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MANAGEMENT OF ROOT-DENTINE HYPERSENSITIVITY FOLLOWING NON-SURGICAL PERIODONTAL THERAPY: CLINICAL AND SCANNING ELECTRON MICROSCOPIC STUDY

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ABSTRACT

Background: Root- dentine hypersensitivity is one of the most common symptomatic conditions which cause complaints of discomfort in patients. Management of root-dentine hypersensitivity should be based on a correct diagnosis of the condition to differentiate it from the other clinical conditions that are similar in their presenting features as well as on the severity of the condition. Root-dentine hypersensitivity has long been a problem in dentistry and it can occurre as a sequale of non-surgical periodontal therapy. The goal of treatment of root-dentine hypersensitivity ideally should be the restoration of the original impermeability of the dentinal tubules and the relief of root-dentine hypersensitivity experienced by the patient or at least to reduce the level of discomfort to enable the patient's quality of life to be maintained. **Aims:** The purposes of this study were the clinical and scanning electron microscopic evaluation of a unique dual-action dentine desensitizer (D/Sense Crystal) ** for management of root-dentine hypersensitivity following non-surgical periodontal treatment. **Results:** The results of this study showed that D/Sense Crystal has a significant and rapid clinical effect in reducing the root-dentine hypersensitivity. At the same time no side effects, were recorded, neither at teeth level, nor at soft tissue level. **Conclusion:** It was concluded that desensitizing of hypersensitive dentine with D/Sense Crystal is effective and the maintenance of the positive result was more prolonged.

INTRODUCTION

According to Addy and Urquart, (2002), root-dentine hypersensitivity is characterized by 'pain derived from exposed dentine in response to chemical, thermal, mechanical, tactile or osmotic stimuli which cannot be explained as arising from any other dental defect or pathology. A recent modification to this definition has been made to replace the term 'pathology' with the word 'disease' to avoid any confusion with other conditions such as atypical odontalgia. Recently, the term root sensitivity or root-dentine hypersensitivity has been used to describe sensitivity arising from periodontal disease and its treatment. The rationale is that sensitivity following periodontal therapy may be a distinct condition from that of dentine sensitivity occurring after hydrodynamic stimulation (Addy 2002, Gillam & Orchardson, 2006).

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The establishment of healthy periodontal conditions by non-surgical periodontal treatment may result in a number of undesired side effects, such as, the gingival recession that leaves the root surface exposed to the oral environment (Badersten et al. 1984), and the iatrogenic denudation of root – dentine due to removal of the cementum layer by scaling and root planing procedures (Jacobson et al. 1994, Claffey 2004). A large number of dentinal tubules will, thus, be exposed leading to direct avenues to the pulp for bacteria and bacterial elements present in the oral environment (Bergenholtz & Lindhe1978). As a result the patient may experience As a result the patient may experience increased sensitivity of the exposed Dentine is a vital tissue, it is composed of millions of tubules, its diameter at root surface to thermal, tactile, evaporative and osmotic stimuli (Bissada 1994).

Dentine is a vital tissue, it is composed of millions of tubules, its diameter at dentino- enamel junction is 0.06 Um, and 3.0 Um at the pulpal wall, and most of these tubules are filled with fluid, an odontoblast process, collagen, and occasional non-myelinated pulpal nerves. These nerve fibers are in contact with the odontoblasts and act as mechanical receptors that cause pain. (Ten Cat 1998). There are several theories about the cause of dentine sensitivity; the most widely accepted are the hydrodynamic theory, and the ethiopatogenetic theory that is based on the excitability threshold changes of intrapulpal nerve fibers. The hydrodynamic theory was first proposed by Gysi (1900), and he reported that fluid distortion on the cavity floor caused sharp pain. Brannstrom, in (1966,1986 and 1996) demonstrated that dentine sensitivity is the result of rapid fluid movement in the tubule complex, aggravated by aggressive air drying.

