

Denture biofilm increases respiratory diseases in the elderly.

A mini-review

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Abstract: Purpose: This mini-review discusses the clinical implication of respiratory pathogens in the biofilm on acrylic resin removable dentures in the elderly. **Methods:** A search was conducted using the keywords: “dentures”, “acrylic resin”, “biofilm”, “pneumonia”, “elderly”, “respiratory pathogens”, and “respiratory diseases” in databases PubMed/Medline, Lilacs, SciELO and textbooks between 1999 and 2024. **Results:** The elderly are more susceptible to chronic diseases and/or life-threatening infections because of senescence itself and functional and degenerative alterations. Respiratory tract diseases (such as pneumonia) are of greater concern in the elderly because they have been associated with the aspiration of food and oral pathogens and with reflux. This relationship is more aggravating in the presence of removable dentures, common in the elderly after the sixth decade of life, since denture biofilm is a reservoir of respiratory pathogens. Lack of manual dexterity and visual acuity negatively interfere with denture cleaning and favor pathogenic denture biofilm maturation. Reduced salivary flow, a more acidic pH, and a reduced cough reflex associated with poor denture cleaning increase the potential of denture biofilm infections and aspiration pneumonia, which is related to a high mortality rate in the elderly. To prevent respiratory diseases in this population, measures to control denture biofilm should be adopted, such as the superficial or intrinsic modification of the acrylic resin denture bases and the use of effective methods of denture cleaning. (*Am J Dent* 2024;37:288-292).

CLINICAL SIGNIFICANCE: Respiratory pathogens colonizing denture biofilm can be aspirated into the respiratory tract, increasing the risk of respiratory infections, especially in the elderly. The knowledge of health professionals on methods of biofilm control can prevent respiratory diseases in elderly denture wearers.

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Introduction

The average age of the global population is increasing because of the advancement of health care and public policies. Aging directly impacts health care services because the elderly are more susceptible to chronic diseases and/or life-threatening infections.^{1,2} Such alterations occur because of a systemic factor combination including senescence itself (decreasing motor and immune functions), reduction of respiratory capacity, functional alterations in the cutaneous and mucous barriers, and degenerative bone and cartilage diseases.³

Pneumonia is a life-threatening lower respiratory tract disease, prevalent in the elderly. This population is more vulnerable because of a reduced gag reflex, mucociliary function, feverish response, and many degrees of cardiopulmonary dysfunction and other health problems that compromise immune competence.¹ The Global Burden of Disease Study⁴ revealed that such infections resulted in 2.18 million deaths in 2021 and are the seventh most prevalent cause of global mortality in all age groups. Of these deaths, almost half occurred in the group of individuals over 70 years,⁴ which highlights that pneumonia is still a health problem related to the main morbidity and mortality risks in the elderly of many countries, including the developed ones.^{5,6}

In the elderly, the main cause of pneumonia is related to the aspiration of food or oral microorganisms due to swallowing disorders such as dysphagia (difficulty swallowing) or other

diseases such as gastroesophageal reflux.^{6,7} The aspiration of contents of the oropharyngeal and upper gastrointestinal tract followed by the oral microorganism secretions that invade the larynx and the lower respiratory regions is the primary condition for the infectious response of the lungs known as aspiration pneumonia (AP).^{6,7} AP affects mainly the elderly with up to 80% of the cases in individuals over 65 years.^{7,8} AP has been reported to be the second most common hospital-acquired infection in the elderly, with a mortality rate of up to 72%.⁹ In comparison with non-aspiration pneumonia, AP causes more admissions to the intensive care units (ICUs), requires mechanical ventilation, and increases the admission time and mortality.¹⁰ The high incidence of AP in the elderly is also related to this population's higher probability of having neurological diseases affecting esophageal function and/or swallowing, such as gastroesophageal reflux.⁷ Moreover, the pharynx muscles and the mechanisms of protection against aspiration are reduced in individuals over 70 years of age. The aspiration of oropharyngeal secretion increases in the bedridden elderly treated with sedatives or narcotics, those with a lower level of consciousness, or those submitted to nasogastric intubation.¹¹

