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Evaluation of the Occluding Effect of Sensodyne with Strontium Chloride 0n Microleakage through Dentinal Tubules of Endodontically Treated Teeth

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Abstract

Background Dentin hypersensitivity may be defined as pain arising from exposed dentin. The relationship between dentin hypersensitivity and the patency and Microleakage through dentinal tubules has been established in vitro. Currently the most accepted mechanism of nerve activation associated with dentin hypersensitivity appears to be hydrodynamic in nature.

Objectives The concept of tubule occlusion as a method of dentin desensitization is a logical conclusion of the hydrodynamic theory.

Methods Forty two human maxillary anterior teeth were selected, the crowns were cut away at the CEJ, the root canals prepared, cleaned and filled then the coronal access closed with zinc phosphate cement. The specimens were randomly divided into four groups, two of them experimental A and B and two controls C (positive) and D (negative). All the specimens were coated with sticky wax except the ring that had cementum removed while the negative control specimens were entirely coated with sticky wax. All the specimens were stored in human saliva which was changed daily for 21 days with daily brushing of specimens of group A with a Sensodyne tooth paste (that with active ingredient Strontium chloride). At the end of the 21 days, the specimens were immersed in pelikan ink for three days then the sticky wax was removed, after that the teeth were cleared to make them transparent to provide a three dimensional assessment of dye penetration. The teeth were subjected to linear dye penetration measurement and scanning electron microscope analysis to investigate whether Sensodyne with Strontium chloride occlude dentinal tubule orifices.

Results Strontium chloride, the active ingredient of Sensodyne tooth paste has a tubule occluding property which may indicate a therapeutic potential in vivo. Also scanning electron microscopic analysis revealed presence of deposits in and around the tubular orifices.

Conclusion Sensodyne with strontium chloride proved effective (*in vitro*) in occluding the orifices of patent dentinal tubules.

Keywords Dentin hypersensitivity, Dentinal tubules occlusion, Sensodyne with strontium chloride.

Introduction

Dentin hypersensitivity is a common painful dental problem, exposure of cervical dentin and patency of the dentinal tubules may occur through the loss of covering enamel -and / or gingival recession with loss of cementum. Both processes have multifactorial etiology [(1)]. These exposed dentinal tubules transmit various thermal, chemical, and bacterial stimuli from the dentinal surface to the pulp [(2)]. Currently, the hydrodynamic theory [(3)] is the most widely accepted theory for explaining the mechanism of dentin hypersensitivity, this theory explains that fluids move within

dentinal tubules in response to external stimuli and that this movement of fluids stimulate mechanoreceptors in the pulp to cause pain.

Many studies reported that most of the tubules on sensitive dentin are opened and that the occlusion of these tubules reduces the sensitivity by preventing or minimizing the permeability of dentin [4].

This permeability allows the bidirectional movement of materials from the oral cavity to the pulp and vice versa. The pulp irritation associated with Microleakage through dentinal tubules is often dictated by the permeability of dentin [5].

Microleakage may be presumed to occur after exposure of the dentinal tubules to oral fluids, factors affecting this microleakage are:

Patency of the dentinal tubules, number of the dentinal tubules exposed and the exposure time [6].

Natural occlusion of the exposed dentinal tubules can occur through the formation of calculus, deposition of intra tubular crystals from dentinal fluid or saliva, formation of peri tubular dentin or intra tubular deposition of collagen or plasma protein [7].

For certain reasons such as excessive acidic food, traumatic tooth brushing, alteration of the composition of saliva and periodontal diseases and therapy, the external openings of the dentinal tubules may become uncovered and Microleakage may occur [1].

Different findings concerning the occluding effect of desensitizing agents on open dentinal tubules have been reported [1] and the effect of various desensitizing agents to occlude the patent tubules had been reported by a number of studies and various agents had been used either topically or with a dentifrice.

The problem of microleakage through dentinal tubules following the application of a desensitizing agent was not solved and the evidences from previous research works were not clear, for this reason this study was addressed to this problem, the desensitizing agent used was Sensodyne that contains Strontium chloride, the choice was based on the popularity of the product and its relative effectiveness.

