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Original Article

Clinical and Laboratory Evidence for Probiotic-Releasing Denture Base Materials (Devices): Viability, Antibiofilm Effect and Clinical Outcomes

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ABSTRACT

A frequent inflammatory disease in denture wearers is denture stomatitis, which is closely linked with the colonization of denture surfaces with Candida species, in particular, Candida albicans. Denture materials give the optimal microbial adhesion and biofilm formation site which may cause long-term infections and mucosal inflammation. Traditional antifungal therapies can help alleviate symptoms but the reoccurrence of the fungal infection is common because of the biofilm resistance and microbial disproportion in the mouth. Most recently, probiotics are suggested as an attractive alternative control measure of fungal colonization and oral microbial balance. This systematic review sought to determine clinical and laboratory evidence on the usefulness of probiotic-based interventions in the management of Candida biofilms in denture materials and denture wearers. The review was studied according to the PRISMA 2020 principles. PubMed, Scopus, Web of Science, and Google Scholar were searched thoroughly to reveal studies that were published since 2019. Following the elimination of duplicates and sifting of titles and abstracts, 40 full-text articles were evaluated to be eligible. Lastly, 20 articles passed the inclusion criteria and were incorporated in the systematic review. The studies included were randomized clinical trials, observational clinical studies and laboratory studies assessing probiotic strains of Lactobacillus rhamnosus, Limosilactobacillus reuteri, and multispecies pro-biotic formulations. Laboratory experiments showed that probiotics have the ability to prevent Candida adhesion, interfere with biofilm formation on denture surfaces, and clinical experiments have shown a decrease in Candida colonization and improvement in the symptoms of denture stomatitis. The research results indicate that probiotic-based interventions can offer positive results in the treatment of denture-associated fungal infections. But, to establish the effectiveness and safety of probiotic measures in denture management over the long run, further large-scale clinical trials with standard protocols are needed.

Keywords: Probiotics, Denture stomatitis, Candida biofilm, Denture materials, Oral microbiome, Antibiofilm activity

Introduction

Denture stomatitis is an inflammatory disease that is prevalent in denture users and has a close relationship with the colonization of the denture surface by Candida species, especially Candida albicans. Denture surfaces offer a favorable place of microbial attachment and biofilm growth potentially resulting in infections and constant inflammation of the oral mucosa. The oral microbiome is rather significant in this process since the interactions between the bacteria and fungi as well as the interactions between the bacteria and the host factors impact the occurrence of the oral disease. The studies have found that the denture microbiome is a complex microbial community that is not comparable to the microbial community of natural teeth, and is closely linked to the oral state of health [1]. Research on the oral microbiome also insinuates that microbial dysbalance may also be a cause

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of various oral diseases such as fungus and biofilm-associated infections [2]. The composition of microbiota can be altered by the variations in the oral environment and the surface characteristics of the prosthetic materials in the patients with removable and fixed prostheses [3]. Also, the existence of microbial biofilms may contribute to resistance to traditional antimicrobial medication, and thus infections related to dentures are hard to treat [4].

Microbial adhesion and biofilm are also affected by the nature of denture base materials. Denture base resin acrylic denture base polymethyl methacrylate has been widely used due to its good aesthetic and mechanical characteristics. Nevertheless, their porosity and roughness of the surface may encourage the growth of microbes and their settlement. Denture-related stomatitis has been documented to be high in edentulous patients, with the importance of the materials used in prosthetics to accumulate microbes noted, being the main cause of stomatitis [5]. Lab tests have also established that Candida albicans can readily attach to acrylic denture base and create biofilms, which aid in the occurrence of infections [6]. Recent studies have discussed antimicrobial denture materials that can be used to limit the adhesion of fungi and enhance the outcomes of oral health [7].

The recent addition of probiotics is one of the possible methods to regulate the disbalance of microbes and prevent fungal biofilms. These commensal microorganisms may repress the pathogenesis by general competition, synthesis of antimicrobial products, and regulation of host immune systems. Experimental work in the laboratory has demonstrated that probiotic strains can prevent the growth of Candida and decrease the formation of biofilms on the surfaces of dentures [8, 9]. It can also be clinically indicated that probiotic interventions can decrease the Candida colonization and the existence of denture stomatitis in denture wearers [10-13]. Nevertheless, the evidence on the subject is still scattered in both clinical and laboratory research, and a systematic review of the recent findings on probiotic methods of managing the denture-related Candida biofilms is warranted.