Poor oral health has been reported to be a major risk for aspiration pneumonia in the elderly; reportedly, one in every 10 deaths could have been avoided through appropriate regular dental hygiene.¹² This risk is especially concerning for individuals with removable dentures, since several species of respiratory pathogens have been identified in denture bio-

Table. Summary of evidence on key topics related to implications of respiratory pathogens in the biofilm on acrylic resin removable dentures in the elderly.

Key topic	Evidence	References
Prevalence of respiratory pathogens	46 to 83.5% of dentures colonized by potential respiratory pathogens Common species: <i>S. aureus</i> , <i>K. pneumoniae</i> , <i>P. aeruginosa</i> , <i>S. pneumoniae</i>	2, 13, 29, 30
Risk factors	Acrylic resin properties (hydrophobicity, roughness, porosity) Continuous denture wear - Sleeping with dentures Dentures >5 years old Poor oral and denture hygiene	18-20, 23-25
Impact on respiratory health	Increased risk of aspiration pneumonia Higher mortality from aspiration pneumonia in the elderly	9, 32, 35, 36
Biofilm control strategies	Intrinsic or surface modification of denture acrylic bases Daily brushing associated with immersion in chemical disinfection agents: 0.25% and 0.5% sodium hypochlorite (complete denture) 0.12% chlorhexidine digluconate (metal frame removable partial dentures)	44-47, 50-52

film,^{2,13,14} particularly when considering that the use of these prostheses increases with age¹⁵ and that the majority of elderly people are unable to clean the dentures properly.¹⁶

As acrylic resin removable dentures act as reservoirs of respiratory pathogens, this mini-review discusses its clinical implication in the elderly.

Discussion

Removable dentures: A favorable environment for microorganism proliferation - Polymethylmethacrylate (PMMA) based acrylic resin is the main material of removable denture bases. Despite its esthetic and mechanical advantages,¹⁷ acrylic resins have unfavorable surface characteristics that include hydrophobicity, roughness, and porosity,¹⁸⁻²⁰ all of which contribute to the adhesion of debris and microorganisms.²¹ Moreover, acrylic resin maxillary removable complete dentures themselves may produce a local anaerobic environment with reduced pH because of the decreasing of oxygen flow and saliva for the underlying tissues, even without other predisposing conditions.²² Consequently, biofilm develops over the prosthetic surface, especially in the presence of unsatisfactory oral hygiene and denture cleaning conditions.

Continuous denture wear facilitates pathogen colonization over the underlying tissues.²³ Sleeping with the dentures results in higher risks of oral lesion and infection²⁴ because the underlying tissues are constantly in contact with the acrylic resin bases, reducing the protective effect of the saliva and tissue oxygenation and decreasing the underlying tissue resistance to mechanical and microbiological aggressions (Table).²³

Existing dentures with more than 5 years of use are also an aggravating factor for biofilm accumulation. The acrylic resin develops fissures with use, with greater porosity and surface roughness, which favors microbial adhesion and colonization.²⁵ Notwithstanding, the elderly may be resistant to replace existing dentures, which negatively affects their quality of life,²⁶ increases the biofilm accumulation, and increases the risk of infections in immunocompromised individuals (Table).²⁵

Implications of denture biofilm on respiratory diseases - The biofilm formed on the removable dentures is characterized by a complex microbiome of bacteria and fungi, with a polysaccharide matrix.²⁷ The formation and growth of the biofilm favors microorganism proliferation and survival by decreasing antimicrobial agent action and increasing the biofilm protection against the host's immune cells.²⁷ Similarly

to oral biofilm, denture biofilm is colonized by respiratory pathogens.^{2,13,28-30} Since the dentures are close to the respiratory tract, denture wearers are at high risk of aspirating opportunistic denture biofilm microorganisms.²

