Effect of Different Desensitizing Toothpastes on Dentinal Tubule Occlusion, Microhardness and Chemical Analysis of the Dentin Surface

Thesis Submitted to Operative Dentistry Department

Faculty of Dentistry, Ain Shams University

for Partial fulfillment of the Requirements for the Doctor's Degree

In Operative Dentistry

By

Hoda Raafat Mohamed Riad

B.D.S, M.Sc, Faculty of Oral and Dental Medicine

Cairo University

2019

Supervisors

Prof. Mokhtar Nagy Ibrahim

Former Dean, Professor of Operative Dentistry, Operative Dentistry Department

Faculty of Dentistry, Ain Shams University

Prof. Hanan Abdel Aziz Niazi

Professor of Operative Dentistry, Operative Dentistry Department

Faculty of Dentistry, Ain Shams University

Prof. Mohammed Hussein Zaazou

Researcher Professor of Operative Dentistry

Restorative and Dental Materials Research Department

Head of Oro-Dental Research Division. National Research Centre

Acknowledgement

I would like to express my deepest gratitude to ***Prof. Dr. Mokhtar Nagy Ibrahim,*** *former Dean of Faculty of Dentistry and Professor of Operative Dentistry, Ain Shams University, for his staunch and relentless support throughout this research. Without his patience, care, advice and great knowledge, this work wouldn't have come to such an end. May Allah have mercy on his soul.*

My most sincere thanks and appreciation are also due to ***Prof. Dr. Hanan Abdel Aziz Niazi,*** *Professor of Operative Dentistry, Faculty of Dentistry, Ain Shams University, for her continuous efforts, help and support throughout this research and during the writing of the thesis. Her hard work and vast knowledge added a lot to my clinical and academic skills*

My appreciation and gratitude are also extended to ***Prof. Dr. Mohammed Hussein Zaazou,*** *Researcher Professor of Operative Dentistry, Restorative and Dental Materials Department, Head of Oro-Dental Research Division, National Research Centre, for his support during this research; without his dedication and wisdom, this study wouldn't have reached such an end.*

I would like to express my deepest gratitude and appreciation to ***Dr. Lamia Mahmoud Moharam,*** *Associate Researcher Professor of Operative Dentistry, Restorative and Dental Materials Department, National Research Centre, whose efforts, support, patience, knowledge and devotion paved the way to complete this study.*

I would like also to thank ***Dr. Alaa Hamed Salama,*** *Associate Researcher Professor, Pharmaceutics Technology Department, National Research Centre, for her help and patience to complete this work.*

And my appreciation is extended to ***Dr. Osama Sayed Mosallam,*** *Researcher of Operative Dentistry, Restorative and Dental Materials Department, National Research Centre, for his contribution to this study.*

Dedication

I have the honor to express my sincerest love and respect to my dear parents, who provided the impetus, motivation for me to achieve this work and bestowed upon me immense love, care, guidance and foresight.

List of Contents

List of Tables

List of Figures

“Dentin hypersensitivity has been defined as short, sharp pain arising from exposed dentin in response to stimuli typically thermal, evaporative, tactile, osmotic or chemical which cannot be ascribed to any other form of dental pathology” [3]. Dentin hypersensitivity is widely prevalent and, therefore, this condition has acquired an important domain in dental research [73].

The “Hydrodynamic theory” explained the etiology of dentin hypersensitivity which implies that the dentinal fluid moves within the dentinal tubules with capillary motion. Since the dentinal tubules are patent on the outer dentin surface in cases of hypersensitive dentin, therefore treatment should be based on tubular sealing; either by their plugging chemically or mechanically or their content alteration [27]. In addition, dentin surface chemical analysis should be performed after the application of the desensitizing agent to identify the chemical structure of the occluded tubule plug and to investigate the change in the mineral content of dentin [57].

Dentin microhardness is defined as the resistance to local deformation, and its tests are based on the induced permanent surface deformation that remains after the elimination of the load. A positive relationship was found between dentin microhardness and calcium content [47]. Moreover, microhardness testing, together with intra-oral models, has great importance in de- and re-mineralization experiments [33].

Many treatments have been advocated for dentin hypersensitivity, among which desensitizing toothpastes are preferred for their convenience and cost-effectiveness. On the market, there are two main types of sensitivity-resistant toothpastes: potassium-containing toothpaste, which has a depolarizing effect on nerve conduction, and toothpastes which block the exposed dentine tubules and interrupt the external stimulation to achieve a desensitizing effect such as; NovaMin

containing toothpaste [35]. Considerable clinical research evidence supports NovaMin, which was developed to help in regenerating bone defects and is basically a calcium sodium phosphosilicate structure. This product was also found to react with the salivary contents and release sodium, calcium and phosphate resulting in hydroxycarbonate apatite deposition over the dentin surface and inside the dentinal tubules aiding in remineraliztion of the tooth structure and, hence, act as a desensitizing agent [6].

