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ASSESSMENT OF THE EFFECT OF PREHEATING ON THE VISCOSITY OF RESIN SEALANTS

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ABSTRACT

Pits and fissures sealants should have a high degree of viscosity and wettability, which would allow deep penetration of the material into the highly retentive occlusal surface of premolars and molars of children. Usually, the viscosity of liquids decreases with increasing temperature. Therefore, this study **aim**s to assess the influence of temperature on resin sealant viscosity. **Material and methods:** The viscosity of the resin sealant Grandio seal (VOCO) was determined with a rotary viscometer. The material was heated using a composite heating furnace. The viscosity of Grandio Seal resin sealant was measured at three temperature values: at room temperature of 21.5°C (1st group), heating to 41.0°C (2nd group), and heating to 51.0°C (3rd group). **Results:** With an increase in the number of revolutions per minute, respectively the speed of the viscometer, a decrease in the material's viscosity was reported. An increase in temperature led to a decrease in the material's viscosity. The lowest viscosity was measured at 51ºC. **Conclusion:** By heating the resin sealant the material's viscosity was significantly reduced, potentially leading to better sealant penetration in the pits and fissures system and retention.

KEYWORDS: resin sealants, viscosity, heating, pits and fissures.

INTRODUCTION

The occlusal surfaces of permanent children's teeth immediately after eruption are the riskiest localization for the development of carious lesions [1]. One of the main reasons for this is their complex occlusal morphology [1]. The typical occlusal surface is highly retentive [2]. The enamel in the deepest areas is thin to absent with small rods and tiny crystals that form highly retentive areas with various shapes [3]. These are the areas with the lowest mineralization immediately after the eruption of the teeth and require early placement of sealants [4].

Pits and fissure sealants are considered an effective measure for preventing and controlling occlusal caries, as they act as a mechanical barrier and prevent the accumulation of dental biofilm [5, 6]. Other advantages are that they are easy to work with, cheap, and prevent the need for more expensive and invasive restorative treatment [7]. Adequate use of pit and fissure sealants prevents 71% of occlusal caries. At the same time, its incorrect application can lead to microleakage, damage over time, partial loss of the sealant, and the initiation of a carious lesion underneath it [8, 9].

An ideal sealant material should have biocompatibility, durability, and should be affordable and easy to use [10]. Regarding the physico-chemical characteristics of the sealant, it should have a high degree of viscosity and wettability, which would allow deep penetration of the material into the highly retentive and complex pits and fissures on the occlusal surface of premolars and molars [11]. The deeper the sealant penetrates, the better its mechanical retention and effectiveness because the contact area of the material and tooth surface will be greater [10]. Resin-based materials have traditionally been used as sealants for occlusal surfaces [11]. These materials generally maintain a low viscosity, thus facilitating deeper penetration into all areas of the occlusal surface [12, 13]. Several factors can affect the viscosity of fluid materials, such as temperature, pressure, filler size, and others [14]. Generally, the viscosity of liquids decreases with increasing temperature [14]. Therefore, the aim of this study was to assess the effect of preheating on the resin sealant viscosity.

MATERIAL AND METHODS

Determination of the viscosity of the resin sealant was performed with a Myr Rotary Viscometer series VR3000 - Figure 1 (Viscotech Hispania, SL, El Vendrell, Spain). The device works on a rotary principle. It has an adapter (vessel) for 8-13 ml small volumes. Special spindles with a diameter of F8 were made, and the obtained dependencies were a function of the number of revolutions per minute (Revolutions Per Minute - rpm), not of the actual rate of shear deformation of the adjacent frictional fluid layers. The study was conducted with revolutions between 12 and 200 (12, 20, 30, 50, 60, 100, 200) and a duration of up to 180 seconds. The relationship between the number of revolutions and the change in viscosity was monitored. The results report the rotation speed at which the viscosity reached dynamic equilibrium in the time interval of 180 seconds. For each operating mode, ten control measurements were carried out.

***Figure 1**. (Viscometer Myr VR 3000; additionally, manufactured spindles; determination of viscosity under standard conditions in a foil-insulated vessel.)*

The material was heated using a composite heater (AzDent Dental Composite Resin Heater, Henan Baistra Industries Corp., ZHENGZHOU, China), which has three operating modes – 41.0°C, 51.0°C, and 71.0°C. The device has several compartments where up to 8 syringes can be heated simultaneously. A light indicator reflects the temperature reached. After switching it on, the required time to reach the desired temperature was 15 min, and the required time to heat the material was 30 min. Before the beginning of the experiment, the heater was fixed suitably so that its displacement could not occur in the spindles' rotation process. To ensure a constant temperature of the heated material, its viscosity measurements were performed in a syringe lined with an insulating film and placed in one of the heater compartments after reaching the required temperature (Figure 2).