The aim of this study was to determine and evaluate the dye microleakage through exposed dentinal tubules at the cervical level of endodontically treated teeth and to evaluate the occluding effect of Sensodyne dentifrice (with the active ingredient Strontium chloride) on the exposed cervical dentinal tubules using the scanning electron microscopy.

Methods

This study was done in Al-Majd General Company for Military Industries in Al-Jadiriya near Al-Furrosiya Club.

Forty two recently extracted human maxillary anterior teeth were randomly collected to be used in this study. No data regarding age, sex, and causes for extractions were recorded.

All the teeth, after extraction were stored in normal saline at room temperature. Any calculus, soft tissue or debris was removed by ultrasonic scaling. Then the crown of each tooth was cut away at the Cementoenamel junction by a diamond disc and conventional handpiece and standard endodontic access preparations were made by carbide round bur No.3. The root canal contents were removed with barbed broachs, patency of the apical foramen was determined using No.1 0 file, and the working length was established 1mm short of the length at which this file exited the foramen.

The canals were chemomechnically prepared to a No. 30 Master Apical File and instrumentation completed by step back flaring to No. 60 file. Copious irrigation with 2.5% solution of sodium hypochlorite was used throughout the canal preparations, and then the canals were dried with paper points.

Master gutta percha cones were fitted to within I mm of the working length in 37 out of 42 teeth, five teeth were not obturated and reserved as positive controls. The canals and gutta-percha cones were coated with zinc -

oxide base sealer and obturation completed using the lateral condensation technique, excess gutta percha was removed with heated instrument to a level apical to the orifices of the canals by two millimeters then the coronal access preparations were closed with zinc phosphate cement. All the teeth were stored in 100% humidity at 37^{o}C for 48 hours to allow the sealer enough time to set. Then in 37 out of the 42 teeth, the dentin was exposed by removing the cementum, in five teeth, the cementum was not removed (dentin not exposed) and reserved as negative controls.

A 3mm wide ring of root surface, 2mm apical to the coronal rim of each specimen was cut by a rotary instrument attached to a special micro -lathe. Each root was fixed by a vise (clamp) horizontally in front of the instrument and this was set to cut only one millimeter all around the root while it was rotating to obtain a collar of 3mm width and 1mm depth around the root in order to remove all the cementum and expose the dentine in this area.

The specimens were then randomly divided into four groups:

1- *Group A:* 16 teeth. In this group, the specimens were treated with the desensitizing agent Sensodyne (with strontium chloride) on the exposed dentin.

2- *Group B:* 16 teeth. In this group, the specimens were not treated with the desensitizing agent on the exposed dentin.

3- *Group* C: (positive control) = 5 teeth, in this group the canals were not obturated but the cementum was removed and dentin exposed

4- *Group D:* (negative control) = 5 teeth, in this group the canals were obturated but the cementum was not removed and the dentin not exposed.

The external surfaces of each specimen of group A, Band C was coated with two layers of sticky wax except for the ring that had cementum removed, while the external surface of specimens in group D was entirely covered with two layers of sticky wax.

The ring cut of the surfaces of specimens of group A, Band C was treated with saturated solution of citric acid pH1 for 30 seconds to remove the smear layer then washed with distilled water for five minutes.

All specimens were stored in whole human saliva collected from the same person and changed daily for 21 days. During this period, the specimens of group A were brushed with Sensodyne dentifrice (including strontium chloride) using a medium brush twice daily for one minute each and then rinsed with distilled water and re-immersed in saliva which was collected daily from my clinic secretary man.

At the end of three weeks, the specimens were removed from the saliva, washed with water and then immersed in Pelikan Ink for72 hours, after that removed and washed with water for 30 minutes and then the sticky wax was removed by a sharp wax knife.

