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Various Methods of Surface Pre-treatment on the Denture Base Acrylic Resin to Improve its Bond Strength to the Soft Liner

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ABSTRACT

Successful construction of the denture using two different types of materials relies partly on a satisfactory bond between the materials. The most common reason for failure of a soft-lined denture was the failure of "adhesion" between the liner and denture base. To improve the bond between a soft liner and a denture base material, various surface pretreatments for the denture base acrylic have been studied and used. They may be categorized into mechanical, chemical, mechano-chemical and plasma treatment. A detailed review of these existing surfaces pretreatment is lacking in the literature.

INTRODUCTION

A well-formed alveolar ridge is a primary requisite for conventional complete denture fabrication. In view of the increasing expectancy of life, old aged individuals will be compelled to wear complete dentures for a longer period of time, which may jeopardize the ridge form [1]. Protection of ridges from the onslaught of masticatory forces has thus become increasingly relevant [2]. To protect the edentulous ridges, a resilient denture liner is an intelligent option adopted by the prosthodontist [3-5]. A resilient denture liner can be defined as an elastic or viscoelastic material applied to the fitting surface of denture [6,7]. These lining materials can be applied temporarily or permanently to the tissue surface of denture base. Two most important properties resilient liners should have are resiliency and maintenance of adhesion to the denture base. Soft lining materials have been shown to improve the retention in atrophic flat ridges with inadequate vestibular depth and also reduce the traumatic impact to the residual alveolar ridges by distributing masticatory load. The soft liner can act as a shock absorber and is expected to bond well to the denture base [8-10]. The importance of the bond strength was recognized when Wright H concluded that the most common reason for failure of a soft-lined denture was the failure of "adhesion" between the liner and denture base [11,12].

LITERATURE REVIEW

To overcome the issue of poor bond strength, researchers have considered modifying the acrylic resin surface before applying soft liner. The bonding characteristics have been evaluated by various test methods. Three widely accepted methods for testing adhesion of soft liners to denture base resins are peel, lap-shear and tensile testing [13-16]. The tensile test method was described by American Society for Testing and Materials (ASTM) and is preferred [17]. Several surface modification methods eg. Mechanical roughening, chemical treatment, mechano-chemical treatment etc. have been investigated [18-21].

Surface Pre-treatments

Various denture base surface pre-treatments used in various studies are given below:

Chemical: Dichloromethane for 5 seconds,

Ethyl acetate for 120 seconds,

Methyl methacrylate for 180 seconds,

Methylene chloride for 15 seconds,

Mechanical: Sandblasting using alumina.

Lasers - ER:YAG, CO2, etc.

Mechano-chemical: Sandblasting followed by chemical treatment.

Plasma treatment: Oxygen, argon, nitrogen etc.

Mechanical

Sandblasting has been used to alter the surface of the denture base resin with the intention of providing increased surface area and mechanical locks. The procedure involves spraying a stream of aluminium oxide particles under high pressure against the material surface intended for bonding. This abrasive process removes loose contaminated layers and creates roughened surface that provides some degree of mechanical interlocking or "keying" with the adhesive [22].

Craig and Gibbons reported that the adhesive values obtained with the roughened surface were approximately double those of the smooth surface [14]. Store sandblasted the acrylic resin surface before placing a resilient lining material and concluded that a slightly irregular surface provided mechanical locking for the soft material, thereby increasing the strength of the bond [23].

On the contrary, Amin and Jacobsen NL reported that roughening the acrylic resin base by sandblasting before applying soft liner had a weakening effect on the bond [18,24]. In addition, Usumez reported that sandblasting of the denture base resin before resilient-material application resulted in higher mean tensile bond strengths than those of control specimens, but these increases were not statistically significant [25].

Poor bond strengths can be due to stresses that occurred at the interface of the denture base resin and soft liner. Another possibility may be that the size of irregularities created by the sandblasting medium may be insufficient to allow flow of the resilient lining material into them [26]. Akin in 2011 studied the effect of sandblasting with different size of aluminum oxide particles on tensile bond strength of resilient liner to denture base and concluded that different sizes of alumina particles affected the strength of the bond. Thus using sandblasting as a means to improve the bonding between the denture base resin and the soft lining material needs more research by using different sizes of alumina particles.

Chemical

Pretreatment of the acrylic denture base using various chemicals such as ethyl acetate, methyl methacrylate, methylene chloride, dichloromethane has been studied. The use of methyl methacrylate monomer for 180 seconds was found to be very effective in increasing the tensile bond strength. However, chemical treatment might result in partial dissolution of the denture base resin, thereby resulting in fracture of the latter during clinical service [27]. Sarac 2005 showed that the shear bond strength of the repair material to all denture base resin materials tested was increased with chemical treatments using acetone, methylene chloride and methyl methacrylate [28].