Figure 2. *(Device for heating composite materials. Fixation of the syringe in the heating device.)*

The viscosity of Grandio Seal (VOCO, Cuxhaven, Germany) resin sealant was measured at three temperature values:

- First group – measurement of material viscosity at room temperature of 21.5°C with air conditioner;
- Second group – measurement of the viscosity of the material after heating to 41.0°C with composite heater;
- Third group – measurement of the viscosity of the material after heating to 51.0°C with composite heater.

Statistical methods: Spearman's correlation coefficient was introduced for data processing. The coefficient was determined for two consecutive measurements under the same conditions.

RESULTS

Diagram 1 shows the relationship between the number of revolutions of the viscometer and the change in viscosity of the Grandio Seal composite sealant.

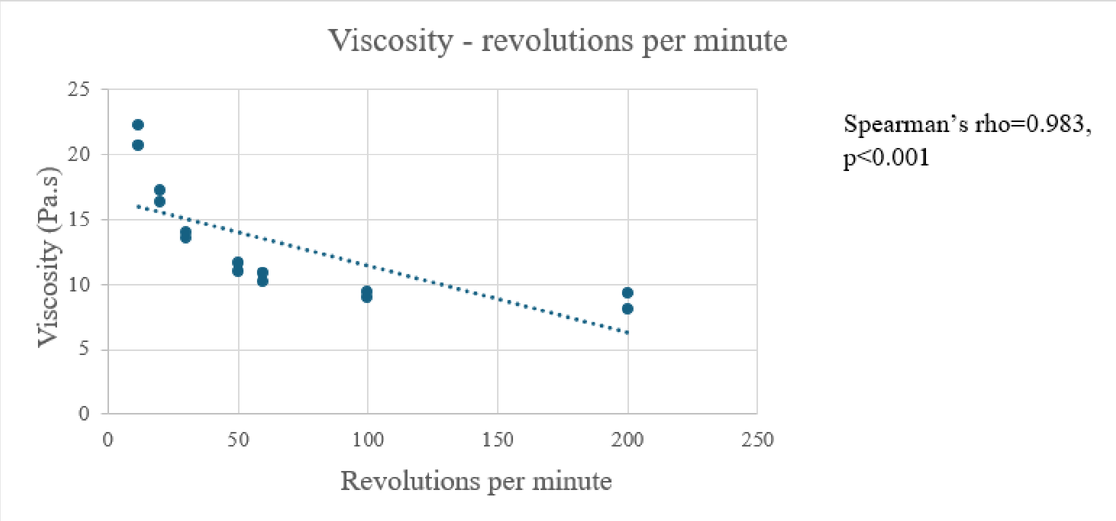

Diagram 1. *(Diagram demonstrating the relationship between the revolutions of the viscosimeter and the change in the viscosity of the material.)*

The results show a statistically significant relationship with a correlation coefficient of 0.983. With an increase in the number of revolutions per minute, respectively the speed of the viscometer, a decrease in the viscosity of the material was observed. An inverse relationship between the variable indicators was established, and the data were statistically significant ($p<0.05$, Diagram 1). The observed differences in viscosity, resulting from the change in velocity, are explained by the different degrees of difficulty in restructuring between adjacent sliding layers.

The study of the resin sealant's viscosity was carried out at three temperature environments: 21.5, 41.0, and 51.0 °C. The measurements were performed in the entire possible deformation range of the viscometer. Diagram 2 shows the dependence of viscosity on the change in temperature and the speed of rotation of the viscometer's spindle.