Dentine sensitivity can be treated by different ways; first by reducing the dentinal tubules hypoconduction by occluding them; second, by reducing the nerve fibers excitability and by a combination of these two approaches. (Dondi et al. 1994, Tagami et al. 1994, Gillam & Orchardson, 2006). Substances capable of forming a crystalline precipitate that occludes the dentinal tubules are found in solutions and dentifrices or can be applied through ionophorosis as stannous fluoride and strontium chloride (Rees 2000). Potassium nitrate, potassium bicarbonate and potassium chloride are active agents that can reduce nerve excitability (Gangarosa 1994, Gillam & Orchardson, 2006), while the combination treatments as the use of bipotassium oxalate that has an obstructive mechanism and also has a direct action on pain receptors. Also protein denaturing substances such as formaldehyde, glutaraldehyde, zinc chloride, zinc iodide, phenols, concentrated alcoholic solutions and strong or weak acids, act directly on the nerves and cause precipitation of dentinal fluid proteins that can occlude the dentinal tubules (Bruce 2001).

Recently, Lasers have been used to treat dentinal hypersensitivity; Nd: YAG laser can induce occlusion or narrowing the dentinal tubules (Lan and Liu 1996, & 1999 & Yonaga et al.1999) as well as direct nerve analgesia (Whitters et al. 1995). According to Pashley (2000), it may be through the coagulation and precipitation of plasma proteins in dentinal fluid or through alteration of the intradental nerve activity. McCarthy et al. (1997) also suggested that reduction of root-dentine hypersensitivity may be as a result of creating an altered surface layer on the root physically occluding the tubules (smear layer creation), The combination use of Laser irradiation with chemical agents such as sodium fluoride (Liu and Lan 1994) and stannous fluoride (Moritz et al. 1998) can enhance treatment effectiveness by more than 20% over that of laser treatment only (Lan et al. 1999). The use of Laser therapy for dentine sensitivity can cause pulp affection because the laser beam can penetrate deeply through dentine (Zennyu et al. 1996), bone and non-pigmented soft tissues (Dederich, 1993) causing temperature rise exceeding the threshold of pulpal tolerance.

Grossman (1935) and also Gangarosa (1994) suggested a number of requirements for agents used in treatment of dentinal hypersensitivity. Therapy for dentin sensitivity should be, non irritant to the pulp; relatively painless on application; easily carried out, rapid in action; effective for long period and without staining effects, but up to date most of the therapies have failed to satisfy one or more of these criteria, so the purpose of this study was the clinical and scanning electron microscopic evaluation of a one step, dual-action dentin desensitizer (D/Sense Crystal) for management of root-dentine sensitivity following non-surgical periodontal treatment.

MATERIALS AND METHODS

With approval of the Human Ethics Committee at the King Abdulaziz University, the present study was conducted on 52 adult patients with age range from 29-55 (mean 42 years), referred to the department of periodontology, Faculty of Dentistry for periodontal treatment. All patients received non-surgical periodontal therapy. At the reevaluation visit (6 weeks after periodontal therapy), the effects of the non-surgical periodontal therapy on the periodontal status were evaluated. Tests for painful responses were carried out on the buccal surface of each tooth included in the study to evaluate the effect of the non- surgical periodontal therapy on root-dentine sensitivity. The effect of D/ Sense Crystal on pain scoring of the root-dentine sensitivity was evaluated one month and six months post-treatment.

Inclusions criteria of all participations were: Need for non-surgical periodontal treatment, Good oral hygiene following non-surgical periodontal treatment, No open carious lesions No treatment received for periodontal disease in the past three months, No orthodontic treatment in the past three months, No ongoing treatment for dentine hypersensitivity and Patients should not be on medication that could affect the responsiveness of the pulp sensory organ, including analgesics, anti-inflammatory or mind altering drugs.

Clinical Examination

All the patients were subjected to periodontal examination before and after the non-surgical periodontal treatment. Plaque index (PI) of Silness and Loe (1964) Gingival index (GI) of Loe and Silness (1963)Periodontal pocket depth (PD)Gingival recession (GR)Radiographic examination to evaluate the presence or absence of cracked tooth syndrome, fractured or leaking restoration and caries, which display similar symptoms that mimic the pain associated with dentin. All tentative experimental teeth were tested for pulp vitality.