The specimens were decalcified in 5% nitric acid for five days with renewing the acid daily and at the end of five days, the specimens were washed for four hours under running water. After that, the specimens were dehydrated in increasing concentrations of Ethyl alcohol, and then immersed in Methyl Salicylate for 24 hours to make them transparent.

Maximum apical extension of the dye using a Vernier. Two readings were taken for each specimen by two evaluators and the average of the two readings were considered for statistical analysis. The collected data was analyzed by a professional statistician using means, standard deviation, tables and bar charts then the t-test was used to compare between the two experimental groups A and B.

Eight specimens randomly selected, four from each group A and B were examined in a scanning electron microscope at 20 kV after gold platting. Micro- photographs of the exposed dentinal surface were taken at various magnifications.

Many photos were scanned and exposed then we choose the clearest ones. All the specimens were gold – platted and scanned at 20 Kv.

Results

All the experimental teeth of group B (not treated with Sensodyne) showed much more dye penetration than the experimental teeth of group A (treated with Sensodyne), table 1.

Table 1. Level of dye penetration (in mms) for groups A and B.

Specimen No.	Group A treated with Sensodyne	Group B untreated with Sensodyne
1	0.35	1.65
2	0.36	2.10
3	0.54	1.80
4	0.56	2.14
5	0.37	1.57
6	0.58	0.98
7	0.36	1.30
8	0.34	2.19
9	0.50	2.03
10	0.45	1.60
11	0.34	0.99
12	0.51	2.05
13	0.57	1.50
14	0.35	2.14
15	0.58	1.40
16	0.55	1.25
The mean leakage	0.456875	1.668125

The positive control group (group C) demonstrated complete dye penetration, while the negative control group (group D) showed no dye penetration.

Figure 1 shows the comparison between the mean leakages for both groups A and B while table 2 shows the summary of the statistics for both groups A and B (The mean leakage, standard deviation, the maximum and minimum values).

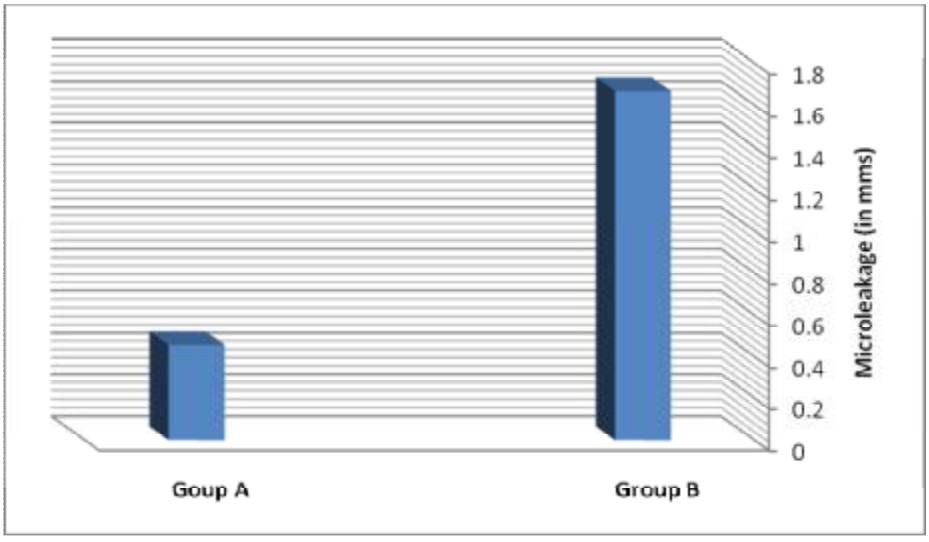

Figure 2. Comparison between mean leakage (in mms) for both groups A and B.

Table 2. Descriptive statistics for experimental groups A and B.

Group	No.	Mean±SD	Maximum Leakage	Minimum Leakage
A	16	0.456375±0.697	0.51	0.14
B	16	1.668125±0.399753	2.19	0.98

Comparative of significance using the t-test showed very highly significant difference ($P<0.0001$) between the two groups through the difference of mean value (leakage).

