
<tr>
<td>2</td>
<td>0.15±0.006</td>
<td>1.83±0.39</td>
<td>3.98±0.46</td>
<td>11.25±1.14</td>
<td>571.91</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.001 I versus III: P&lt;0.001</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
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<tr>
<td>3</td>
<td>0.15±0.003</td>
<td>0.87±0.38</td>
<td>2.76±0.46</td>
<td>8.70±0.92</td>
<td>498.5</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.001 I versus III: P&lt;0.001</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
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<tr>
<td>4</td>
<td>0.13±0.003</td>
<td>0.49±0.3</td>
<td>1.39±0.43</td>
<td>6.16±0.70</td>
<td>417.06</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.001 I versus III: P&lt;0.001</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
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<tr>
<td>5</td>
<td>0.05±0.046</td>
<td>0.29±0.15</td>
<td>0.74±0.33</td>
<td>2.95±0.68</td>
<td>117.88</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.001 I versus III: P&lt;0.01</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.01</td>
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<tr>
<td>6</td>
<td>0.007±0.003</td>
<td>0.112±0.09</td>
<td>0.57±0.25</td>
<td>1.54±0.63</td>
<td>41.901</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.05 I versus III: P&lt;0.01</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.05</td>
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<tr>
<td>7</td>
<td>0.19±0.002</td>
<td>1.09±0.34</td>
<td>2.58±0.64</td>
<td>6.32±0.73</td>
<td>274.82</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.01 I versus III: P&lt;0.001</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
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<tr>
<td>8</td>
<td>0.03±0.01</td>
<td>0.15±0.28</td>
<td>1.09±0.51</td>
<td>2.85±0.65</td>
<td>89.206</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.05 I versus III: P&lt;0.001</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
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<tr>
<td>9</td>
<td>0.004±0.002</td>
<td>0.007±0.002</td>
<td>0.04±0.02</td>
<td>1.45±0.34</td>
<td>181.63</td>
<td>&lt;0.0001</td>
<td>I versus II: P&lt;0.05 I versus III: P&lt;0.05</td>
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<td>II versus IV: P&lt;0.001 III versus IV: P&lt;0.001</td>
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</table>

RESULTS

The mean (±standard deviation [SD]) concentration of initial fluoride release and fluoride release after recharge are mentioned in Table 1. All the differences were statistically significant (P < 0.05).

For all the sealants, the greatest amount of fluoride released was on day 1 (Graph 1). After day 1, fluoride released declined rapidly until recharge but continued until the entire test period. At day 1, fluoride release was highest from Fuji VII followed by Beauti sealant, Fissurit F, Aelite Flo. GIC based sealant released the higher amount of fluoride compared to S-PRG containing sealant and resin-based sealant.

Mean (±SD) concentration of fluoride release after recharging with 0.2% NaF are shown in Table 1 (days 7-9). Again Glass ionomer based sealant released a higher amount of fluoride than resin-based sealant. There was a significant but variable increase in the amount of fluoride released following recharge after 24 h. Subsequently, concentrations fell to pre-exposure levels (Graph 2).
The primary approach in prevention of dental caries comprises of use of pit and fissure sealants. Fluoride from the sealants reduces demineralization and enhances remineralization, thus helping to prevent initiation and progression of caries. Fluoride releasing sealants are commonly used in dental programs as a primary preventive measure against caries. In this study, fluoride release was more from glass ionomer based sealant compared to other materials. Fluoride release was seen from all the materials throughout the test period. After Fuji VII, resin based sealant containing S-PRG filler released a considerable amount of fluoride. Compared to Fuji VII and Beautisealant, Fissurit F and Aelite Flo released very less fluoride. Bayrak et al. also showed greater fluoride release from glass ionomer based sealant compared to resin-based sealant.

The initial high level of fluoride release seen in the case of Fuji VII is called the “burst effect” of fluoride and is because of rapid release of fluoride from the glass particles as they set. The initial superficial rinsing effect also may be responsible for the initial high level of fluoride release. Later fluoride releases becomes slower and is because of the gradual dissolution of glass into the hydrogel matrix.

Beautisealant released fluoride much less than Fuji VII. The mechanism of fluoride release and recharge may be similar to glass ionomer sealant. They contain S-PRG as a fluoride component. There is no glass ionomer matrix phase since there is no significant acid-base reaction.

Resin based sealant, Fissurit FX and Aelite Flo, released much less fluoride. This is mainly because of an absence of any acid-base reaction which was seen in glass ionomer based sealant. Glass ionomer matrix phase is not present in resin-based sealant. The dissolution of inorganic fluorides is responsible for a release of fluoride from these sealants.

The recharge agent used was 0.2% NaF solution which contain around 900 ppm of fluoride. Following recharge, there was an increase in fluoride release from all the materials. However, there was rapid fall in fluoride release in subsequent days. After recharge, Fuji VII released the greatest amount of fluoride compared to other materials. This shows that material with greater release capacity has higher recharge capacity.

Koga et al. showed that conventional resin based sealant lacked the property of recharge. In this study, resin based sealants released fluoride after recharge though in smaller amount compared to glass ionomer based sealant. Shimazu et al. concluded that resin-based sealant containing S-PRG filler had greater recharge capacity than conventional sealants which is in accordance with our study. The exact mechanism of recharge is not known. Many factors influence the recharge capacity like the permeability of the material, the surface energy of the material and composition of the material. Greater the permeability of the material greater is the ability of the material to absorb and re-release fluoride.

Sodium Fluoride was used to recharge specimens because it is commonly used in mouthwashes and toothpaste. Since toothpaste and mouthwashes can be used on regular basis they can serve as a potent recharging agent to prevent secondary caries.

There are certain limitations of this study. The medium used is ultrapure water which does not simulate an oral environment. Furthermore, this study was carried out for a shorter duration of time. These limitations should be considered in future studies.
CONCLUSION

Keeping in mind the limitations of the study certain conclusions can be drawn; fluoride containing pit and fissure sealants released fluoride over a considerable duration. Different sealants released variable amounts of fluoride with different fluoride release patterns. Glass ionomer based sealant with a higher release and recharge capacity can be used in children with high susceptibility to caries. All the materials had the ability for recharge with Fuji VII being the greatest and Aelite Flo being the least.

REFERENCES


Source of Support: Nil, Conflict of Interest: None declared.