Pain Scoring

Tests for painful responses were carried out on the buccal surface of each tooth included in the study. Dentinal hypersensitivity is characterized by short, sharp pain arising from exposed dentin in response to stimuli typically, evaporative, osmotic or chemical and which cannot be ascribed to any other form of dental defects or pathology. The patients asked where the pain occurs? How much it hurts? How long the pain lasts? In some cases the patients were able to specify which tooth was the problem, but if the sensitive tooth could not be isolated, an air-blast (60psi, 22^{o}C) derived from a dental syringe was directed to the root surface for 1 second. After this stimulation the pain or the discomfort scored according to the modified verbal rating scales (VRS) (Clark and Troullos 1990), which looks like the following: 0 = no discomfort, 1= mild discomfort, 2 = moderate discomfort, 3 = severe or marked discomfort, and 4= agonizing or marked discomfort that lasted more than 10seconds.

Clinical Treatment Technique

A one step, dual-action dentine desensitizer (D/Sense Crystal) (fig.1) was used in this study for

the management of root-dentine hypersensitivity. By using the soft needle applicator, the accurate and direct application of D/Sense Crystal solution to the sensitive root surface was used as a single step technique, because it is in the form of a syringe containing a patented solution of water, potassium binoxalate and nitric acid. It reacts with the smear layer to precipitate micro crystals of calcium oxalate and potassium nitrate (fig.5). These crystals penetrate deeply into the tubules, and seal the entire dentinal surface with a continuous, acid-resistant complex. D/Sense Crystal works best on clean and dry dentine, or may be applied to moist dentine. At room – temperature, the solution of the desensitizer can feel very cold to sensitive dentine. To overcome this problem, the syringe was warmed to body temperature under running warm water for about 10 seconds and this will decrease the pain during application. Gently rub and saturate the dentine surface for 20 seconds. Use a gentile stream of air to dry the surface for 30 seconds up to the formation of a frosty white precipitate. According to the VRS the effect of D/Sense Crystal on pain scoring of the root-dentine sensitivity in all patients was evaluated one month and six months post-treatment.

Scanning Electron Microscopic Study

Ten extracted human permanent molars due to periodontal reasons were used in this study. These teeth had intact clinical crown. Root planing for the teeth was made to remove debris and calculus from the root surface and its trunk. To provide experimental surfaces each tooth was sectioned longitudinal with a water-cold and diamond saw. The anatomical crown was removed 2mm above the cemento-enamel junction and the roots were amputated at the lower end of the root trunk. 10x10mm of buccal surface was prepared and irrigated with 10ml of 17% ethylene diamine tetracetic acid (EDTA), followed by 10ml of 5.25% sodium hypochlorite (NaOcl) to remove the smear layer. The pH of the EDTA was adjusted to 7.5 by addition of NaOH. The specimens were dried, coded, mounted on scanning electron microscopic (SEM) stubs, gold-sputtered and the entire surface evaluated in a scanning electron microscope at a magnification ranging from x16 to x1000. D/Sense Crystal was applied to the dentine surface in one step technique as the same technique used clinically. The effect of D/Sense Crystal on dentine surface was examined and photographed at a magnification ranging from x16 to x1000 by using the scanning electron microscope.

RESULTS

In the present study the dual way of action of D/Sense Crystal was used to treat the root-dentine hypersensitivity in 52 adult patients with age range from 29–55 (mean 42 years). The patients were managed periodontally through the use of non-surgical periodontal treatment (scaling & root planing) to arrest periodontal disease progression and to restore the periodontal health. At the reevaluation time (6 weeks after periodontal therapy) all sites with gingival recession and complained from root-dentine hypersensitivity were managed with D/Sense Crystal. The effects of D/Sense Crystal were evaluated clinically and by using the scanning electron microscope. Table (1) shows the effects of non-surgical periodontal treatment on gingival index (GI), plaque index (PI), pocket depth (PD) and the gingival recession (GR). The GI mean value before the non-surgical treatment was 2.1± 0.422 and reduced to mean value 0.67± 0.297 post treatment. PI mean value in table (1) reduced from 2.6± 0.7 to 1.5± 0.631. PD means value of 4.8± 1.2 reduced to the mean value 2.9± 0.67 by the treatment. Table (1) also shows that there is increase in GR mean value from 2.4± 1.35 to 3.2± 1.05 by the treatment. The statistical analysis by using the paired t test value showed that the non-surgical periodontal treatment produced a statistical significant difference at the

