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Denture hygiene, Sodium hypochlorite, Biofilm, Denture stomatitis, Patient education, Oral health promotion, Preventive dentistry, Patient compliance

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A Systematic Review of Denture Hygiene: Microbial Challenges, Preventive Care, Patient Education, and Emerging Antimicrobial Technologies

ABSTRACT

Objectives: To assess the efficacy of different denture hygiene procedures and note the importance of prevention and education of the patient in enhancing oral health outcomes in denture wearers.

Methods: The PRISMA 2020 guidelines were used to conduct a systematic review and register it in PROSPERO. In vitro articles and randomized controlled trials that were published between January 2000 and April 2024 were considered. Others that were tested included mechanical cleaning, chemical disinfectants (sodium hypochlorite, chlorhexidine, effervescent tablets), phytotherapeutic agents and newer methods such as photodynamic therapy and microwave disinfection. These outcomes were the decrease of microbes, elimination of biofilms, material compatibility, and patient outcomes.

Results: A total of six studies (five RCTs and one in vitro) were included. The highest antimicrobial effect was observed in 10 minutes in 1 percent sodium hypochlorite, which reduced the number of bacteria and fungi. Chlorhexidine and Triclosan were effective as a combination with brushing. The microwave disinfection had similar outcomes to nystatin in the context of denture stomatitis treatment. Tablets were effervescent and enhanced the quality of life and microbial control.

Conclusions: Chemical disinfectants, particularly sodium hypochlorite, remain the most effective denture hygiene method. Multimodal approaches enhance outcomes, though long-term evidence is limited.

Clinical Relevance: Effective denture hygiene depends on both appropriate cleaning protocols and patient education, which are essential for improving compliance and long-term oral health.

1.INTRODUCTION

Denture hygiene has a major role to play in the oral as well as the systemic well-being. The majority of dentures are made of polymethyl methacrylate (PMMA), which has an intrinsic porosity at the surface and microcracks, which facilitate the presence of microorganisms and biofilm proliferation [1,2]. Localized oral situations associated with the build-up of resilient biofilm are closely related to denture stomatitis, inflammation of the mucosa, and halitosis [3–5]. The sustained use of dentures, particularly overnight, is another factor that contributes to these risks in terms of interrupting the normal flow of saliva and the regeneration of mucosa, which creates an environment where the growth of microbes thrives [6,7].

Multimodal regimens with brushing followed by exposure to disinfectant solutions or adjunctive technologies such as ultrasonic cleaning, microwave irradiation, or photodynamic therapy (PDT) have been shown to be better at removing biofilms. The combination methods have been found to reduce reported reductions in microbial loads of more than 95% with randomized controlled trials [8].

Chlorhexidine gluconate is an excellent antibiotic with the ability to attack fungal species, although, it may cause mucosa irritation or staining. Effervescent tablets using alkaline peroxide are a milder option, but take a long time to achieve the same level of disinfection [9,10]. Phytotherapeutic extracts such as neem, Triphala, Aloe vera, and thymol have possible antibacterial and antifungal properties and do not affect the integrity of materials. The nanoparticle-enhanced cleansers and PDT can have the ability to destabilize deep-seated biofilms and leave denture bases unharmed [11,12].

It is a systematic review that seeks to integrate the quality of clinical evidence to establish the most effective and biocompatible denture hygiene protocols which can be used to promote the oral and systemic health of the individuals wearing dentures.

Other than clinical performance, patient awareness, behavioral habits, and adherence to daily cleaning policy have a direct correlation with denture hygiene. Proper dental care for maintaining dentures is the key to preventing oral conditions and enhancing the overall health outcome, which is necessary to educate patients, particularly the elderly [13]. Therefore, denture hygiene must be considered as a clinical activity, as well as a major part of oral health promotion and preventive care measures.