PICO question

The search question was developed based on the PICO framework as this framework helped develop a clear research question and provides a clear approach to selecting and analyzing the literature. The population (P) that was factored in this review consists of denture wearers and denture base materials that can be colonized by microbes especially by Candida species. The intervention (I) entails the application of probiotics or probiotic-like methods that are geared towards the regulation of the microbial growth and the inhibition of the development of biofilms on denture surfaces. The comparison (C) comprises traditional denture material, standard antifungal therapy, or when no probiotic interventions are done. The results (O) that were measured in the review are decreased Candida colonization, prevented biofilm formation, enhanced oral microbial balance, and clinical outcomes (reduced denture stomatitis or reduced oral candidiasis in denture users).

Aim of the study

This systematic review will investigate all the clinical and laboratory evidence that is available to determine how probiotic-based strategies can be used to manage Candida biofilms related to denture materials and denture wearers. The review is dedicated to the investigation of the effectiveness of probiotics in preventing colonization of Candida, prevention of biofilm formation on dental prosthesis and improving oral microbial balance. it is aimed at investigating reported clinical outcomes, such as the reduction of denture stomatitis and enhancement of oral health in individuals using removable dental prostheses.

Materials and Methods

Study design and protocol

The research was done as a systematic review in order to assess the existing clinical and laboratory data on probiotic-based interventions on control of Candida biofilms related to denture materials and denture wearers. The review has been performed according to the guidelines of Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA 2020) to make it as transparent, reproducible, and methodologically sound as possible in the description of the review process. PRISMA framework was used to identify, screen, and assess eligibility and inclusion of relevant studies. The systematic review approach enabled the integration of the clinical and laboratory research studies on the effects of probiotic interventions on Candida colonization and denture-related infections.

Eligibility criteria

The search of the literature was conducted with the eligibility criteria in place to provide consistency. They were studies released in 2019-2025 that examine the effect of probiotics on the colonization of Candida, biofilm growth, or denture stomatitis in denture wearers or on denture materials. The clinical trials and in vitro investigations were considered on probiotic strains like Lactobacillus or Streptococcus salivarius. How the studies were left out included animal models, opinion pieces, editorials, abstracts of conferences that lack the full-text and non-English literature and narrative reviews (used only as background). The participants involved were denture wearers or denture surfaces; the interventions were the use of probiotics, comparisons were the traditional intervention, and the outcomes were measured in terms of Candida reduction, biofilm inhibition, and clinical improvements.

Information sources

Relevant studies were found by conducting a comprehensive search of several electronic databases. The databases that were searched were PubMed, Scopus, Web of Science, and Google Scholar. The reason why these databases were chosen was that they offer comprehensive coverage of biomedical, dental and microbiological studies. Along with the database search, the reference lists of the articles of interest were also analyzed in order to determine other studies that would qualify as part of the inclusion group. There was a limitation on the literature search to include the evidence that was published in 2019-2025 to include the latest evidence on probiotics-based interventions to denture-associated fungal infections.

Search strategy

Selection of search was done through the combination of keywords and Medical Subject Headings (MeSH) terms that were related to probiotics, denture materials, and fungal biofilms. The search terms were combined with the help of the Boolean operators so that to guarantee comprehensive search of the relevant studies. The terms that were used in the general search structure that were applied throughout the databases were the following: (probiotic OR Lactobacillus OR Streptococcus salivarius) AND (denture OR denture base resin OR acrylic denture) AND (Candida OR biofilm OR denture stomatitis). Each database was modified slightly with regard to indexing requirements. The search was done using several related keywords which guaranteed the retrieval of studies that studied various probiotic strains or denture materials.

