**ABSTRACT**

**Objectives:** Hypersensitivity is a common clinical annoying multietiological problem. Many desensitizing agents have been launched in market in different forms attempting to overcome such a problem. The purpose of this study was to evaluate the ability of a new desensitizing agent to occlude dentinal tubules and reduce their diameter as measured by environmental scanning electron microscopy. At the same time its effect on microshear bond strength of a one step self etch adhesive would be investigated.

**Materials and Methods:** Fifteen buccal surfaces of sound human premolars were used. Enamel was wet abraded to expose flat dentin surfaces, polished with diamond pastes and further demineralised with 37% phosphoric acid for 5 seconds to remove the smear layer. All specimens were first scanned using environmental scanning electron microscope. The number and diameters of dentinal tubules were measured. Specimens were randomly divided into three groups (n=5): G1, no brushing (control); G2, brushing with the new product gel containing a combination of ACP, KNO3 and NaFl; G3, brushing with homecare Fluoride gel. Brushed specimens were treated for 4 min per day, for 14 days. Specimens were observed under ESEM for calculation of the mean number of occluded tubules and the mean diameters of the remaining ones. Afterwards, the desensitized specimens were treated with a contemporary one step self etch adhesive according to manufacturers instructions and composite microcylinders were packed. Microshear bond strength test was performed using a testing machine (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) with a load cell of 5 kN and data were recorded using computer software (Nexygen-MT Lloyd Instruments).

**Results:** Statistical analysis of the data obtained revealed a significant dentinal tubule occlusion as well as a significant decrease in the apertures the remaining dentinal tubules for group 2 relative to groups 1 and 3, respectively. Meanwhile, the mean values for the microshear bond strengths were 22.961 Mpa, 23.596 Mpa and 22.778 Mpa for groups 1, 2 and 3 respectively. These values were not statistically significantly different.

**Conclusions:** The new product, Relief ACP, proved its efficiency in obliterating the dentinal tubules and reducing their diameter more than the other two groups. At the same time micro shear bond strength of the single step self etch adhesive Xeno IV to desensitized dentin wasn’t reduced.
INTRODUCTION

Dentinal hypersensitivity, is a significant clinical problem, in which a sound, exposed dentinal surface is sensitive to stimuli that would normally cause no discomfort. (Ling TTY & Gillam DG 1996) Although it is neither life threatening nor a serious dental problem, but it can be a particularly uncomfortable and unpleasant sensation for patients and can dictate types of foods and drinks ingested. (Addy M & Hunter ML 2003, Dababneh RH et al 1999) Two common conditions need to be satisfied for dentin hypersensitivity to occur: dentin has to become exposed by loss of enamel or periodontal tissues and the dentin tubule system has to be opened and be patent to the pulp. This provides a direct link between the external environment and the internal pulp of the tooth. If the tubules are not exposed it seems unlikely that hypersensitivity will be found. (Addy M 2002, 2005 and Bamise CT 2008)

Usually, no obvious cause can be identified for this condition, however, dentine may become exposed via several means. For example, the enamel or cementum which normally covers the dentine surface may be removed or denuded as a result of attrition, abrasion or erosion. (Barbour ME & Rees GD 2006)

Alternatively, in some individuals the cementum and enamel which normally cover the dentine do not meet and result in dentine exposure as a result of a developmental anomaly. In general, it appears that dentinal hypersensitivity is rarely a result of just one of the above factors, but rather a combination of more than one factor. (Dababneh RH, 1999, Addy M, 2005, Sykes LM, 2007)

In a review article by Bartold PM 2006 about dentinal hypersensitivity he summarized the treatment strategies into a variety of self care as well as professional treatment strategies designed to depolarize the nerve or occlude and or seal the dentinal tubules. There is a surprisingly large number of treatment options for managing dentinal hypersensitivity. Chemical or physical agents are used to either desensitize the nerve or cover the exposed dentinal tubules. The most common form of management is the placement of a topically applied agent either by a dental professional or by the patient at home.

Most “at home” desensitizing agents are generally restricted to dentifrices and mouthrinses containing one or a combination of agents that act synergistically. Of these, the most common “active ingredients” are potassium nitrate, stannous fluoride, sodium fluoride, sodium monofluorophosphate and strontium chloride. (Kerns DG et al, 1991, Scherman A et al 1992, Trowbridge O et al 1990, Cox CF 1994) The newest products aimed at hypersensitivity management are those containing amorphous calcium phosphate as the active ingredient. ACP forms hydroxyapatite in enamel and increases enamel hardness, hence its primary application as an agent to remineralize carious lesion as well as reduce susceptibility to their formation. Products containing amorphous calcium phosphate also show promise for management of sensitivity via topical application (Hewlett ER, 2007, Markowitz, K. and Pashley, D.H. 2008).

On the other hand, the use of restorative materials is generally an invasive solution to the problem of hypersensitivity. Commonly used materials include composite resins and glass ionomer restorations. Generally this approach is reserved for situations where there has been significant prior loss of cervical tooth structure or as a last resort for a tooth which does not respond to other less invasive desensitizing protocols.