5% level (P<0.05) on GI, PI, PD and the GR. Table (2) shows the changes in pain scoring one month post treatment with D/Sense Crystal to evaluate the effect, of a dual-action dentine desensitizer. Table (2) shows that 48 individuals (92.3%) rated the results as excellent (pain disappearance) and 2 individuals (3.9%) had a meaningful reduction in pain (50% of pain reduction), while only one individual (1.9%) rated the results as poor (pain reduction lesser than 25%). Table (2) also shows that one individual (1.9%) did not respond to the treatment by D/Sense Crystal. Table (2) shows the change in the mean value of pain scoring for all patients was reduced from 2.096± 0.357 (pretreatment) to 0.163± 0.669 (post treatment). Table (3) shows the changes in pain scoring six months post treatment with D/Sense Crystal to evaluate the effect, of a dual-action dentine desensitizer. Table (3) shows that 40 individuals (76.9%) rated the results as excellent (pain disappearance), 6 (11.5%) individuals had a meaningful reduction in pain (50% of pain reduction), 4 individuals (7.7%) showed a poor response and only 2 individuals (3.8%) did not respond to the treatment by D/Sense Crystal. Table (3) also shows that the mean value of pain scoring after six months was reduced from 2.171± 0.439 (pretreatment) to 0.293± 0.831 (post treatment). The paired t test showed that the treatment of root-dentine sensitivity by using D/Sense Crystal results in a statistical significant difference at the 5% level (P < 0.05). Table (4) shows the insignificant changes in pain scoring between one month and six months post treatment with D/Sense Crystal (P > 0.05). The average pain scores for all patients were unchanged and all teeth treated with D/Sense Crystal remained stable over the next 12 months post treatment. The clinical evaluation of D/Sense Crystal showed that there was a fast relief of sensitivity and there was no pain during the application of D/Sense Crystal solution onto the sensitive root-dentine surfaces. The clinical use of D/Sense Crystal did not result in any staining or discoloration of the dentine surfaces. At the same time the clinical study showed that the D/Sense Crystal did not cause any harmful side effects not only on the tooth surfaces but also on the surrounding mucosa. D/Sense Crystal when applied next to the soft tissues or subgingivally (for the hidden recession) did not cause any allergic reaction or soft tissue burns, so D/Sense Crystal is a soft tissue compatible material (Fig.5).

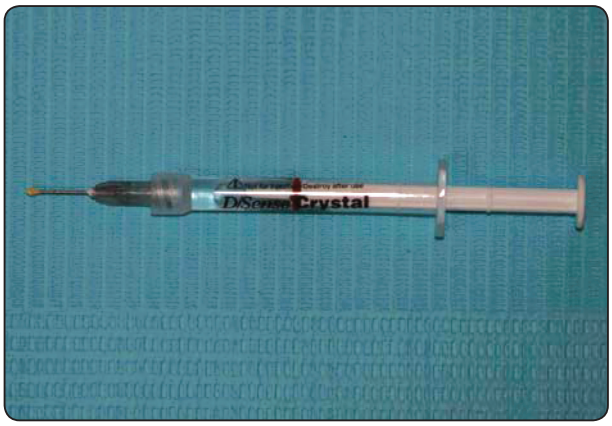

Fig. (1): A syringe with the soft needle tip of a one step, dual-action dentine desensitizer (D/Sense Crystal).

Fig. (2): A syringe with the soft needle tip of a one step, dual-action dentine desensitizer (D/Sense Crystal).

The scanning electron microscope showed that the surface of the specimens were covered with smear layer produced by root planing and in some specimens cracks became clearly visible at x1000 original magnification (Fig. 2). The irrigated specimens with 17% EDTA and 5.25% NaOcl appeared smooth and the dentinal tubules were open and patent (Fig. 3). On the other hand examination of the specimens after application of dual-action dentine desensitizer (D/Sense Crystal) on the exposed dentine surface showed that the formation of a homogenous crystalline layer of insoluble salts that precipitate, seal and occlude the open dentinal tubules (Fig. 4).

TABLE (1) Mean and SD for gingival index (GI), plaque index (PI), pocket depth (PD), and (GR) gingival recession by non- surgical periodontal treatment (pre-post) for 52 patients.