Study selection process

The PRISMA screening procedure was used to select the studies. Firstly, it was necessary to compile all the records that were obtained in the databases and eliminate duplicate articles. On the first database search, 312 records were found. A total of 260 records to undergo title and abstract screening were left after eliminating 52 duplicates. In the screening phase, 220 studies were disqualified as those that were not related closely to probiotics, denture materials, or Candida biofilms. The rest of the 40 full-text articles were evaluated to fit the eligibility criteria on the established inclusion and exclusion criteria. Following the full-text analysis, 20 studies were deemed as relevant and were incorporated into the ultimate systematic review. The PRISMA flow diagram was used to chart out all the steps of the selection process so as to show how many records were identified, screened, excluded and incorporated in the review.

Data extraction

Structured data extraction approach was used to extract data because it was necessary to have a consistent collection of relevant information in the studies used. The variables that were taken out of each study included the names of the authors, the year of publication, the country in which the study was conducted, the study design, the type of probiotic and denture material involved, the independent variables that the measures were taken, and the significant observations. Other data pertaining to experimental situations or clinical results were also noted where possible. Such organized means of extractions enabled the comparison of the results of various studies and made it possible to synthesize evidence concerning the probiotic effectiveness in regulating Candida biofilms.

Risk of bias and quality assessment

In order to assess the methodological quality of the included studies, the established risk-of-bias assessment tools were used based on the nature of study design. In the case of randomized clinical trials, Cochrane Risk of Bias Tool was applied to determine possible bias concerning randomization, concealment of allocation, outcome evaluation, and reporting. In the case of observational studies, the Newcastle-Ottawa Scale was used to determine

the quality of the studies using selected, comparability, and outcome assessment criteria. The risk-of-bias analysis allowed to estimate the strength of evidence that was included and interpreted the findings of the review.

Data synthesis

The included studies had different study design, probiotic strains, denture materials, and outcome measures making the use of narrative synthesis approach. The heterogeneity of the data available did not permit the use of quantitative meta-analysis. Rather, descriptive analysis was employed in summarizing the results and the results were compiled in tables to enable comparison of the study characteristics and results. The fabricated results were directed to the viability of probiotics, anti-Candida antibiofilm activity, and claimed clinical benefits with denture wearers.

Results and Discussion

Study selection

The study identification and selection process was done according to the PRISMA 2020 guidelines. An intensive search of electronic databases such as PubMed, Scopus, Web of science and Google scholar located a total of 312 records on probiotics, denture materials and Candida biofilms. Sifting 52 duplicate records out, 260 articles were left to undergo screening on title and abstract. In this screening process, 220 studies were eliminated due to lack of significance to probiotic interventions, denture materials, or fungal biofilm formation. Others were not included in the research as it investigated unrelated oral diseases and some of them were review papers or those without the required result.

After a preliminary screening procedure, 40 full-text articles were located and evaluated with regard to the established inclusion and exclusion criteria. In the process of full-text assessment, 20 articles were discarded because of the following reasons: There were no probiotic interventions, there was not enough data on Candida biofilms, or the article did not have any relevance to denture materials. 20 articles were included in the systematic review. These are studies that involve a combination of both laboratory and clinical trials that were conducted to determine the impact of probiotics on Candida biofilms and denture related infection. The PRISMA flow diagram is used to demonstrate the selection process.