2. MATERIALS AND METHODS

2.1 Study Design

This systematic review followed the PRISMA 2020 guidelines to promote the transparency of the methods, reproducibility, and scientific rigor of the study [14]. The purpose was to critically accumulate, establish, and synthesize evidence according to the Randomized Controlled Trials (RCTs), controlled clinical trials, and well-designed in-vitro studies assessing the antimicrobial efficacy, safety, and material compatibility of various denture hygiene interventions. The protocol of the review was registered in the PROSPERO database (Registration ID: CRD420251081095). This review result is expected to aid in evidence-based clinical decision-making and patient education methods related to denture care.

2.2 Eligibility Criteria

Inclusion Criteria:

The criteria used in studies included RCTs, controlled trials, and in vitro studies involving denture wearers of removable complete or partial dentures among adults, irrespective of gender, age, and systemic health. The groupings of Interventions were as follows:

1 .Mechanical brushing and chemical immersion using sodium hypochlorite (NaOCl), chlorhexidine gluconate (CHX), or alkaline peroxide-based effervescent tablets.

2. Herbal and phytotherapeutic products such as Azadirachta indica (neem), Triphala, and essential oils.

3. Photodynamic therapy (PDT), ultrasound or ozone-based cleaning, and antimicrobial nanoparticle systems (e.g., silver, titanium dioxide).

Exclusion Criteria:

The studies that were excluded were those that dealt with fixed prostheses or orthodontic appliances, narrative reviews, letters, commentaries, abstracts without full texts, studies that had no microbial endpoints, and animal or non-human studies. Articles that had been published in English and within this time frame (January 2000-April 2024) were considered.

Outcomes Measured:

The main outcomes were a decrease in microbial load, in particular, against Candida albicans and Streptococcus mutans, measured by colony-forming units (CFU), real-time PCR, or spectrophotometric techniques. The staining, scanning electron microscopy (SEM), and confocal laser scanning microscopy were used to analyze biofilm dislodgement and surface decontamination. Secondary outcomes measured denture base compatibility, using surface roughness, color stability test, and mechanical strength test, user satisfaction, and safety using questionnaires and clinical observation.

2.3 Article Sources and Search Engines

Seven databases, such as PubMed/MEDLINE, Scopus, Web of Science, EMBASE, ScienceDirect, Cochrane CENTRAL, and Google Scholar, were searched in detail. To reduce publication bias, grey literature and conference proceedings were filtered.

2.4 Search Strategy

Database searches combined Medical Subject Headings (MeSH) and free-text terms using Boolean operators (“AND,” “OR”) and truncation symbols. A representative search string was:

("Denture Hygiene" OR "Denture Cleanser*" OR "Denture Disinfection") AND ("Candida albicans" OR "Streptococcus mutans") AND ("Chlorhexidine" OR "Sodium Hypochlorite" OR "Photodynamic Therapy" OR "Plant Extracts" OR "Nanoparticles") AND ("Randomized Controlled Trial" OR "RCT"). Search filters and syntax were tailored for each database.

2.5 Study Selection

All the records were opened in Zotero reference manager to organize and eliminate duplicates. Titles and abstracts were filtered by two independent reviewers, and then the full text was evaluated. Differences were solved either by discussion or by a third reviewer to make sure the selection was not biased.

2.6 Data Extraction

The method of data extraction was a standardized Microsoft Excel form, which was pilot-tested. The most important ones were the details of the study (author, year, design), the demographics of the participants, the type of denture, the details of the interventions (agent, concentration, duration), the results of the microbial and material, and the feedback of the users.

2.7 Quality Assessment

RCTs were assessed with the Cochrane Risk of Bias 2 (RoB 2) tool, and in vitro studies were evaluated with the Joanna Briggs Institute (JBI) checklist. All of the

studies were categorized as “low risk”, “some concerns”, or “high risk” of bias, and the difference between the views was resolved by consensus or by reviewing the third.

3. RESULTS

Six studies were included in the study selection process; they included five randomized controlled trials (RCTs) and one in vitro experimental study, as shown in Figure 1. The studies included examined a variety of denture hygiene interventions, such as chemical disinfectants like sodium hypochlorite and chlorhexidine, mechanical cleaning, use of effervescent cleansing tablets, and microwave disinfection. The research was carried out in a wide range of populations, such as hospitalized patients, patients with denture stomatitis, and in vitro biofilm models, which gave a thorough analysis of both clinical and laboratory-based results. The most important results evaluated in the works were the reduction of microbial loads, the removal of biofilms, the treatment of denture stomatitis, and patient-reported outcomes like comfort and quality of life (Table 1).

