Current trends in reducing microbial adhesion to acrylic denture base resins

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ABSTRACT

Many novel techniques and products have been used to prevent and reduce microbial adhesion to denture resins. The formation of dental plaque by adhesion of microorganisms on acrylic resin denture surfaces is the primary cause of several oral diseases such as radicular decay and oral stomatitis.¹ Acrylic polymethyl methacrylate resins (PMMA) was one of the first materials used for provisional crown and bridge restorations. To form the polymer, PMMA prepolymerized fine particles are mixed with a liquid monomer resulting in chains of polymer. PMMA provisional materials are susceptible to bacterial adhesion and colonization when compared to materials used for final restorations due to the increased surface roughness and possible inferior fit provided by the temporary restoration.² This is especially true when these temporary restorations are unexpectedly worn for long periods of time.

Provisional restorations have diagnostic and preprosthetic functions such as correcting irregular occlusal planes, reestablishing vertical dimension, and molding the contours of the gingiva.³ Provisional prosthetic restorations prevent leakage into dentinal tubules by covering the prepared dental tissue until the fabrication of a permanent prostheses. These materials play a major role in prosthetic treatment by providing thermal isolation, esthetics, and an appropriate fit for the prepared dental tissue.⁴ ⁵

Provisional restorations worn for long durations allow bacterial colonization on their surfaces. Due to the high surface roughness on provisional prosthetic materials and their low marginal adaptation, bacterial colonization on provisional prosthetic materials is higher than that on permanent prosthetic materials.² Various surface characteristics may affect the quantity and quality of bacterial adhesion and accumulation on the surfaces.⁶ An increase in surface roughness facilitates microbial adhesion, which is difficult to eliminate from inaccessible areas such as pits and grooves.⁷

Many kinds of oral bacteria (Streptococcus mutans, Streptococcus oralis, Streptococcus gordonii, and Actinomyces naeslundii) have been shown to contribute to the initial attachment and mature development of biofilms on acrylic denture surfaces.⁸ Among other microbial populations, Candida albicans is a fungus commonly detected on acrylic resin denture surfaces.⁹

MATERIALS AND METHODS

A preliminary PubMed search of articles regarding antibacterial agents for reducing microbial adhesion to acrylic resins was done which yielded 37 articles. Individual articles were reviewed from Google database and hand search was done from back volumes

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**DISCUSSION**

Adhesion of microbes to acrylic dentures is an often neglected clinical problem, which can lead to stomatitis. Microbes adhere quite strongly to denture base materials as a result of the microporosity on the denture surface; Candida adheres directly or through a layer of denture plaque to denture base acrylic resin. Without this adherence, microorganisms would be removed from the oral cavity when food is being swallowed. Although *C. albicans* has been found to be the predominant oral yeast isolated from dentures, *Candida dubliniensis, Candida parapsilosis, Candida krusei*, and *Candida tropicalis* have also been isolated.

Plaque is typically removed using physical means such as toothbrushes, interdental brushes, or dental floss. However, in many cases, it is impossible to completely remove plaque because of anatomical and technical reasons. The use of resin materials for dental treatments exacerbates the presence of plaque as they favor plaque formation and possible microbial infection.

To counter this problematic association between dental resins and dental plaque, many studies have focused on endowing resin-based dental materials with antibacterial properties. Currently, antibacterial agents [Table 1] incorporated into dental materials are classified into organic agents (such as quaternary ammonium salts), 12-methacryloyloxydodecyl-pyridinium-bromide (MDPB), quaternary phosphonium salts and natural products and inorganic agents (such as silver and titanium dioxide)..

**POLYMERS**

The use of fluorinated polymers can overcome some limitations of conventional denture base resins, especially as they have an extremely low surface energy and display excellent hydrophobicity. Fluorinated resins present more stable mechanical properties when compared with conventional polymers. Another interesting property which has expanded their use has been their potential resistance to microbial adherence.

Poly (2-tert-butylaminoethyl) methacrylate (PTBAEMA) is a functionalized polycationic polymer with pendant amino groups that act as a very efficient contact biocide. It has low solubility in water, which makes this biocide, especially useful for incorporation into materials designed to be in contact with water since one can expect very low leachability of PTBAEMA from polymer blends and compounds. Denture base acrylic resin combined with 10% and 25% PTBAEMA showed a significant antimicrobial activity against *S. aureus* and *S. mutans* biofilm but had no significant effect on the *C. albicans* with respect to biofilm formation.

**MDPB**

Antibacterial resin monomers are unique molecules that provide dental resins with “bioactive function,” i.e., the ability to control bacterial infection. They have strong antibacterial activity when unpolymerized and also demonstrate contact inhibitory effects after being polymerized without releasing antibacterial components. Intensive research has been conducted on antibacterial monomers based on quaternary ammonium, such as MDPB. The polymerizable monomer MDPB shows antibacterial activity when immobilized in a resin-based material. A resin incorporating the antibacterial monomer 12 MDPB was investigated. The resin exhibited an inhibitory effect on *S. mutans* growth, reducing the number of bacteria to approximately 3% of control resin without MDPB. The addition of the MDPB did not influence strength and performance.

**Quaternary Ammonium and Phosphonium Compounds**

Quaternary ammonium and phosphonium groups possess contact-killing antimicrobial activities.