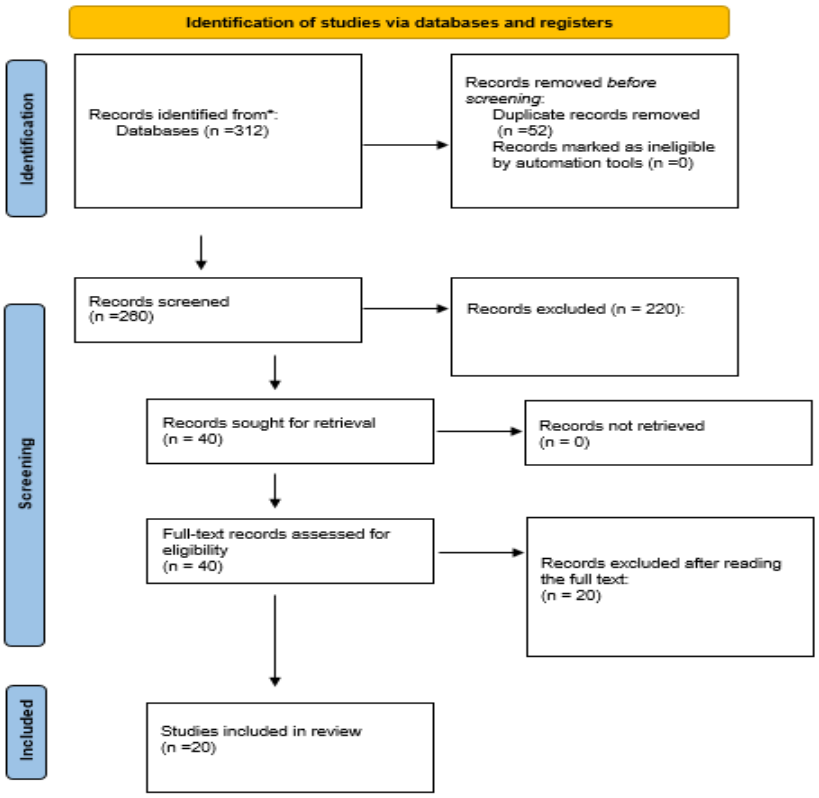

Figure 1. PRISMA flow diagram showing the study selection process.

Study characteristics

The articles included in this study were published in the last 2019-2025 and reported on different probiotic interventions that would regulate Candida colonization or enhance oral microbial balance in denture settings. Types of study designs were randomized clinical trials, observational clinical studies and laboratory experiments comparing the effect of antimicrobial use on denture material with regard to antimicrobial activity on the antimicrobial biofilm. Various probiotic strains were studied and they included Lactobacillus rhamnosus, Limosilactobacillus reuteri and multispecies probiotic formulations. The evaluated outcomes that were measured in the studies were; the decrease of Candida colonization, the prevention of fungal biofilm formation, the denture hygiene, and the decrease of the symptoms of denture stomatitis.

Table 1. Characteristics of studies included in the systematic review

Author(s)	Year	Country	Study Type	Probiotic / Intervention	Main Outcome
Abualsaud, R.; Aleraky, D.M.; Akhtar, S.; Khan, S.Q.; Gad, M.M.	2021	Saudi Arabia	In vitro study	Denture base resin containing nano-zirconia	Reduced *Candida albicans* biofilm formation
Adam, R.; Kimmie-Dhansay, F.	2021	South Africa	Observational clinical study	Denture wearers	High prevalence of denture-related stomatitis
Bajunaid, S.O.; Baras, B.H.; Weir, M.D.; Xu, H.H.K.	2022	USA	Laboratory study	Antimicrobial denture acrylic resin	Inhibition of *Candida* adhesion
Catanoze, I.A.; Cunha, B.G.; Costa, G.Q.; Freitas da Silva, E.V.; Duque, C.; Guiotti, A.M.	2022	Brazil	In vitro laboratory study	*Lactobacillus* probiotics	Inhibition of *Candida* biofilm on denture surfaces
Chhabra, T.; Shah, V.; Sethuraman, R. [14]	2019	India	Randomized crossover trial	Probiotic denture adhesive	Reduced *Candida* colony forming units
D'Ambrosio, F.; Santella, B.; Di Palo, M.P.; Giordano, F.; Lo Giudice, R.	2023	Italy	Narrative review	Oral microbiome in prosthesis wearers	Microbial changes in prosthetic environments
Elsayes, S.A.; El Attar, M.S.; ElHadary, A.; Aboulela, A.G.; Essawy, M.M.; Soliman, I.S.	2024	Egypt	Randomized clinical trial	Multispecies probiotics	Reduction in oral candidiasis among denture wearers
Evirgen, Ş.; Kahraman, E.N.; Korcan, S.E.; Yıldırım, B.; Şimşek, A.T.; Aydın, B.; Ünal, M.	2025	Turkey	Clinical study	Probiotic supplementation	Reduction of oral and prosthetic microbiota
Guzmán-Soto, I.; McTiernan, C.; Gonzalez-Gomez, M.; Ross, A.; Gupta, K.; Suuronen, E.J.; Mah, T.F. [15]	2021	Canada	Laboratory model study	Biofilm model systems	Understanding mechanisms of biofilm formation
How, Y.H.; Yeo, S.K. [16]	2021	Malaysia	Review study	Oral probiotic delivery systems	Probiotic carriers for oral health improvement
Hu, L.; Mao, Q.; Zhou, P.; Lv, X.; Hua, H.; Yan, Z. [17]	2019	China	Randomized clinical trial	*Streptococcus salivarius* K12	Reduced oral candidiasis
Hu, L.; Mao, Q.; Zhou, P.; Lv, X.; Hua, H.; Yan, Z. [18]	2019	China	Systematic review and meta-analysis	Probiotics	Effectiveness in prevention and treatment of oral candidiasis
Krittika, K.; Sukhija, U.; Bhathal, M.K.; Kukreja, N.; Chhabra, S.; Sachdeva, S.	2024	India	Randomized clinical trial	Probiotic oral rinse	Reduction in *Candida* species
Lee, X.; Vergara, C.; Lozano, C.P.	2019	Australia	Clinical trial	*Lactobacillus rhamnosus* SP1	Improvement of denture stomatitis severity
Morrison, A.G.; Sarkar, S.; Umar, S.; Lee, S.T.M.; Thomas, S.M.	2023	USA	Review study	Oral microbiome research	Relationship between microbiome and oral disease
Poon, Y.; Hui, M.	2023	China	Laboratory study	Lactobacilli metabolites	Inhibition of *Candida* biofilm formation
Rajão, A.; Silva, J.P.N.; Almeida-Nunes, D.L.; Rompante, P.; Rodrigues, C.F.; Andrade, J.C. [19]	2025	Portugal	Laboratory study	*Limosilactobacillus reuteri*	Reduction of *Candida* biofilms