The scanning electron microscopic analysis showed many deposits on the dentin surface in and around the orifices of the dentinal tubules for specimens of group A (Figure 2).

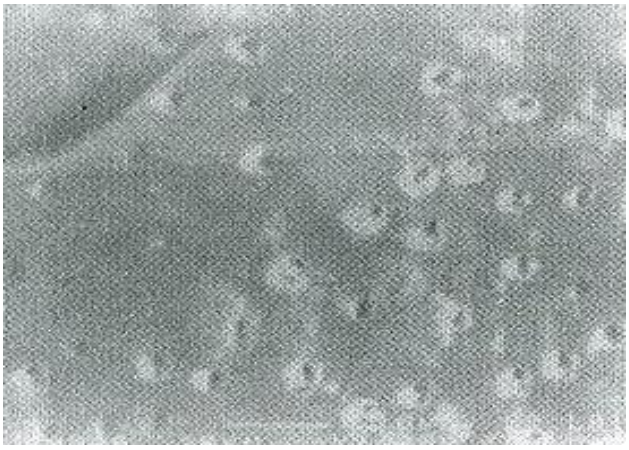

Figure 2. Scanning electron microphotographs showing an area of dentin treated with Sensodyne (Group A).

While the SEM analysis for specimens of group B showed the dentin surface free of any deposits and the dentinal tubules orifices were patent (Figure 3).

Figure 3. Scanning electron microphotographs showing an area of dentin not treated with Sensodyne (Group B).

Discussion

Microleakage is considered as one of the major causes of endodontic failure [8]. Exposure of the root canal space to oral fluids through the loss of temporary seal, recurrent caries, marginal leakage or possibly exposed dentinal tubules may lead to salivary and bacterial contamination [9]. This microleakage may occur between the sealer and the walls of the root canal or between the sealer and root canal filling material.

Microleakage may be presumed to occur after exposure of dentinal tubules to oral cavity fluids, determinant factors are maintenance of patency of dentinal tubules, number of dentinal tubules exposed and the exposure time.

When dentin is exposed due to abrasion, grinding, scaling, caries or cementing a crown, a mat of mineralized material may form within two weeks occluding the dentinal tubules (Natural occlusion) [7], but for many reasons such as excessively acidic food, alteration of the composition of saliva or traumatic tooth brushing, the exposed dentinal tubules remain uncovered and patent [1].

Periodontal diseases and therapy are other important causes of exposure of cervical dentin and dentinal tubules particularly after treatment with citric acid which opens and enlarges the orifices of the tubules.

Studies on the occlusion of dentinal tubules were performed in vivo and in vitro and different findings concerning the occluding effect of the desensitizing agents have been reported. Most of these studies have focused on coronal dentin where important variables such as dentin surface area, thickness and surface characteristics can be controlled.

This study focused on radicular dentin, the permeability of radicular dentin has been observed to be much lower than that of coronal dentin and there is a good correlation between tubule number and diameter and the permeability [10]. In addition to the microleakage through exposed dentinal tubules, the present study investigated the potential tubule - occluding effect of strontium chloride hexahydrate 10% included in Sensodyne toothpaste.

Pelikan Ink was used as a dye and a clearing method was used to study the microleakage which provided us a direct three dimensional measurements.

The cleared positive control teeth (group C) showed complete dye penetration throughout the root canal length while the cleared negative control teeth (group D) showed no dye penetration.

This proved that the dye microleakage in other groups was through the exposed dentin which indicated good experimental design and good coating process.

From the analysis of data of the experimental groups A & B it was found that group B (untreated with Sensodyne) had higher mean of dye penetration than group A (treated with Sensodyne) with high significant difference ($P < 0.0001$) between the two groups. This proved the occluding effect of Sensodyne on the exposed dentinal tubules of specimens of group A. this effect was confirmed by the scanning electron microscopic study of specimens from both groups A & B which showed irregular deposits in and around the orifices of dentinal tubules of specimens of group A . While specimens of group B showed opened orifices of the tubules.