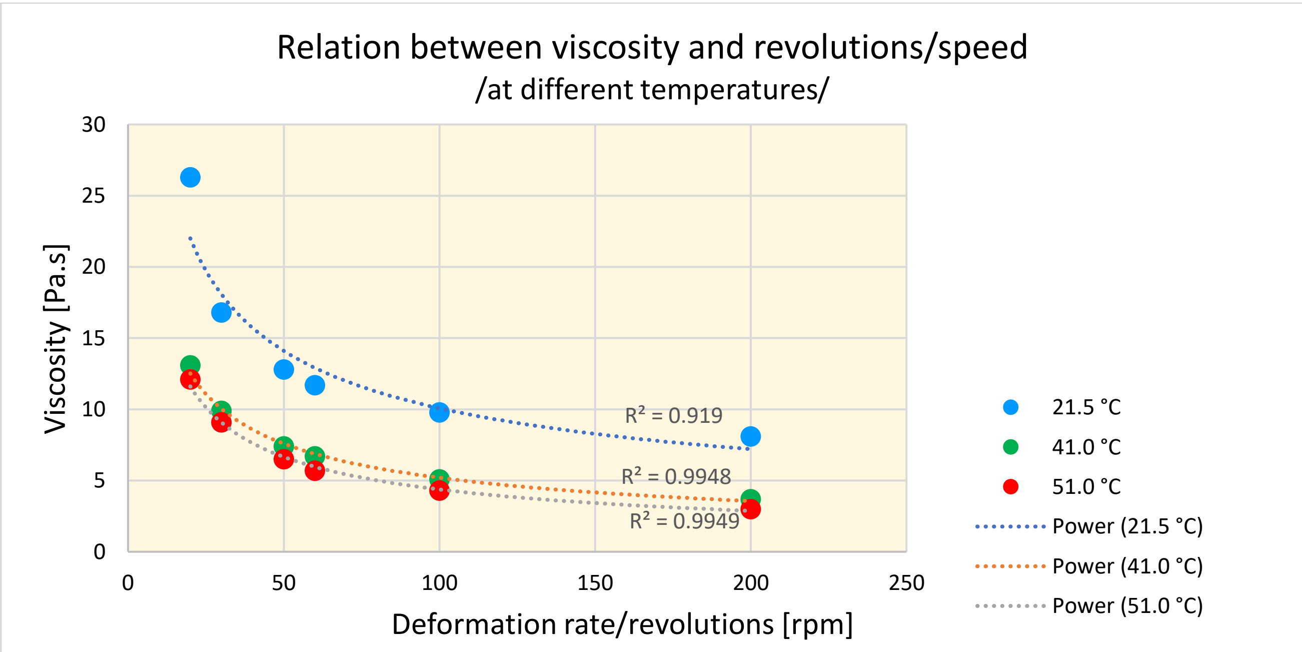

Diagram 2. *(Dependence of viscosity on the viscometer's rotation speed at different temperatures.)*

The viscosity change interval monotonically decreased with increasing of the temperature, as there is an inverse relationship between the two quantities. The decrease in viscosity was significant - 8.1 Pa.s at 21.5 ºC versus 3.0 Pa.s at 51.0 ºC, and the differences between individual groups were statistically significant ($p<0.05$, Diagram 2).

Discussion:

Several studies have shown a strong relationship between sealant application and caries reduction [7, 15]. The effectiveness of a sealant and its preservation over a long period is directly dependent on its viscosity since the retention of resin sealants occurs through the micromechanical bonding of the resin and the enamel [10]. The present study analyzed the viscosity of Grandio Seal highly filled nano-hybrid pit and fissure sealant and evaluated the effect of temperature changes on it. Several studies have evaluated different sealant mechanical properties [16, 17]. However, we are unaware of any in vitro evaluation of the effect of sealant heating on its viscosity.

Grandio Seal resin sealant is a nano-hybrid material with high density and wear resistance due to its high hardness [18]. These qualities increase the adhesion and retention of the material [15]. Several studies have shown that the material exhibits better mechanical properties, such as hardness and wear resistance, compared to similar products [16, 17]. Nano-filled and nano-hybrid resin sealants can be used as an alternative to other pit and fissure filling materials [17]. Our research showed that its viscosity decreased significantly when this material was heated to 41ºC or 51ºC before usage, and this would contribute to better penetration into pit and fissure system, thus, its longer retention on the molars occlusal surfaces. The better the flowability of a sealant, the less likely it is to form voids during its application [19]. The better the material can infiltrate and fill the microroughness in the enamel after etching, the stronger the micromechanical adhesion.

Dental filling materials are often preheated by placing the resin syringe in a particular device [20]. A few heating devices are available on the market, such as ENA Heat, Calset, AzDent, and others [21]. These devices are often used to increase the adaptation of the resin material to the tooth surface [22]. In addition, preheating reduces the viscosity, increases the degree of conversion and microhardness of composite resins, and improves the marginal adaptation of the material [23]. Preheating composite resins can assist clinicians in creating longer-lasting resin restorations. This is very important, especially in childhood [20].

Conclusion: Preheating of the resin sealant with composite heater reduced significantly the material's viscosity, improving sealant penetration into the pit and fissure system.

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