In attempting to solve the problem, a new product Relief ACP gel combining ACP, KNO3 and NaF has been launched to the market. The purpose of this study was to evaluate the ability of this new professionally applied desensitizing agent to occlude dentinal tubules and reduce their diameter in comparison to a traditional home care fluoride gel product containing stannous fluoride as the active ingredient. At the same time its effect on microshear bond strength of a one step self etch adhesive would be investigated.
MATERIALS AND METHODS

Materials:

Three types of commercially available materials have been used in the study (Table 1).

Relief ACP is a new product professionally applied gel with a formula combining the benefits of sodium fluoride, potassium nitrate and amorphous calcium phosphate. A homecare fluoride gel was also used containing the active ingredient 0.4% stannous fluoride. For bonding, a contemporary single step selfetch adhesive containing fluoride has been used.

Specimens preparation and grouping

Fifteen buccal surfaces of sound human premolars were used. Enamel was wet abraded to expose flat dentin surfaces, polished with diamond pastes and further demineralised with 37% phosphoric acid to remove the smear layer. Specimens were randomly divided into three groups according to treatment modality (n=5): G1, stored in distilled water with no brushing; G2, brushing with the new product relief ACP gel; G3, brushing with homecare Fluoride gel. Brushed specimens were treated for 4 min per day, for a period of 14 days. Afterwards, the desensitized specimens were treated with a contemporary one step self etch adhesive according to manufacturers instructions and composite microcylinders were packed.

Test Procedures for Environmental Scanning Electron Microscope (ESEM):

The mean number and diameters of dentinal tubules of all demineralized specimens were first scanned and measured using environmental scanning electron microscope* at a magnification of x 3000. Then the different groups of the treated specimens were secondly observed under ESEM for calculation of the mean number of occluded tubules and the diameters of the remaining ones.
Test procedure for microshear bond strength

Each acrylic embedded tooth slice with its own bonded composite microcylinders was secured with tightening screws to the lower fixed compartment of a materials testing machine** (Model LRX-plus; Lloyd Instruments Ltd., Fareham, UK) with a loadcell of 5 kN and data were recorded using computer software (Nexygen-MT Lloyd Instruments)***.

A loop prepared from an orthodontic wire (0.014” in diameter) was wrapped around the bonded microcylinder assembly as close as possible to the base of the microcylinder and aligned with the loading axis of the upper movable compartment of the testing machine.

Micro-Shear Testing

A shearing load with tensile mode of force was applied via materials testing machine at a crosshead speed of 0.5 mm/min. The relatively slow crosshead speed was selected in order to produce a shearing force that resulted in debonding of the microcylinder along the substrate-adhesive interface. The load required to debonding was recorded in Newton.

Micro-Shear bond strength calculation

- The load at failure was divided by bonding area to express the bond strength in MPa:

\[
\delta = \frac{P}{\pi r^2}
\]

where; \( \delta \) = bond strength (in MPa)

\( P \) = load at failure (in N)

\( \pi = 3.14 \)

\( r \) = radius of microcylinder (in mm)

- The stress-deflection curves were recorded using computer software (Nexygen-MT Lloyd Instruments)

RESULTS

The results of the ESEM have shown significant (p<0.05) decrease in count of dentinal tubules of group 2 desensitized with Relief ACP before and after treatment (Figs1a & 1a/). This indicates obliteration of a large number of dentinal tubules. At the same time, there is a significant decrease (at p<0.01) in diameter of the remaining tubules before and after treatment with Relief ACP. (Tab.2) and Figs (2a, 2b). The results have also shown a decrease in count and diameter of group treated with homecare SnFl gel, (Figs1b, 1b/), however of no statistical significance(Tab2) and Figs(2a&2b)

**TABLE(1) Materials used in the study**

<table>
<thead>
<tr>
<th>Material</th>
<th>Relief ACP</th>
<th>Home Care Fluoride Gel</th>
<th>Xeno IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition</td>
<td>0.375 % Amorphous Calcium Phosphate (ACP), 0.22% NaFl, 5% KNO3</td>
<td>0.4% stannous fluoride</td>
<td>PENTA, Mono-, Di and Trimethacrylate resins, cetylamine hydrofluoride, acetone-water</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Discuss Dental</td>
<td>Alphadent</td>
<td>Dentsply</td>
</tr>
</tbody>
</table>
The results of the study have shown no significant difference between the two groups in the difference of number of dentinal tubules or change percent of their counts before and after treatment. (Table 3) & Figs (3a&3b).

The results have shown there is no significant difference in microshear bond strength among different groups whether treated with a desensitizing agent or not. (Table 4) and (Fig. 4).
DISCUSSION

It has been well recognized that the main cause of dentin hypersensitivity is attributed to exposed dentinal tubules found in areas where tooth structure has been lost. In attempting to simulate these conditions, the enamel surface has been wet abraded to expose the dentine surface and the smear layer has been intentionally removed to expose the dentinal tubules. The results of the ESEM have shown a significant decrease (p≤0.05) in the count of dentinal tubules for group 2.