Redfern, J.; Tosheva, L.; Malic, S.; Butcher, M.; Ramage, G.; Verran, J.	2022	UK	Microbiome study	Denture microbiome analysis	Identification of denture biofilm communities
Sharma, S.; Mohler, J.; Mahajan, S.D.; Schwartz, S.A.; Bruggemann, L.; Aalinkeel, R.	2023	USA	Review study	Microbial biofilm research	Mechanisms of biofilm formation and resistance
Ashouritoustani, R.; *et al.* [20]	2025	Not specified	Systematic review	Probiotic delivery methods	Comparative effectiveness in oral candidiasis

Antibiofilm effects

The capacity of probiotic microorganisms to prevent Candida adhesion and biofilm formation on denture surfaces was also assessed in several laboratory studies. These investigations showed that probiotic strains may make antimicrobial compounds and they may compete with pathogenic fungi with regards to adhesion site and hence minimise biofilm formation. To illustrate, an in vitro test revealed that Candida albicans had a reduced growth on acrylic resin denture surfaces in the presence of probiotic strains, which indicated a high antagonistic effect against fungal biofilms [8]. The studies examining metabolites that lactobacilli produce have found that they inhibited the biofilm formation and filamentation of various Candida species, which indicates that probiotic-derived compounds could disrupt the virulence of fungi [9]. More recent research has focused on the possibilities of the newly discovered probiotic strains that could disrupt oral Candida biofilms and enhance microbial balance in the oral cavity [19]. The results of these laboratory studies confirm the idea that the probiotic-based methods could be considered as an alternative method of fungal colonization prevention on the denture materials.

Clinical outcomes

Some clinical studies that were used to conduct this review also showed positive outcomes of probiotic interventions to denture users. Some of the trials have shown a decrease of Candida colony-forming units (CFU) and improvement of oral health parameters after the use of probiotics. As an example, a randomized clinical trial that examined multispecies probiotics discovered that there was a substantial decrease in oral candidiasis in new denture wearers [10]. The other clinical study found that the consumption of probiotics was linked to reduced oral and prosthetic microbial loads, indicating that probiotics have a positive impact on the oral microbiome [11]. Equally, oral rinses containing probiotics were proven to lower the amount of Candida in denture users compared to the traditional remedies [12]. Previous clinical studies also revealed that the use of Lactobacillus rhamnosus has led to improvement of the severity of Candida related denture stomatitis in the elderly [13]. These results are all showing that probiotics could be used to achieve better clinical results by decreasing fungal colonization, and promoting healthier oral microflora in denture wearers.