Total no. Of patients / 52	**Pre Treatment**		**Post Treatment**	
	Mean	SD	Mean	SD
GI	2.1	0.422	0.67	0.297
PI	2.6	0.7	1.5	0.631
PD	4.8	1.2	2.9	0.67
GR	2.4	1.35	3.2	1.05

TABLE (2) The effect of D/Sense Crystal on pain scoring on all individuals one month post treatment according to the modified verbal rating scales (VRS).

Patient number	**Excellent " pain disappearance"**	**Meaningful "50% of pain reduction"**	**Poor "pain reduction lesser than 25%"**	**Non responders**	**Pre Treatment**		**One month Post treatment**	
					Mean	**SD**	**Mean**	**SD**
52	48 (92.3%)	2 (3.9%)	1 (1.9%)	1 (1.9%)	2.096	0.357	0.163	0.669

TABLE (3) The effect of D/Sense Crystal on pain scoring on all individuals 6 months post treatment according to the modified verbal rating scales (VRS).

Patient number	**Excellent " pain disappearance"**	**Meaningful "50% of pain reduction"**	**Poor "pain reduction lesser than 25%"**	**Non responders**	**Pre Treatment**		**6 months Post treatment**	
					Mean	**SD**	**Mean**	**SD**
52	40 (76.9%)	6 (11.5%)	4 (7.7%)	2 (3.8%)	2.096	0.357	0.293	0.831

TABLE (4) Comparison between the mean and SD of pain scoring of all individuals at one and 6 months post treatment according to the modified verbal rating scales (VRS).

	Mean	SD
One month	0.163	0.669
Six months	0.293	0.831

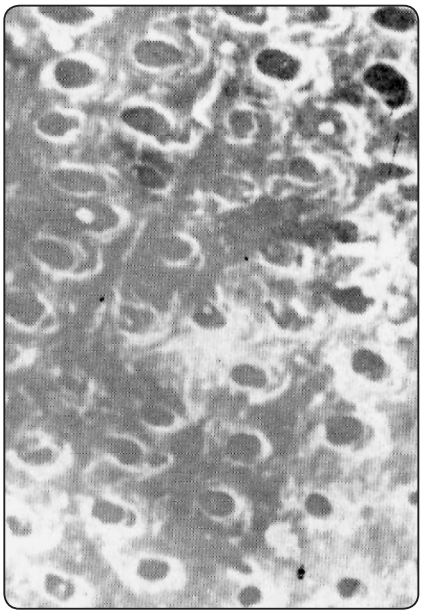

Fig. (3): Root specimen irrigated with EDTA exposing the orifices of the dentinal tubules (X 1000).

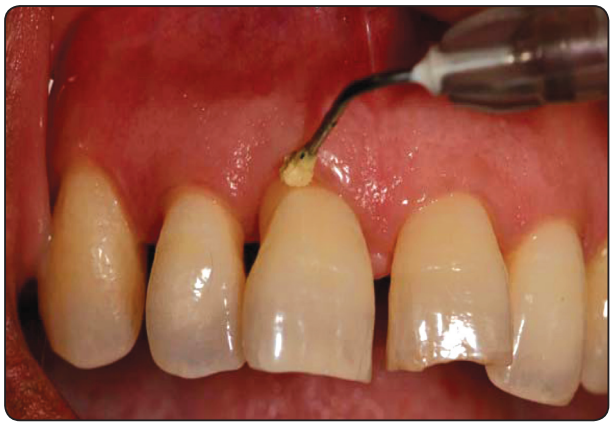

Fig. (5) The syringe with soft needle tip can provide an accurate and direct application of D/SENSE crystal solution to a sensitive root surface of a patient with a previous history of non-surgical periodontal therapy without harming the soft tissue.

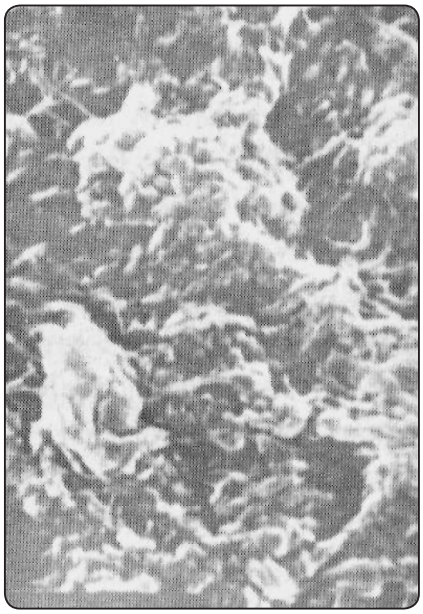

Fig. (4): Root specimen after the application of D/SENSE Crystal showing the homogenous crystalline layer of insoluble salts for tubular occlusion (X 1000).