<table>
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<th>Table 1: Differences between inorganic and organic antimicrobial agents</th>
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<td><strong>Property</strong></td>
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<td>Antimicrobial effect</td>
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<td>Heat resistance</td>
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An antimicrobial and antifungal cationic quaternary ammonium methacryloxy silicate molecule (QAMS) has been synthesized by sol-gel reaction between a tetraalkoxyxilane and two trialkoxysilanes.\(^{[23]}\) Containing a methacryloxy functional group and a long C-18 carbon chain, the QAMS molecule is soluble in MMA monomer and has been incorporated into PMMA orthodontic acrylic resin. The QAMS-copolymerized acrylic resin demonstrated improved fracture toughness without adversely affecting flexural modulus and strength of the acrylic. In previous in vitro studies, acrylic resins containing 4-6% QAMS were found to possess in vitro immediate diffusional as well as contact-killing antimicrobial properties when tested with *S. mutans*, *A. naeslundii*, and *C. albicans*.\(^{[26]}\)

### Natural Products

Natural products include secondary metabolites or phytochemicals derived from plants, fruits, herbs, or spices. They offer a rich source of structurally diverse molecules with a wide range of biological activities and could prove useful as alternative or adjunctive anticaries agents.\(^{[27]}\) Potential cariostatic mechanisms identified include inhibition of bacterial growth or acid production, inhibition of glucan synthesis by interfering with glucosyltransferase activity, and inhibition of bacterial adhesion.\(^{[28]}\)

Polyphenols from propolis (apigenin and tt-farnesol) and cranberry proanthocyanidins have been shown to exert useful ecological effects on the plaque biofilm. Apigenin is a potent inhibitor of water-insoluble glucan synthesis, while tt-farnesol disrupts *S. mutans* membrane permeability and acid production.\(^{[29]}\) An animal study found a combination of these two phytochemicals with fluoride suppressed dental caries without affecting the viability of normal oral flora, being as potent as a fluoride-chlorhexidine control in caries inhibition, but without the broad antibacterial action of the control.\(^{[30]}\) Similarly, cranberry proanthocyanidins, which lack significant biocidal activity, can modify plaque biofilms by reducing acidogenicity and glucan synthesis, and these surrogate end points were also translated into cariostatic effects in vivo.\(^{[31]}\) A number of other polyphenol compounds have been found to be effective in killing *S. mutans*, with the minimal inhibitory concentrations of some bioactive molecules such as xanthorrhizol (from *Curcuma xanthorrhiza*) or macelignan (from *Myristica fragrans*) almost comparable to chlorhexidine.\(^{[32]}\) While most of the tested anticaries phytochemicals showed growth inhibitory or antiadhesive effects, a potentially interesting natural agent in caries prevention is *Galla chinensis*, which was able to beneficially regulate the de-/remineralization balance of dental hard tissues.\(^{[33]}\)

Natural products remain a largely unexplored source of effective and non-toxic antibiofilm molecules that could potentially be used as useful alternatives to traditional microbicides. Future research needs to focus on translational approaches to advance the development of effective anticaries products containing phytochemicals or essential oils.

### Inorganic Agents

Mechanical cleaning of dentures is effective in preventing infections such as aspiration pneumonia and denture stomatitis. For denture wearers with a physical handicap and the elderly, however, mechanical cleaning can present problems. The effect of coating denture base acrylic resin with TiO(2) in the inhibition of oral microbial adhesion has been investigated. The results indicate that a TiO(2) coating on a denture base acrylic resin inhibits adhesion of *S. sanguinis* and *C. albicans*.\(^{[34]}\)

Epidemiological studies report that approximately 70% of removable denture wearers suffer from denture stomatitis. *C. albicans* adhesion and biofilm formation are regarded as essential prerequisites for denture stomatitis. Nanosilver has demonstrated antifungal activity and inhibited *C. albicans* biofilm formation. Antifungal activity and an inhibitory effect on adhesion and biofilm formation by denture base resin containing nanosilver have been demonstrated.\(^{[35]}\)

Casemiro *et al.*\(^{[36]}\) evaluated the antimicrobial activity of acrylic resins containing different percentages of silver and zinc zeolite. They found that the addition of 2.5% silver and zinc zeolite to the materials resulted in antimicrobial activity against all strains. However, the flexural strength and impact strength of the acrylic resins decreased significantly with the addition of zeolite.

Silver-based inorganic antimicrobial agents work by inhibiting the function of enzymes in the metabolic systems of microbes. The silver ions impregnate the microbe surface and are then absorbed by the cells through active transfer. The silver ions react with several metabolic enzymes within the metabolic system of the microbes. The activity of these enzymes is hindered and the growth of microbes is inhibited.

The addition of inorganic antibacterial agents (Zeomic, Bactekiller, and NOVARON) to denture base resin resulted in the reduction of *S. mutans* attachment and the residual viable count in comparison to the controls.\(^{[39]}\) When Zeomic, Bactekiller, and NOVARON were added, the resulting residual monomer content was of the same level as the controls. Therefore, adding inorganic antibacterial agents to the self-cured acrylic resins are an extremely effective first step toward developing self-cured acrylic resins that have an antibacterial property.
CONCLUSION

Based on the assumption that giving a self-cured acrylic resin, an antibacterial property may possibly prevent bacterial action and maintain a clean environment, many novel techniques and products have been reported for developing self-cured acrylic resins having an antibacterial property. It remains to be seen whether these techniques and products are commercially feasible and clinically viable.

REFERENCES


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