Surface preparation with dichloromethane causes the surface to swell and permits diffusion of the polymerizable material. Such preparation can create surface pores approximately 1 mm in diameter on acrylic resin teeth or on acrylic denture base resin. Therefore, the application of dichloromethane is beneficial for the surface structure of denture teeth prior to denture base processing or on the denture base resin prior to repair. However, dichloromethane is currently not recommended for use in dental practice owing to its carcinogenic effect. Shimizu in 2006 concluded that the 120 seconds application of ethyl acetate yielded the highest bond strength by causing the surface to swell, thus permitting diffusion of the denture base resin [29]. Kulkarni in 2011 conducted a study to evaluate the effect of denture base surface pre-treatments on bond strengths of two long term resilient liners. He concluded that surface treatment of the acrylic resin with monomer prior to resilient liner application is an effective method to increase bond strength between the denture base and soft liner [30].

It can be noted that the use of chemicals for surface modification of the acrylic resin has delivered better results, although the chemicals chosen and the time duration in contact has to be given importance.

Plasma

Plasma is a gaseous mixture of electrons, free radicals, ions and excited molecular states which are created by inelastic collisions between high energy electrons and ground state atoms or molecules. Surface plasma treatment of polymer surfaces has been shown to be a viable method to enhance the adhesion properties without altering the bulk characteristics. Plasma irradiation raises the wettability and can make the surface washed, degreased, uneven and activated simultaneously. Recent studies even indicated that plasma treatment could increase the bond strength between heat-cured and self-curing acrylic resins [31]. However, surface-modified polymers often exhibit time-dependent properties making the treatment less effective. In particular, a process called "aging" partially restores the original hydrophobic surface. In addition, it must be taken into consideration the presence of many suspended particles and volatile organic compounds in trace quantities in the air, which meant that the air exposure of the oxygen plasma-treated specimens caused them to be unavoidably contaminated. Consequently, the concentration of oxygen-containing groups on the treated surfaces decreased after two days exposure to air, thereby accounting for the decrease in bond strength for the two-day exposure group. In light of the time-dependent characteristics of plasma-treated surfaces, a plasma-treated surface should therefore be bonded soon after surface modification treatment in order to obtain optimal bond strength between the treated denture base resin surface and soft liner. Also, plasma oxygen treatment is mainly used for industrial purposes hence its use in dentistry is limited.

Laser

Laser has been shown to be relatively safe and easy means of altering the surface of the materials. Since development of the ruby laser by Maiman in 1960, lasers have become widely used in medicine and dentistry. They can offer the user not only a high degree of process controllability, but also a great deal of process flexibility. Various lasers used for this purpose are: CO2 laser, neodymium:yttrium-aluminum-garnet (Nd:YAG) laser, potassium titanyl phosphate (KTP) laser, Erbium:yttrium-aluminum-garnet (Er:YAG) laser.

The impact of high energy of the laser causes instant vaporization of water with massive volumetric expansion. This expansion causes the surrounding material to ablate, increasing the surface area. Soft liners penetrate in these irregularities or pits produced by the lasers.

The system comes with an air/water spray and has a dual role: to support the cutting and to serve as a coolant to preserve the surface temperature to prevent the acrylic surface from overheating. Jacobsen et al. reported that surface treatment with a CO2 laser was ineffective in reducing adhesive failure of soft-lined prostheses in a clinical situation. Usumez found that using a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser increased the surface roughness of denture base materials and that Nd:YAG laser-treated specimens had higher bond strength values compared with the control group specimens, although the difference was not statistically significant. However, Akin reported that altering the PMMA surface with an Er:YAG laser increased the bond strength but that Nd:YAG and potassium titanyl phosphate lasers were ineffective. In addition, Tugut reported that the Er:YAG laser treatment of the PMMA surface before the application of the resilient lining material increased tensile bond strength [32]. On the contrary, the study conducted by Gundogdu studied the effect of different surface treatments on the bond strength of two different resilient lining materials to an acrylic resin denture base and found no significant differences between the control and laser groups [33].

DISCUSSION

Er:YAG lasers are solid state lasers whose lasing medium is erbium-doped yttrium aluminium garnet (Er:Y3Al5O12). They typically emit infrared light with a wavelength of 2940 nm. Er:YAG laser has shown to provide better bond strength in comparison to other lasers such as CO2, KTP, Nd:YAG. This finding was further studied by Tugut exclusively using Er:YAG laser at different pulse durations and energy levels. He concluded that the 300 mJ, 3 W, long pulse duration laser treatment produced the highest mean tensile bond strength. It was also observed that the highest laser energy level (400 mJ, 4 W) damaged the adhesive surface and resulted in large cavities instead of small pits.

Sheikh SA in a study comparing plasma and Er:YAG surface treatment to improve the bond strength between soft liner and denture base resin, concluded that Er:YAG surface treatment to be appropriate than plasma treatment considering the clinical feasibility and cost effectiveness [34].

Various lasers are available at our disposal for use, intelligent choice of the type of laser along with much importance to the pulse durations and energy levels have to be put into use for obtaining better bond strength between the acrylic denture base resin and the soft lining material.

CONCLUSION

- Numerous studies have been conducted using various surface pre-treatments to the denture base acrylic resin to improve the bond strength between the soft liner material and the denture base acrylic resin. To choose a particular method is dependent on the clinicians' choice, availability and the cost effectiveness based on the clinical scenario requiring the pre-treatment. Evidence based pre-treatment is preferable which will require systematic reviews and/or meta-analysis.

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