Sumi et al¹³ reported that 46% of dentures of dependent elderly were colonized by potentially pathogenic bacteria for the respiratory system, the predominant species being *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Enterobacter cloacae*. A diversity of potential respiratory pathogens was identified in biofilm of 64.3% of dentures of patients with chronic obstructive pulmonary disease, including *K. pneumoniae*, *S. aureus*, *Serratia marcescens*, *Pseudomonas aeruginosa*, and *Enterobacteriaceae* spp. (Table).²⁹

O'Donnell et al² showed that the biofilm of 64.6% of the dentures evaluated was colonized by six species of respiratory pathogens: *P. aeruginosa*, *Streptococcus pneumoniae*, *Streptococcus aureus*, *Streptococcus pyogenes*, *Moraxella catarrhalis*, and *Haemophilus influenzae* B. Fujinami et al²⁸ identified bacterial genera in denture biofilms that are also present in the respiratory tract of patients with pneumonia, such as *Streptococcus*, *Corynebacterium*, *Haemophilus*, *Neisseria*, *Prevotella*, *Fusobacterium*, and *Veillonella*. In a recent study,³¹ thirty opportunistic respiratory pathogens were identified in 83.5% of the removable dentures evaluated, with the most common species being *Stenotrophomonas maltophilia* (34.0%), *P. aeruginosa* (27.8%), and *Streptococcus agalactiae* (27.8%). Furthermore, a high load of respiratory pathogens including antibiotic-resistant strains of *S. aureus* and *K. pneumoniae* was identified in the removable dentures of patients after COVID-19 infection (Table).³⁰

The evaluation of the immunological capacity against *S. aureus* revealed greater monocyte activation, but with lower phagocytic activity in removable denture wearers than in nonwearers.²⁷ Accordingly, the use of removable dentures by elderly residents in nursing homes was considered a modifier factor for increasing the risk of pneumonia associated with the risk of aspiration.³² Moreover, denture biofilm in association with the compromised immunity of a hospitalized individual and the aspiration of oropharyngeal contents into the lower respiratory tract leads to an increased risk of aspiration pneumonia, particularly 48 hours after hospitalization.³³ The reduced salivary flow, lower pH, and decreased cough reflex associated with poor oral hygiene resulted in the greater potential of the oral and denture biofilm to cause respiratory infection, which is proportional to longer hospitalization time.³⁴

Therefore, it is highly recommended that hospitalized patients, particularly those who are critically ill or who cannot maintain adequate oral hygiene, minimize wearing dentures to reduce the risk of biofilm accumulation. In addition, caregivers should be encouraged to assist with oral hygiene and ensure that dentures, if used, are regularly cleaned and disinfected.

Studies³⁵ on oral hygiene and cleaning care and the use of dentures in the elderly residents in nursing homes have shown that hygiene significantly reduced mortality from pneumonia, and considerably increased sensitivity to the cough reflex.³⁶ Elderly residents in nursing homes who sleep with dentures are considerably more prone to have aspiration pneumonia than those with predisposing factors such as a history of cerebral vascular accident, respiratory disease, and cognitive impairment (Table).³⁷ In addition, systemic impairment of the elderly and factors such as loss of manual dexterity, cognitive ability, visual acuity, and autonomy results in low frequency and unsatisfactory oral hygiene and removable denture cleaning.³⁸ Infrequent cleaning of removable dentures (less than once a day) was shown to be strongly associated with a higher incidence of pneumonia in community-dwelling elderly people after 1 year of evaluation.³⁹ Furthermore, it was observed that mortality from pneumonia was reduced by half in institutionalized elderly people who received oral hygiene and denture cleaning care.⁴⁰