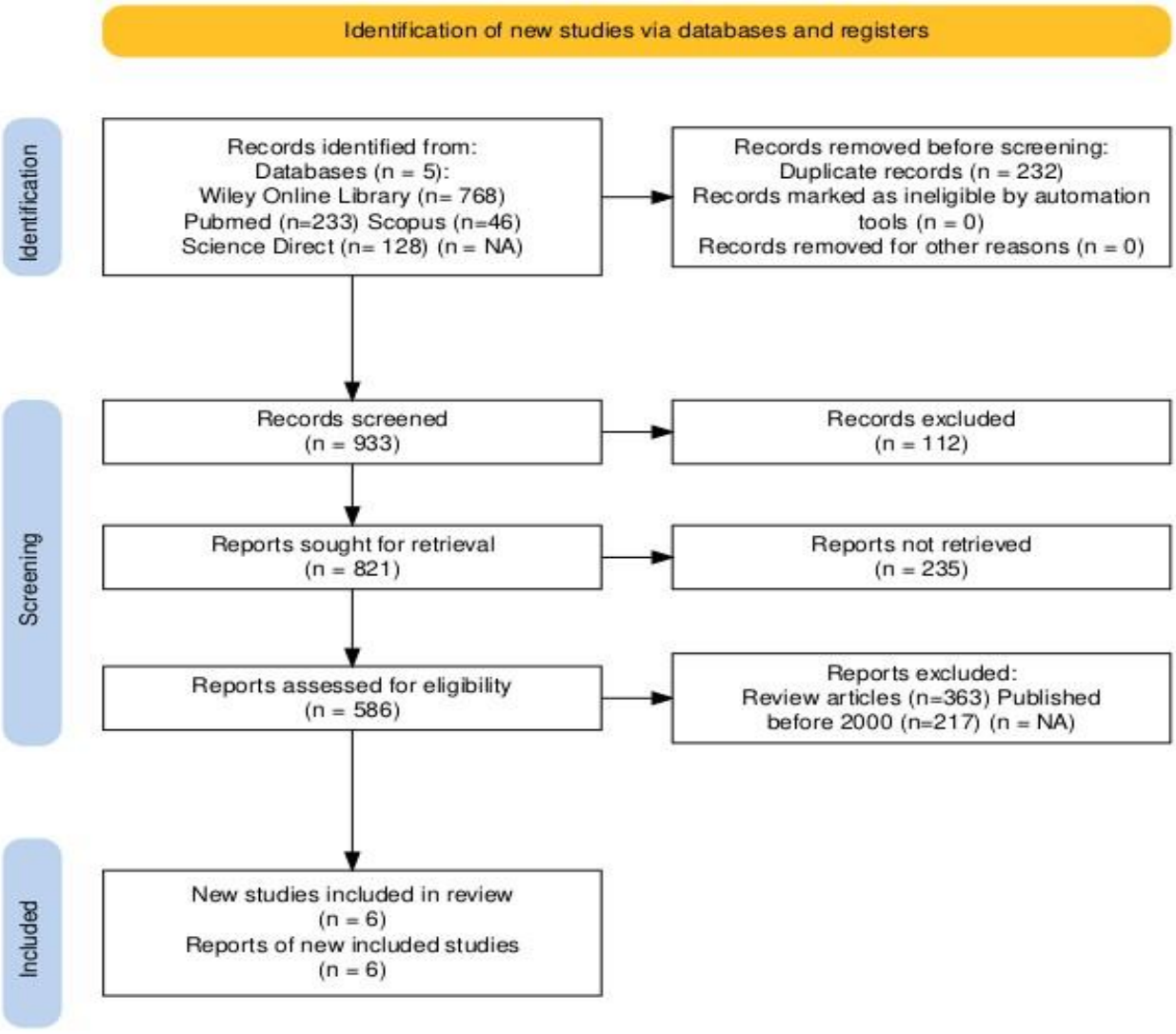

Figure 1: PRISMA Flowchart

Table 1: Characteristics of included studies

Author et al, Year	Population / Context	Intervention(s)	Key Findings
ACG Gomes et al , 2024 [16]	Hospitalized complete denture users	1% NaOCl, 2% CHX, microwave disinfection, brushing	1% NaOCl (10 min) showed highest antimicrobial efficacy; CHX and microwave with brushing also effective
MM Silva et al 2012 [25]	Complete denture wearers with denture stomatitis	Microwave disinfection vs topical nystatin	Microwave disinfection showed comparable effectiveness to nystatin in reducing Candida

			and stomatitis
AB Riberio et al 2019 [17]	Complete denture wearers (study protocol)	Hygiene protocols including NaOCl, triclosan, and cleansing agents	Study outlines protocols; clinical outcomes focus on microbial reduction and QoL improvement (protocol-based evidence)
PV Sanita et al 2012 [21]	Patients with type 2 diabetes and denture stomatitis	Microwave disinfection vs nystatin	Both methods equally effective in reducing Candida and treating denture stomatitis
A Rajendran et al 2022 [19]	Removable partial denture users	Soap, cleansing tablet, brushing combinations	Cleansing tablet combined with brushing showed greatest reduction in Candida albicans
JL Brown et al 2022[22]	In vitro denture biofilm model	Brushing, toothpaste, chemical cleanser + brushing	Only cleanser combined with brushing achieved consistent and significant biofilm reduction

4. RISK OF BIAS ASSESSMENT

Risk of bias in the six included studies, five randomized controlled trials (RCTs) and one in vitro experiment, was generally low, which suggests high methodological quality. All five clinical RCTs were found to have a low risk of bias in all domains of interest, such as randomization, deviations of intended interventions, missing outcome data, outcome measurement, and selective reporting using the Cochrane ROB 2.0 tool. Outcome measures were based on validated microbial and clinical measures and were objective and consistent in all studies. There was low reporting bias since none of the trials reported anything other than what they meant to report.

Although the in vitro experimental study was methodologically rigorous in its design, it raised certain concerns by being limited to clinical settings, as it was not able to consider individual patient variability. The evidence base, in general, shows that the overall risk of bias is low, which helps to support internal validity and reliability of the results on the efficacy of denture cleaning protocols (Figure 2). Notably, some of the interventions proved to be effective and, at the same time, basic and easy to practice in the real-life setting by patients, which makes them relevant to everyday hygiene practices.