DISCUSSION

The successful treatment of periodontal disease depends on the effective removal of bacterial deposits from the tooth surfaces. This can be accomplished by thorough daily oral hygiene measures achieved by the patient (Axelsson et al.1991), and by professionally performed mechanical debridement (Ha¨mmerle et al. 1991). Root-dentine sensitivity which is the consequence of the non-surgical periodontal treatment develops one week after treatment, and this iatrogenic sensitivity can be explained by the presence of a smear layer accompanying scaling and root planing. A smear layer is formed when dentine is cut or abraded, over a period of a week, tooth brushing, and normal oral function removes the smear layer exposing the underlying dentinal tubules. Also the acidic environment encouraged by acidic food and drinks has the ability to dissolve the newly created smear layer and this may be the reason why root- dentine hypersensitivity is cyclic in nature (Brannstrom 1996, Niazy et al. 1999& 2000).

Conventional non-surgical periodontal therapy consists of mechanical supra- and subgingival tooth debridement was used in the present study to reduce the bacterial load and to alter the microbial composition towards a flora more associated with health. In turn, these microbiologic changes resulted in significant reduction in plaque and gingival indices with lower levels of inflammation and relative stability in periodontal attachment levels. Probing depths for initially deep sites were significantly reduced by a combination of gingival recession and the improvement of gingival adaptation at the base of the lesion due to the resolution of gingival inflammation. These results of the present study are in agreement with that of Badersten et al. (1984). They studied the amount of improvement that results for combined effects of oral hygiene and supra- and subgingival debridement in patients with advanced periodontal disease. They concluded that, mean plaque scores were reduced to < 20% and mean bleeding scores to < 20% irrespective of the initial pocket depth. Also they found that, pocket depths of sites with initial probing depth around 8 mm, were reduced to an average of about 5 mm due to 2 mm of gingival recession and 1 mm of improved gingival adaptation at the base of the lesion. Also results of this study are in agreement with that of Fogel & Pashley (1993), *and Tammaro* et al. (2000), where they concluded that; non-surgical periodontal therapy induced beneficial changes to the periodontal tissues, as expressed by a reduction of the gingival inflammation, and a reduction of probing pocket depth but over instrumentation can lead to hypersensitivity due to excessive cementum and dentine removal. Also Umeda et al. (2004) and Suvan (2005), concluded that conventional mechanical therapy is a necessary step in periodontal therapy and is relatively effective in suppressing periodontal pathogens, reducing pocket depth and in promoting clinical improvement.

Brannstorm's hydrodynamic theory (1986), described the mechanism of pain production associated with dentine sensitivity. According to the hydrodynamic theory, a stimulus applied at the dentinal surface is transmitted and amplified by fluid flow in the dentinal tubules. This flow if rapid, causes distortion of the pulp tissue at the pulp dentine border where the nerve endings are located, and because of the geometry of the dentinal tubules, the effect of the stimulus becomes more concentrated at the pulpal side of the tubules. So, the hydrodynamic theory explained both the transmission of a stimulus across the dentine to pulpal nerve and the mechanism of the amplification of the stimulus. Any type of stimulus that cause fluid flow in the dentinal tubules results in activation of the pulpal afferent fibers, presumably by mechanical distortion of the nerve endings and this explains why any type of stimulus (chemical or thermal) initiate only a painful sensation (Narhimvo, 1985).There is a further theory that is based on the excitability threshold changes of the intrapulpal nerve fibers, when the threshold is lowered, an increase in the sensitivity to any stimulus will occur at levels that usually do not cause pain. This theory could explain why pain can occur even when there is no dentine sensitivity.