Denture biofilm control - Denture biofilm control is mandatory to decrease its harmful impact on the individual's general and oral health.^{31,41} The main approaches to control denture biofilm are to change the vulnerable surface features, to use external forces to eliminate the formed or maturing biofilm, and to regulate the signaling route (specific biochemical pathways) to disrupt the communication between microorganisms, potentially preventing them from initiating or maintaining biofilm formation.⁴² Therefore, a better comprehension of the adhesion, formation, and maturation mechanisms of denture biofilm would lead to the development of even more efficient therapeutic strategies.⁴³

Because the surface features of the acrylic resin facilitate denture biofilm formation²¹ and removable denture use creates an environment that favors biofilm pathogenicity,²² intrinsic or surface modification of the acrylic resin denture bases has been recommended. Incorporating antimicrobial nanoparticles into denture base acrylic resins resulted in improved surface properties and reduced adhesion of microorganisms.⁴⁴ Modification of the denture bases by composite surface sealant,⁴⁵ ethyl cyanoacrylate adhesive,⁴⁶ or fibrin biopolymer incorporated with antimicrobial agents⁴⁷ have demonstrated excellent performance as denture coatings by inhibiting and controlling biofilm formation.

Among the methods of biofilm control by denture wearers, brushing with toothpaste, soap, or even water represents the method most adopted by this population⁴⁸ because of ease, simplicity and low cost.¹⁶ Although there are specially designed denture brushes that are more robust and effective than conventional toothbrushes, brushing, when used alone, has low effectiveness in removing denture biofilm,^{49,50} especially when performed by elderly individuals who may have impaired manual dexterity and may not have the visual acuity necessary for effective cleaning.¹⁶ To overcome these limitations, brushing should be combined with chemical disinfection methods.⁵⁰⁻⁵²

Denture cleansers can affect the biofilm structure and interfere with the structure of fungi and bacteria, reducing their metabolism or leading to their death.⁵³ For daily home cleaning, clinical trials have demonstrated the effectiveness of controlling denture biofilm by brushing and immersion in low-concentration chemical agents such as 0.25% and 0.5% sodium hypochlorite^{52,54,55} or 0.12% chlorhexidine digluconate,^{52,56} the latter solution being the most suitable for metal-frame removable partial dentures. As a protocol for controlling denture biofilm in healthy individuals, daily denture brushing accompanied by immersion once a week in 0.5% sodium hypochlorite or 0.12% chlorhexidine for 10 minutes has been recommended.⁵² Although alkaline peroxides have shown antimicrobial action in laboratory studies,^{57,58} they are not clinically effective in reducing the biofilm coverage area⁵⁰ and the microbial⁵⁰ and fungal load,^{50,59,60} even when associated with brushing.

For dentures with mature biofilm, disinfection methods that can completely remove the biofilm should be adopted before starting a protocol aimed at controlling it. To this end, chemical agents with higher concentrations should be used to immerse the denture, such as 1% sodium hypochlorite and 2% chlorhexidine digluconate (Table).^{50,51,56} A recent randomized clinical trial in hospitalized patients that tested 17 complete denture cleaning protocols demonstrated that a single immersion in 1% sodium hypochlorite solution for 10 minutes, even when not associated with brushing, was effective in completely removing the area covered by denture biofilm and in eliminating the microbial and fungal load.⁵⁰ Immersion in 2% chlorhexidine resulted in the same effects only when associated with brushing.⁵⁰

Conclusion - The presence of a high concentration (46-83.5%) of potential respiratory pathogens in denture biofilm is of more concern in the elderly because of their motor and cognitive impairment, affecting their ability to perform appropriate denture cleaning. Moreover, deficiencies in the swallowing mechanism with aging result in continuous aspiration of the oropharynx and/or gastric content during sleep, followed by the secretion of oral microorganisms, including those of the denture biofilm. This process predisposes the individual to respiratory infections, especially aspiration pneumonia, which is highly life-threatening in the elderly. Therefore, to prevent respiratory diseases in this population, it is essential to adopt measures to control denture biofilm both by superficial or intrinsic modification of the acrylic resin bases and by effective methods of denture cleaning.

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