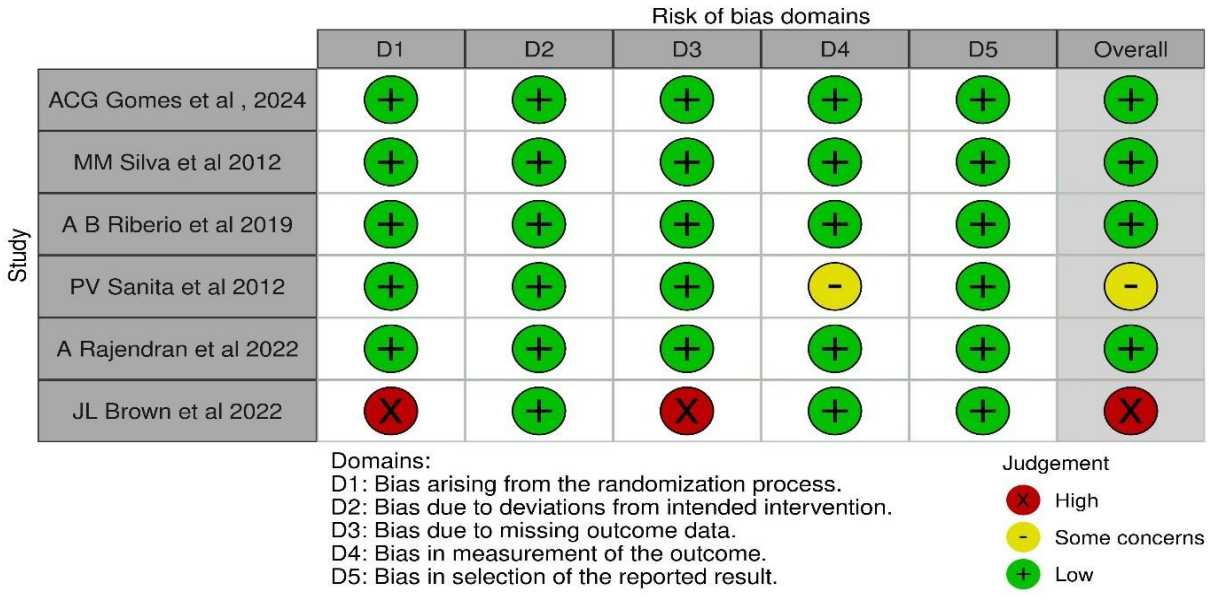

Figure 2: TRAFFIC LIGHT MATRIX - Risk of Bias per Domain

5. DISCUSSION

The systematic review is a synthesis of clinical and mechanistic data on the effectiveness of different denture cleaning procedures in fighting biofilm. Randomized controlled trials and in vitro studies show that chemical disinfectants, particularly sodium hypochlorite (NaOCl), chlorhexidine (CHX), Triclosan, and effervescent tablets are significantly superior to brushing alone in reducing the microbial load and biofilm formation on dentures. Microwave disinfection was also found to have significant antimicrobial potential, as well as a useful non-chemical alternative [4,15]. The two methods possess their own pros and cons based on the patient qualities, compliance rate, and the denture materials.

Gomes et al. randomized controlled trial, which included 340 hospitalized denture users, is the most convincing clinical evidence on the efficacy of NaOCl [16]. A 10-minute immersion in 1% sodium hypochlorite without adjunctive brushing resulted in a significant decrease in microbial colony-forming units (CFUs) and overall biofilm coverage, even in fungal organisms like Candida albicans. NaOCl was more effective in broad-spectrum antimicrobial effect alone as a disinfection agent than CHX and microwave disinfection in all situations.

The biofilm reductions of chlorhexidine (2%) immersion (alone or together with brushing) were similar to NaOCl. CHX is especially beneficial in patients with a high risk of oral infections like diabetes or immunocompromised conditions. The greatest benefit of this procedure is that it is a chemical-free process, making it the best choice with patients who are allergic or sensitive to antiseptics [17].

Aaraujo et al. used a randomized controlled trial (RCT) to compare NaOCl (0.25%), Triclosan (0.15%), and effervescent denture cleaning tablets, with or without palatal brushing, in 108 denture users presenting with clinical evidence of stomatitis [18]. Each of the tested protocols decreased Candida spp. and Streptococcus mutans CFUs by a significant margin, reduced halitosis, and improved mucosal health. Triclosan and NaOCl were also effective, especially against Gram-negative organisms, and tablet-based techniques were convenient and user-friendly [19,20]. Tablets used together with palatal brushing had similar antimicrobial and odor control effects as those of chemical immersion, so they could be used with elderly people or individuals with limited dexterity.

Along the microbiological findings, the psychosocial well-being is also influenced significantly by denture hygiene. Ribeiro et al. reported significant improvements in comfort, retention, and general satisfaction and Oral Health-Related Quality of Life (OHRQoL) following 10 days of standardized cleaning procedures [17]. None of the treatments had any negative effect on the saliva flow and pH, and all treatments had a positive effect on psychological comfort and functional performance.