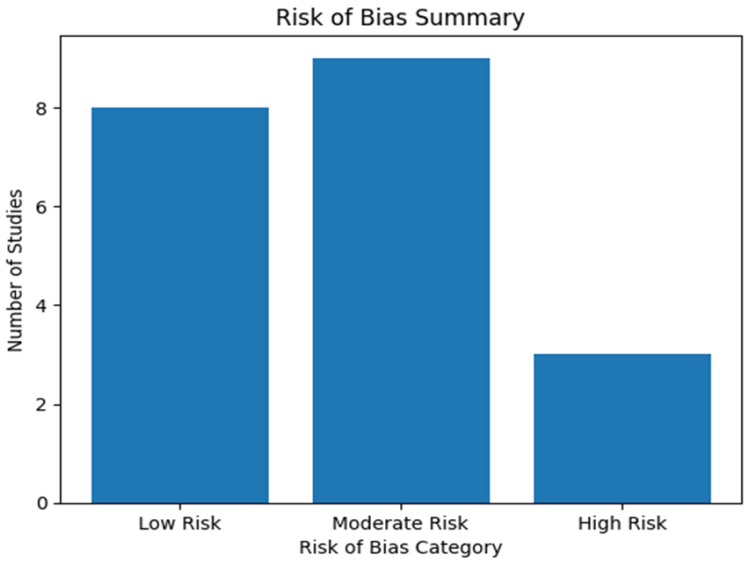

Figure 2. Risk of bias summary of the studies included in the systematic review.

The risk of bias assessment showed that the majority of the included studies had low to moderate methodological risk. Eight articles were classified as low risk, nine articles as moderate risk and three articles as high risk. Small sample sizes and limited procedures in clinical studies to blinding were predominantly linked to moderate risk.

According to the results of this systematic review, probiotic-based strategies demonstrate some promising perspectives of managing Candida colonization and biofilm formation in relation to denture materials and denture wearers. The research articles contained in the present paper show that probiotics could serve to lower the number of fungi and enhance the oral micro-flora of patients with removable tooth prostheses. A number of clinical trials showed a decrease in Candida colony-forming units and a decrease in the symptoms of denture stomatitis after using probiotics, indicating that probiotics can be used as an effective adjunct to managing denture-associated infections [10-13]. These results are also supported by laboratory studies that also reveal that candida adhesion and biofilm formation are significantly inhibited on denture base materials with the presence of probiotic strains [8, 9, 19]. The possible mechanism of action of probiotics antifungal effects is multifactorial. Competitive inhibition is one of such mechanisms in which probiotic microorganisms can occupy the binding sites on the surface of the denture and mouth tissues by the pathogenic fungi. This competition decreases the stability of Candida species to form stable biofilms. Moreover, most probiotic strains secrete antimicrobial metabolites which may include organic acids, hydrogen peroxide, and bacteriocin-like substances that may inhibit fungal growth and virulence. The structure of Candida biofilms could be disrupted, and fungal adhesion mechanisms could be interfered with by these antimicrobial compounds [9, 19]. Moreover, probiotics can be part of the process of restoring the healthy microbiome of the mouth by inhibiting opportunistic pathogens and supporting good microbial communities [2].