TABLE (3) Descriptive statistics and test of significance for the effect of group on number and diameters of dentinal tubules.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Count</td>
<td>Before</td>
<td>106.000</td>
<td>47.286</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>69.000</td>
<td>39.051</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>37.000</td>
<td>9.000</td>
</tr>
<tr>
<td></td>
<td>% change</td>
<td>38.689</td>
<td>13.242</td>
</tr>
<tr>
<td>diameter</td>
<td>Before</td>
<td>8.603</td>
<td>1.096</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>5.593</td>
<td>1.356</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>3.008</td>
<td>0.303</td>
</tr>
<tr>
<td></td>
<td>% change</td>
<td>35.620</td>
<td>7.995</td>
</tr>
</tbody>
</table>

S.D. = Standard deviation.  P = Probability level for the effect of treatment within each group.  
NS = Insignificant (p>0.05).  * = Significant at p≤0.05  ** = Significant at p≤0.01

TABLE (4) Descriptive statistics and test of significance for the effect of group on microshear bond strength

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
<th>S.D.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>dt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.961</td>
<td>0.345</td>
<td>22.643</td>
<td>23.327</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>23.596</td>
<td>0.560</td>
<td>23.220</td>
<td>24.240</td>
<td>a</td>
</tr>
<tr>
<td>3</td>
<td>22.778</td>
<td>0.578</td>
<td>22.220</td>
<td>23.374</td>
<td>a</td>
</tr>
</tbody>
</table>

S.D. = Standard deviation.  dt = Duncan's Multiple Range Test for the effect of group.  
Means with the same letter within each column are not significantly different at p≤0.05

FIG. (4) Mean microshear bond strength in different groups
after treatment with ACP Relief gel which indicates obliteration of a large number of dentinal tubules. At the same time the diameter of the remaining tubules has also significantly decreased for the same group (p≤0.01) indicating their partial obliteration. As for group 3, treated with home care stannous fluoride gel , the results have also shown a remarkable decrease in dentinal tubules counts as well as a recorded decrease in diameter of remaining dentinal tubules before and after treatment, however they were of no statistical significance.

According to the manufacturer, ACP Relief gel contains 0.375% Amorphous Calcium Phosphate (ACP) and 0.22% NaFl as its active ingredients. Many clinical studies have shown that treatment of exposed root surfaces with fluoride toothpaste and concentrated fluoride solutions is very efficient in managing dentinal hypersensitivity (Gedalia et al 1978, Minkov B 1975). Improvement appears to be due to increase in the resistance of dentine to acid decalcification as well as to precipitations in the exposed dentinal tubules. Tal et al 1976 stated that the probable desensitizing effects of fluoride are related to precipitated fluoride compounds mechanically blocking exposed dentinal tubules or fluoride within the tubules blocking transmission of stimuli. At the same time, it has now been found that the dental remineralization efficacy of an oral composition including a source of fluoride ions can be substantially enhanced by the addition of stabilized ACP to the composition. Furthermore, the uptake of fluoride ions into dental hard tooth structure from an oral composition containing a source of fluoride ions can be enhanced by the inclusion of stabilized ACP into the composition. The use of the calcium phosphate precipitation (CPP) method makes possible the occlusion of dentinal tubules to approximately 10 to 15 microns from the dentinal surface, and thus shows good potential for the treatment of dentin hypersensitivity. The precipitate formed in the dentinal tubules by the CPP method is, however, not apatite [HAP; Ca10(PO4)6(OH)2], a component of tooth and bone, but dicalcium phosphate dihydrate (DCPD; CaHPO4.2H2O). However, Fluoride enhances the conversion of DCPD to HAP, which occludes dentinal tubules( Suget T et al 1995, CesarAGA et al, 2003)

Stannous fluoride either aqueous solution or in glycerine gelled with carboxymethyl cellulose is effective in controlling dentinal hypersensitivity (Miller et al 1969). Its action appears to be through the induction of a high mineral content which creates a calcific barrier blocking the tubular openings on the dentine surface. Alternatively, stannous fluoride may precipitate on the dentine surface leading to occlusion of the exposed dentinal tubules (Furseth R 1970).

It is clear that both sodium fluoride and stannous fluoride have the ability to obliterate dentinal tubules, working with the same mechanism. That is why there was no significant difference between the two groups. However, within the same group, the ACP group showed significant decrease in both count of dentinal tubules and significant decrease in diameter of partially obliterated ones. This might be due to synergistic action of added amorphous calcium phosphate (ACP).

Microshear bond strength of one step self etch adhesive containing cetylamine hydro fluoride to the three groups has been measured. It was hypothesized that microshear bond strength to desensitized dentine samples would decrease due to complete or partial obliteration of the dentinal tubules. However, the results have shown no significant difference in microshear bond strengths of control and test groups when using desensitizing agents. This can be explained by the presence of cetylamine fluoride in Xeno IV composition which could have chemically bonded to the precipitated structures.

CONCLUSIONS

The new product, Relief ACP, proved its efficiency in obliterating the dentinal tubules and reducing their diameter more than the other two groups. At the same time, micro shear bond strength of the single step self etch adhesive Xeno IV to desensitized dentin wasn’t reduced.
REFERENCES