Complementary mechanistic studies corroborate these clinical observations. In laboratory models, the daily exposure to disinfectants, and specifically NaOCl, when paired with mechanical cleaning is always able to be utilized to achieve a higher percentage of multispecies biofilm reduction than mechanical cleaning itself. PV Sanita et al. noted that NaOCl was seen to be highly bactericidal and fungal biofilm-bactericidal compared to CHX or iodine potassium iodide solutions [21]. Moreover, such research has shown that biofilms are able to regain faster under the circumstance that cleaning is not performed consistently, thus the necessity to clean periodically. Overall, the in vitro findings substantiate the requirement of having chemical disinfection as one of the components of daily denture hygienic procedures to ensure long-term microbial control [22].

The aggregate information gives a number of pragmatic suggestions. The best protocol in an institutional or hospital setting is the dipping in 1% NaOCl because it provides the most reliable antimicrobial control. Despite their high effectiveness, CHX and Triclosan solutions need to be used together with brushing, and may not be as suitable in older individuals with manual limitations. Another, more convenient and effective, yet balancing, method is effervescent tablets, which are easy to use and convenient. An alternative that can offer an alternative to patients who would not wish to utilize the chemical agents, but would wish to use the microwave disinfection method would require the appropriate procedures to be followed. The time span of the studies that are included and heterogeneity of methodology reduce the opportunity to measure the long-term efficacy, adherence, and the material impact. In addition, the action of NaOCl by which the material could degrade also restricts the extrapolation of the in vitro models to the clinical case.

6. PATIENT EDUCATION AND CLINICAL IMPLICATIONS

The success of cleansing agents is not the sole determinant of the success of denture hygiene, but also the awareness of the patients, their education and the capability to follow the suggested practices in the long run. Based on the evidence that has been synthesized in this review, patient-based, practical, and simple hygiene protocols will be integrated into effective denture care.

It is also advisable that the patients brush their dentures with soft-bristle brush and non-abrasive cleanser daily in order to prevent the damages of surfaces and the development of biofilms. [23,24]. This should then be dipped in a pertinent disinfectant solution such as sodium hypochlorite, chlorhexidine or effervescent cleansing tablets, depending on individual needs and clinical environments. Dentures are to be taken off at night to enable the mucosa to rest and minimize chances of the growth of the microbes.

Clinically, hygiene guidelines must be considered on patient-specific factors like age, manual dexterity, systemic health, and care setting. One such

consideration is that effervescent tablets may be more suitable in patients with low hand skills or in elderly patients, whereas immersion in sodium hypochlorite may be more effective in hospitals or institutions as it has a strong antimicrobial action. Another option that can be used by patients who are not keen on using chemicals is microwave disinfection.

Education of the patients should also be directed towards introducing some of the major dos and dons such as avoidance of abrasive toothpaste, hot water or strong chemicals which might ruin the denture materials. Besides, the oral mucosa and the rest of the dentition must be maintained clean in order to achieve general oral health.

In order to be more effective in improving compliance in the long-term, it is necessary to provide clear instructions and modeling of the cleaning methods and reinforce them through follow-up visits. Educational interventions, such as visual aids and involvement of caregivers, can also be used to increase adherence, especially in the case of elderly or dependent individuals. Finally, incorporating patient education in normal clinical practice is essential in attaining long-term oral health results and enhancing the quality of life in denture users.

7. CONCLUSION

This is a systematic review, which combines results of five randomized controlled studies and one in vitro study comparing various denture cleaning techniques. This is clearly supported by the evidence, which indicates chemical immersion, especially using 1% NaOCl, as the best standalone anti-biofilm protocol. CHX, Triclosan, effervescent tablets, and microwave disinfection also exhibited a high degree of benefit with particular efficacy when used in combination with brushing. Each of the methods enhanced patient comfort, satisfaction, and OHRQoL with no negative impacts on salivary parameters. The most feasible and evidence-based solution, particularly in institutional care and the elderly, is 1% NaOCl immersion due to its low cost, convenience, and extensive antimicrobial effect. Future studies should focus on long-term clinical trials on the sustained effectiveness, material suitability, and safety of these protocols. Nevertheless, the effectiveness of these protocols in terms of clinical settings is not the only critical factor, as patient education and awareness, as well as adherence (long-term), are also crucial. The use of preventive oral health strategies is needed to ensure the greatest results.

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