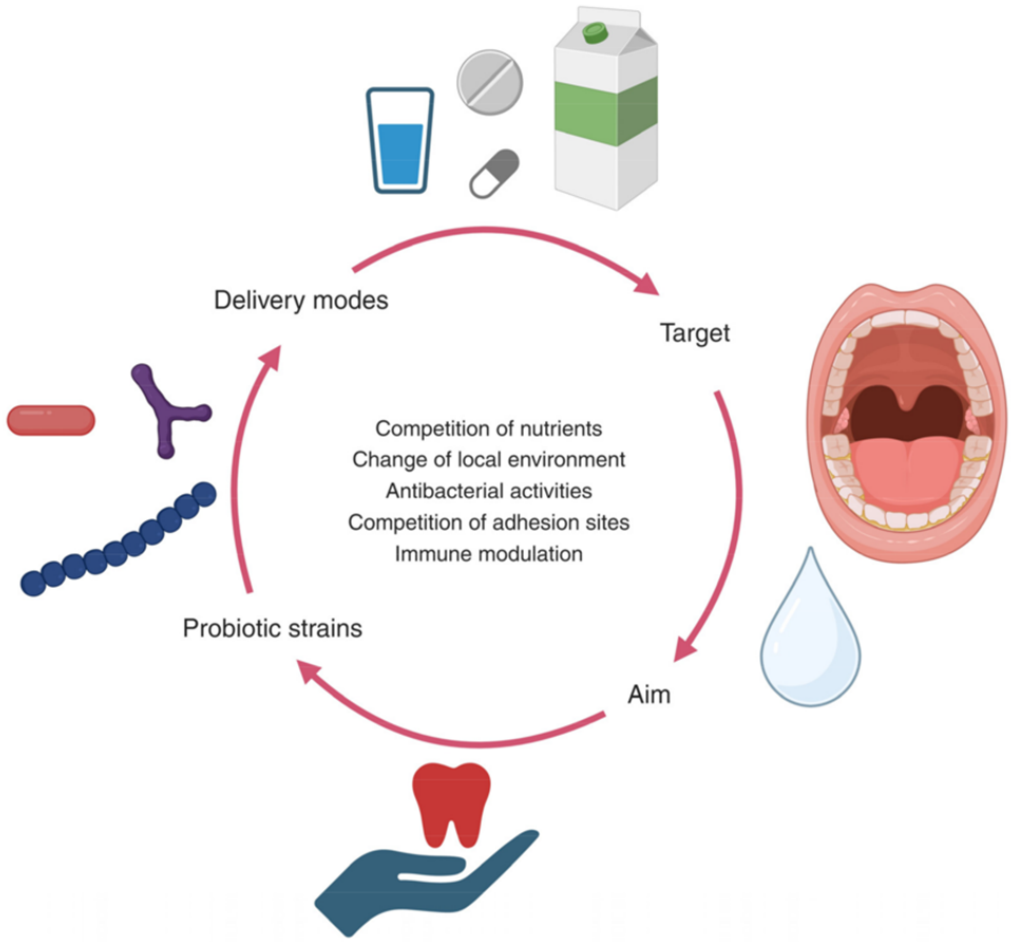

Figure 3. Interaction between probiotic bacteria and oral microbiota illustrating restoration of microbial balance and suppression of pathogenic microorganisms.

Clinically, probiotic use may offer a supportive measure of enhancing denture care and decreasing the rate of denture stomatitis in denture users. Probiotic interventions can thus be used as an extension to the traditional

denture hygiene routines and antifungal management of microbial imbalance and biofilm formation on denture surfaces [1]. These findings are limited in a number of ways. Most of the studies included used rather small sample sizes, which can be a limitation on the generalizability of the findings. Study design, probiotic strains, duration of treatment and outcome measures were heterogeneous which made a direct comparison of the studies difficult. More clinical trials and standardized procedures should be conducted in the future to further elucidate the efficacy of probiotic interventions to prevent and treat denture-associated Candida infections.

Conclusion

This is a systematic review that indicates that probiotics have a bright future in the regulation of Candida colonization and biofilm formation linked with the denture materials and denture wearers. The results of the laboratory and clinical research reveal that probiotic microorganisms have the capacity to prevent fungal adhesion, inhibit biofilm formation, and help achieve better balance of microorganisms in the mouth. Data on clinical trials indicates there is a possibility of helping to manage oral health by reducing the severity of denture stomatitis and the number of Candida colony-forming units in denture wearers using probiotic interventions. Besides being antifungal, probiotics could be used to aid in the care of dentures by altering the mouth microbiome and inhibiting the overgrowth of pathogenic microorganisms. Although these findings are encouraging, the body of evidence is still poor, as most studies have different study designs, probiotic strains and treatment regimes. In many studies, the sample size is also quite small, and it might impact the generalizability of their findings. Consequently, additional, larger clinical trials are required to prove the sustainability and security of probiotic-based approach of preventive and curative treatment of denture-associated fungi in the long run.

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Conflict of Interest: None

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Ethics Statement: This study received an ethical approval # FUGRP/2026/494/1418/1294.

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