

WETTABILITY AND HYDROPHILICITY OF VINYL POLYSILOXANE IMPRESSION MATERIAL

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ABSTRACT

Dimensional steadiness and exactness of vinyl polysiloxane (VPS) elastomeric impression materials have resulted into their wide spread usage in restorative dentistry. They are excessively popular because of their best elastic recovery, no by-product during polymerization, allowing second pour, applauding handling attributes, clean, odorless and being tasteless. However, they are significantly hydrophobic in nature and a minimal surface energy which renders them intractable to moisten with gypsum slurries. Therefore, surfactants are incorporated to improve wetting and reduce hydrophobicity. This narrative review highlights the research done on refinement of wettability and reduced hydrophobicity of the VPS impression material.

Key Words: Dental Impression Materials, Hydrophilicity, Vinyl Polysiloxane Polymer, Wettability

INTRODUCTION

Impression materials are utilized to imprint the teeth and adjacent structures to reproduce an accurate duplication. American dental association, specification number 19 stipulates that 20µm or less reproduction details by an impression material are considered acceptable.¹ Casted study models are used for preparing dentures, inlays, bridges, crowns, prosthetic rehabilitation of intra-oral and extra-oral defects.²

Dimensional stability and precision of elastomeric impression material have resulted into their wide spread use in restorative dentistry.³ Vinyl polysiloxane (VPS) also known as addition reaction silicon were first introduced in 1970.⁴ Although it is very expensive but are excessively popular because of their best elastic recovery, no by-product during polymerization, allows second pour, applauding handling attributes, clean, odorless and are tasteless.⁵⁻⁷

Alongside the advantages as highlighted above, there are certain disadvantages of VPS. It is significantly hydrophobic in nature and a minimal surface energy which renders them intractable to moisten with gypsum slurries. It is also prone to meager wetting of moist oral tissues.⁸ The chemical structure of VPS contains siloxane bond enveloped by hydrophobic and aliphatic hydrocarbon groups which is the prime cause of hydrophobicity.⁹ Additionally, entrapment of air bubble during pouring is another drawback. It causes pits and voids formation.⁷

The modus operandi used to improve wetting and reduce hydrophobicity is done through incorporation

of surfactants. It has been established through studies that the higher the concentration of surfactants, the lower the contact angle which goes to improve the voids in dental dies and casts and hence are easier to pour. It has also been observed that greater contact angles produced more voids in the casts.¹⁰⁻¹³

The narrative review aims to outline the research done on refinement of wettability and reduced hydrophobicity of the VPS impression material, the effect of addition of surfactants, the outcome of surface tension and the use of radio frequency glow discharge (plasma treatment) and the result of disinfectant on the hydrophilicity and wettability of the material.

METHODOLOGY

A comprehensive electronic search was done on PubMed, Google Scholar, Science Direct and Scopus from 2010 to 2018. The following search format was used incorporating the Boolean operators: "Vinyl polysiloxane" or "addition silicones" or "Vinyl polysiloxane" and "wettability" or "Vinyl polysiloxane" and "hydrophobicity" or "dental impression materials" and "wettability" or "dental impression materials" and "hydrophobicity". Bibliographies of all relevant articles were also searched for pertinent articles.

All articles related to improving the wettability of VPS were selected including in vitro studies, comparative studies and review articles. Only articles available in English language were selected. Clinical trials involving humans, animal studies and human case reports were excluded. A total of 25 articles were thoroughly appraised for the narrative review. No statistical analysis was performed. Figure 1 depicts the entire process of identification and selection of relevant studies.

LITERATURE REVIEW

EFFECT OF STRUCTURE of VPS

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It has been determined through few studies that hydrophobicity of the VPS is caused by the chemical structure of the material. It contains siloxane bond encased in hydrophobic and aliphatic hydrocarbon groups. As opposed to VPS, polyether impression material due to its functional groups is highly hydrophilic. Carbonyl (C = O) and ether (C-O-C) present in the material attracts and interacts with water.¹⁴

WETTING

Wetting is a relationship of attraction of a liquid for a solid. The level of wettability is determined by a force balance between cohesive and adhesive forces. Pits and voids in casts and entrapment of air bubbles are dependent on wettability.³ Determination of wettability is estimated by contact angles of drops from gypsum poured onto the impression material.¹¹ High angles (greater than 90 degree) display imperfect wetting whereas zero-degree angle specifies excellent wetting.^{10, 15} Conventional VPS has poor wetting, but the integration of surfactants and few advanced techniques like radio frequency glow discharge has made the VPS more acceptable for use.