The present study demonstrated that the interface between the canal walls and the root canal filling material could be penetrated by the dye through patent dentinal tubules in the cervical surface of roots exposed to saliva. It could be concluded that the dye penetrated the dentinal tubules and then through the canal walls and sealer which represent the previous leakage of saliva.

This conclusion was comparable to what Berutti [6] found that exposed cervical dentin which was exposed to saliva for various periods showed dye penetration between the canal walls and the sealer to increasing depths proportional to the time of exposure to saliva.

The difference between our study and Berutti [6] was the period of exposure to saliva since in our study it was 21 days while in Berutti [6] study was 20, 40 and 80 days. In addition that Berutti [6] did not include occlusion of exposed dentinal tubules by a desensitizing agent.

Despite the different views about the effect of Sensodyne with strontium chloride in occluding patent dentinal tubules, various clinical trials have verified its desensitizing effect. Many earlier reports have indicated the tubule occluding effect of Sensodyne.

Pawlowska [11] found that strontium chloride binds strongly to dentin and this support our study.

Collins and Perkins [12] found that Sensodyne reduced dentin sensitivity and occluded patent dentinal tubules and this also supports this study.

Jensen and Doering [13] proposed that the mode of action of strontium was by binding to the matrix of the tubules thus reducing its radius; this might explain the results of Minkoff and Axelrod [14] who reported that the effect of strontium chloride emerged during the 2nd week and it significantly reduced dentin hypersensitivity by the end of the twelfth week.

The results of the present study were in agreement with the results of Gillam et al [15] who investigated the potential tubule occluding effect of five selected desensitizing agents: Sensodyne, Butler protects, OxaGel, ABbond 2 and One-Step. They found that all these agents produced some occlusion of the tubules with different levels of coverage.

On the other hand, Topbasi [16] reported that Sensodyne did not have significant effect in

occluding dentinal tubules in vitro but most of the tubules were occluded in vivo. The difference in the results between Topbasi [16] study and ours might be due to the difference in the method of storage since they stored the teeth in distilled water while the teeth in our study were stored in natural human saliva.

The results of the present study disagreed with the results of Clark et al [17], Mostafa et al [18] and Addy and Mostafa [19] who attributed the failure of Sensodyne in occluding dentinal tubules to the silica-based abrasive system in it since it produces characteristic irregular deposits of silica-containing diatomaceous earth on the dentin surface with partial occlusion of the tubules which were washable by the saliva. This difference in the results may be that the present study involved the in vitro application of Sensodyne. In the clinical situation it is doubtful that Sensodyne have such a high concentration, this difference in concentration probably accounted for the differences in the results.

Also, the results of the present study were not comparable with the results of Ling et al [20] who found that Sensodyne toothpaste produced granular-like deposits which were localized on the dentin surface between the orifices and around the periphery of the tubular openings but were largely removed by washing or rinsing. This difference in the results might be due to the differences of techniques and amount of toothpaste applied over time, since Ling et al [20] used two minutes brushing and six hours rotation in saliva then ten seconds rinsing with distilled water.

However, the results of the present study suggested that Sensodyne dentifrice with strontium chloride hexahydrate has a promising effect on the reduction of microleakage through exposed dentinal tubules by its occluding effect on these patent tubules and it performed well in vitro.

Conclusions

With the experimental confines of this in vitro study it was concluded that:

1. It was possible that the interface between the canal wall and the root canal filling material to become recontaminated because of microleakage through patent dentinal tubules in the cervical surface of roots exposed to saliva.
2. The cervical dye penetration was significantly more in group B (untreated with Sensodyne) than in group A (treated with Sensodyne), thus indicating the occluding effect of Sensodyne with strontium chloride on the exposed dentinal tubules.
3. The SEM photomicrographs revealed that Sensodyne with strontium chloride produced precipitates form in the orifices of dentinal tubules resulting in occlusion or reduction of their lumen.
4. Sensodyne with strontium chloride proved effective in vitro, in the in vivo situation it may employ other mechanism of action that cannot be simulated in this in vitro model.

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