In hypersensitive dentine, most dentinal tubules appeared open when examined by scanning electron microscope (Matsumoto et al. 1982). Scanning electron microscopic examination of exposed dentin revealed eight times more open dentinal tubules in sensitive dentine as compared to non-sensitive dentine. In addition, the diameter of open tubules in sensitive dentine was twice that of non-sensitive dentine (Oyama and Matsumoto 1991).

The management of root-dentine sensitivity can be made mainly through chemical or physical dentinal tubules occlusion in order to block the fluid movement inside the dentinal canals, or through substances able to block the nerve activity

in the dental pulp by altering the excitability of the sensory nerves (Hafez et al. 2000, Niazy et al. 1999 & 2000). Subsequent treatment could be in the form of a more invasive therapy, e.g., restorations, and periodontal grafts. Although in some situations, pulpal extirpation or extraction of the offending tooth may be the treatment of choice (Ong & Strahan 1989). Periodontal grafts and guided tissue regeneration (GTR) procedures have also been described for the treatment of gingival recession with root-dentine hypersensitivity and are predictable procedures and might be the treatment of choice for many patients as they may provide a good esthetic as well as palliative solution to their clinical problem Drisko (2002). Drisko (2002) also suggested that if the root coverage is not completely successful in relieving, root-dentine sensitivity then remaining exposed cervical dentine could be treated with a more invasive restorative material. It is also imperative to avoid placing subgingival restorations whenever possible in order to prevent plaque retention as well as maintaining the biological width when placing crowns Drisko (2002). Several investigators have also advocated the use of a lidocaine 25 mg/g+prilocaine 25 mg/g anesthetic gel in reducing root-dentin sensitivity following periodontal procedures (Magnusson et al. 2003). The use of a postsurgical application of a 6.8% ferric oxalate sealant (Wang et al. 1993) or a 3% potassium oxalate topical application following subgingival scaling and root planing procedures (Pillon et al. 2004) has also been reported to be effective in reducing root-dentine sensitivity. The use of plastic inserts for scaling procedures may also reduce root-dentine sensitivity (Grant et al. 1993).

In the present study, the new and a unique, one step dual-action dentine desensitizer (D/Sense Crystal) was used to treat the root-dentine sensitivity, where its dual way of action based on the precipitation of insoluble salts which close the orifices (mechanical occlusion) and the soluble potassium, which has a depolarizing action on the nerve fibers. D/Sense Crystal is made of a syringated solution, applied in a one step to the dentine surface (one step technique). D/Sense Crystal can be applied to the sensitive tooth surface in one step technique, because it is in the form of a syringe containing a patented solution of water, potassium binoxalate and nitric acid. It reacts with the smear layer to precipitate micro crystals of calcium oxalate and potassium nitrate. These crystals penetrate deeply into the tubules, and seal the entire dentinal surface with a continuous, acid-resistant complex (formation of a frosty white precipitate). D/Sense Crystal works best on clean and dry dentine, or may be applied to moist dentin These insoluble salts produced a crystalline layer on the dentin surface causing a tubular occlusion (fig. 4). In the same time, a soluble and active potassium salt can penetrate deep into the dentinal tubules to provide desensitizing activity by raising the pain threshold and by reducing the nerve fiber excitability. The high extra cellular concentration of the active potassium salts inhibits the nerve cells repolarization and the transmission of the pain impulse (Gangarosa 1994).

The results of the present study are in agreement with that of Kim (1986). He suggested that the active potassium, ion could penetrate through the dentinal tubules to the nerve endings at the dentine pulpal junction. These ions modify the usual exchange of sodium and potassium in the nerve. Kishore et al. (2002) indicated similar clinical findings of the present study where they found that 10% solution of strontium chloride was significantly reduced the dentine hypersensitivity. Crispin (2001) evaluated the effect of a dual-action dentine desensitizer (D/Sense 2) and he concluded that it was effective in eliminating dentine sensitivity. The results of the present study confirm this conclusion where there is a significant reduction of root-dentine sensitivity

by the treatment of D/Sense Crystal. D/Sense Crystal did not cause tooth staining, or pain during application to the sensitive dentine, and it was a soft tissue compatible desensitizing agent, because no harsh compounds as active ingredients of glutaraldehyde and no hydroxyethyl methacrylate (HEMA) or any chemicals that could cause soft tissue irritation, so it can be applied right next to the soft tissues or subgingivally to reduce, root-dentine sensitivity.

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