EFFECT OF SURFACE TENSION AND SURFACE ENERGY

Surface tension is the characteristic of the surface of a liquid that permits it to withstand an external force.³ The adhesive forces between molecules cause this phenomenon to occur which is called as surface tension. Low surface energy is another mess with the addition reaction silicon. High surface energy accounts for hydrophilicity of the material whereas low surface energy makes it more hydrophobic. Surface energy values of silicones were measured to be twice as less as that of polyether components. This phenomenon clearly relates to the chemical structure of the materials. The chemical structure of VPS contains siloxane bond enveloped by hydrophobic and aliphatic hydrocarbon groups whereas the polar carbonyl and ether groups rendered polyethers high in surface energy. This makes polyether material more hydrophilic than VPS.^{5, 16}

ADDITION OF SURFACTANTS

Surfactants are admixture that lessens surface tension between a liquid and a solid or between two liquids. Surfactants were added to VPS to overcome the hydrophobicity of the material.¹⁷ Entrapment of air bubble causes pits and voids in the die stone cast, these voids greatly degrade the restorative material to an extent of being unacceptable for use. Elastomeric impressions in which nonionic surfactants were incorporated resulted in increased wettability and hence improvement in air entrapment during pouring.¹⁵

Nonylphenoxy poly (ethyleneoxy) ethanol homologs surfactants were added in a specific study, which showed that the more the concentration of surfactants the lesser the contact angle and resultantly increased

hydrophilicity.¹⁸ Topical surfactant is another type of surfactant introduced lately to address wetting issues. Before an impression is drawn it is sprayed on the teeth as well as on the models and dies before pouring.¹⁹

RADIOFREQUENCY GLOW DISCHARGE

Radiofrequency glow discharge or plasma treatment is another highly recommended technique to enhance wettability of VP. The glow discharge process generates active species which abolish contaminants of low molecular weight during collision with the trial surface. These contaminants are incorporated through inappropriate handling and environmental factors which are liable to reduce the surface energy. Hence, their carrying away causes an increase in surface energy. Improvement in castability of an impression material after plasma treatment was noticed.²⁰

Contact angles before and after plasma treatment of different brands of addition silicones, polyethers and condensation silicones have also been compared.²¹ The contact angles were noted on the surfaces covered with saliva. Statistical differences were obtained and there was a general scaling down in the magnitude of the angles which eventually made the material more hydrophilic. It is also revealed that plasma treatment has good effect on the wettability of VPS whereas it did not have the desired effects on polyether impression materials.^{20,22}

EXPOSURE TO DISINFECTANT

Disinfection is a process whereby the chemistry of the material is modified. It may affect the hydrophilicity of the material, making it less or more wettable. Disinfection entails two types of techniques; the material may be sprayed upon or totally immersed in the solution. Although spray technique is considered more effective, yet there is more popularity of immersion method.²³

It has been established through study that short term disinfection can also reorient the wettability on either negative or positive side. Similarly, if the material is subjected to longer duration of immersion this may also restyle the chemical composition or characteristics of the material, thus affecting the wettability.²⁴

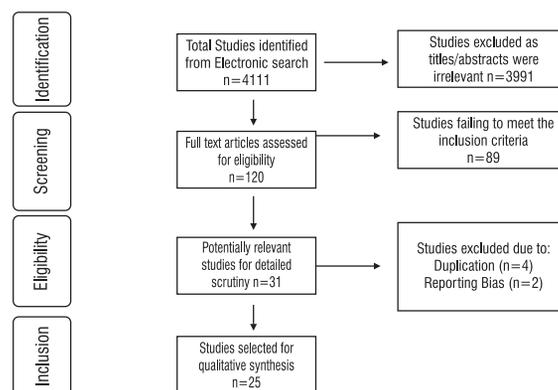


Fig 1: Protocol for selection, screening and inclusion of studies for narrative review

In a study conducted by John S. Blalock,²⁵ different hypothesis were applied in disinfecting VPS impression materials. First hypothesis suggests increased duration of contact with disinfectant (hypochlorite-based) leading to high contact angle making the impression material less wettable. Second hypothesis states that prolong exposure to disinfectant results in dissolution of surfactants and hence increased contact angle thereby making it free of any beneficial wetting characteristics. Third hypothesis mentions that no significant change was noticed in the contact angle of surfactant free VPS material in the varying exposure to disinfectant. As a result this led to the acceptance of this hypothesis.²⁵

CONCLUSION

Conventional VPS is fraught with drawbacks like increased voids and higher contact angles. The new VPS material so introduced overcomes the said weaknesses. Vinyl polysiloxane impression material because of their excellent attributes has displayed greater acceptability amongst the users and can be handled without much hassle. The incorporation of surfactants can enhance wettability of VPS impression material, however further detailed study is required to find out the effects of surfactants on gypsum. Reduced contact angle helps in the improvement of wettability of VPS materials, therefore, efforts should be made to find ways and means to further reduce the contact angles. Encouraging results of plasma treatment on wettability of VPS have been noticed. However, further studies should be carried out to bring out its effects on the type of gas, level of pressure and time duration on the surface properties of the material. Disinfectant should be applied to VPS for a specified time only to have desired wettability factor. Due care should be exercised for exposure of VPS material to disinfectant. This should not exceed the recommended time for better intended results as with increased exposure to disinfectant the contact angle of VPS increases.

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| 2 Moiza Ijaz: | Data Collection + writing. |
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| 4 Ayesha Aslam: | Critical Revision. |