Alternative medicine is gaining popularity nowadays, contributing to a safer medical practice. Both Propolis and Moringa are investigated within this domain. *Moringa oleifera* grows mainly in Northern India and recently, it has been cultivated in Egypt. It is called "the miracle tree" referring to the wide variety of medicinal uses and nutritional purposes of almost all its parts. It has antihypertensive, diuretic and cholesterol lowering, hepato-protective, anticancer, antibacterial and antifungal properties. Lately, Moringa showed an antibacterial effect against some oral pathogens [23].

Propolis is produced by honey bees to build and protect their hives. It is a non-toxic natural resin that possesses promising abilities to augment several medicinal purposes; such as antimicrobial, antiviral, antifungal, anti-inflammatory and anticancer activities. In the dental field, Propolis aids in controlling dental caries and promoting the periodontal health. In addition, it is used as a pulp capping agent and a disinfectant for cavities and during endodontic treatment. Recently, Propolis has been investigated for its effect on dentin hypersensitivity [41].

The continuous search for non-invasive treatment modalities for dentin hypersensitivity which maintain their occlusive effect following the daily acidic challenges, promote remineralization and improve the microhardness of dentin did not yield up till now a solid efficient option that can be considered as a gold standard for management of such condition [52]. In addition, the shift to alternative and herbal

medicine as a new trend in dentistry may have an impact on the treatment of dentin hypersensitivity. Therefore, evaluating the variation in dentinal tubule occlusion, the resistance of the possible occlusive effect to citric acid, microhardness and chemical analysis of dentin after treatment with these products may be of value.

Dentin hypersensitivity is one of the most prevalent and challenging disorders in the dental practice. The hydrodynamic theory proposed by **Brannstrom in 1986** [13] attempted to explain the mechanism behind dentin hypersensitivity; suggesting that the dentinal tubule fluid simulates a baroreceptor when the exposed dentin is stimulated. This implies that stimulation generates a neural signal that leads to a painful sensation, in addition, the theory claims that tubules are open between dentin surface which is exposed to the environment and pulp. Accordingly, this condition can be treated by either approach; interrupt the neural signal or block the dentinal tubules by forming a layer on the surface of dentin and within dentinal tubules [10,20].

I-Dentinal tubule occlusion after application of the desensitizing toothpastes and following acid challenge:

I.1.The effect of NovaMin on dentinal tubule occlusion:

Wang, et al. 2010 [69] tested and compared the effect of three commercially available desensitizing dentifrices on dentinal tubule occlusion immediately, following acid challenge and after storage in artificial saliva under simulated pulpal pressure. A total of 100 dentin discs were prepared and divided into five groups (n=20) according to the treatment applied: Group I (Control 1): EDTA-etched specimens without any treatment; Group II (Control 2): brushing with distilled water for two minutes; Group III: brushing with NovaMin for two minutes; Group IV: brushing with Sensodyne Freshmint for two minutes and Group V: brushing with Colgate Sensitive for two minutes. Each group was further divided into two subgroups (n=10) according to the post-treatment applied (6% citric acid challenge of pH 1.5 for one minute or immersion in artificial saliva at 37ºC for 24 hours). SEM was used to investigate dentin morphology. The results demonstrated that; the three desensitizing dentifrices created deposits on the dentin surface. In addition, they

were able to partially recover following the acid challenge. SEM examination revealed that there were toothpaste deposits in the dentinal tubules of NovaMin group, the amount of deposits decreased following the citric acid challenge where the diameter of the dentinal tubules' diameter increased but the toothpaste crystals were still found on the dentin surface and inside the tubules. The authors concluded that; NovaMin toothpaste demonstrated an excellent occlusion efficacy following brushing and storage in artificial saliva while Sensodyne Freshment toothpaste revealed the strongest acid resistant ability.

Parkinson and Wilson, 2011 [(54)] investigated the level of dentinal tubule occlusion and dentin mineralization of NovaMin containing dentifrice and compared it with different commercially available desensitizing dentifrices in an in vitro four-day trial. Two different parameters were investigated in this study; dentinal tubule occlusion and dentin surface microhardness. The extent of dentinal tubule occlusion and the subsequent effect of an acid challenge for eight treatment groups (calcium sodium phosphosilicate (45S5); strontium acetate; arginine/calcium carbonate; amine fluoride; calcium sulphate/diphosphate; stannous fluoride; casein stabilized amorphous calcium phosphate toothpaste; and a negative control, deionized water) were assessed using SEM. On the other hand, the change in surface microhardness of four treatment groups (calcium sodium phosphosilicate/1450 ppm fluoride dentifrice; arginine/ calcium carbonate/1450 ppm fluoride dentifrice; amine fluoride/1400 ppm fluoride dentifrice; and a control surface consisting of a dentin specimen coated with a varnish) was evaluated using Knoop diamond indenter. For both tests, bovine dentin specimens and followed the same four-day brushing routine and twice daily acid challenge with grapefruit juice on days 3 and 4. The results demonstrated that; NovaMin and stannous fluoride dentifrices showed the highest level of dentinal tubule occlusion. Moreover, NovaMin dentifrice demonstrated a resistance to the acid challenge. Furthermore, NovaMin dentifrice exhibited a