International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Role of Probiotics in Dental Caries Management: A Narrative Review

Geetanjali Khatri Singh[1], Seema Thakur[2], Ashish Justa[3]

[1]MDS, Department of Pediatric and Preventive Dentistry
[2]Professor and HOD, Department of Pediatric and preventive Dentistry
[3]Assistant Professor, Department of Pediatric and preventive Dentistry

Abstract

One of the most common oral disorders in the world is dental caries. It has a direct impact on an individual's wellbeing and quality of life. Dental Caries can limit the individual's capacity of eating, speaking and smiling thereby greatly damaging personal and social life. Poor oral hygiene, the presence of particular carbohydrates in the diet, the formation of dental biofilms, the cariogenic microbial load, decreased salivary flow, inadequate fluoride exposure, gingival recession, genetic factors, and neglecting one's own oral health are major factors linked to the development of caries. A number of preventative steps have been taken to lower the chance that caries would develop. Probiotics are live microbes that when administered in suitable amounts confer health benefits on the host; they are recognized as potential adjunct therapeutic agents for several diseases. This review highlights various aspects of role probiotics in oral health and management of dental caries.

Keywords: Bifidobacteria, Cariogenic bacteria, Dental caries, Lactobacillus, Probiotics, Replacement therapy, Streptococcus mutans.

Introduction

The term probiotic is derived from a greek word which means "for life". According to the World Health Organisation, probiotics are described as "live microorganisms which, when administered in adequate amounts, confer a health benefit to the host".[1] Probiotic bacteria, primarily Lactobacillus and Bifidobacterium species, have been commonly employed in the treatment and prevention of gastrointestinal (GIT) disorders. Numerous studies have demonstrated the positive role of probiotics in disorders such as diarrhoea, peptic ulcers, GIT cancers, inflammatory bowel diseases, constipation, hypersensitivity responses, cardiovascular diseases and urogenital tract disorders.[2] Considering oral cavity to be a continuation of GIT, it has led to an upsurge in the interest of potential effects of probiotics in oral health.

The existing literature has acknowledged probiotics as an effective treatment agent for dental conditions. The therapeutic potential of probiotics against carious tooth has been conceptualised based on the idea of maintaining or restoring the natural oral microbiome by interfering and/or inhibiting pathogenic bacteria. Probiotic interventions positively influence the microbial composition, directly counteract dental plaque biofilm formation, and improve the host's immune system against cariogenic microbes.[3] Hence, the aim of this review is to describe the effect of probiotics on oral health and management of dental caries.

Material and Methods

An electronic search was carried out using databases from Google Scholar, PubMed, Science Direct, and Scopus. Keywords like dental caries, cariogenic bacteria, lactobacillus, and streptococcus mutans were used, either alone or in combination, with various Boolean operators. To remove the studies that were repeated, comparisons between various searches were conducted. Subsequently, all accessible paper abstracts were reviewed. The study covered all investigations on probiotic strains related to dental health. All other languages published than English versions of the articles were not included.

Role of Probiotics in General Health

Bacterial colonisation begins right from the birth of the infant. The adequate establishment of the intestinal flora after birth plays a crucial role in the development of innate and adaptive immune system. The gestational age, mode of delivery and diet influences the initial colonisation in infants. Neonates who are born by caesarean delivery, preterm, exposed to prenatal and perinatal antibiotics show a delay in intestinal commensal probiotic bacterial colonisation.[5] Breast fed infants are found to have Bifidobacteria predominant colonisation, whereas formula fed infants have equal colonization with Bacteroides and Bifidobacteria species. The infants are exposed to bacterial components from their mother while feeding which leads to acquiring few commensals in the initial days of life. This process is termed as "Bacterial imprinting".[6] There are numerous studies demonstrating the positive role of probiotics in disorders such as diarrhoea, peptic ulcers, GIT cancers, inflammatory bowel diseases (IBD), constipation, hypersensitivity responses, cardiovascular diseases and urogenital tract disorders. (Figure 1) Probiotics have previously been shown to alleviate inflammation associated with the GIT diseases.[7]

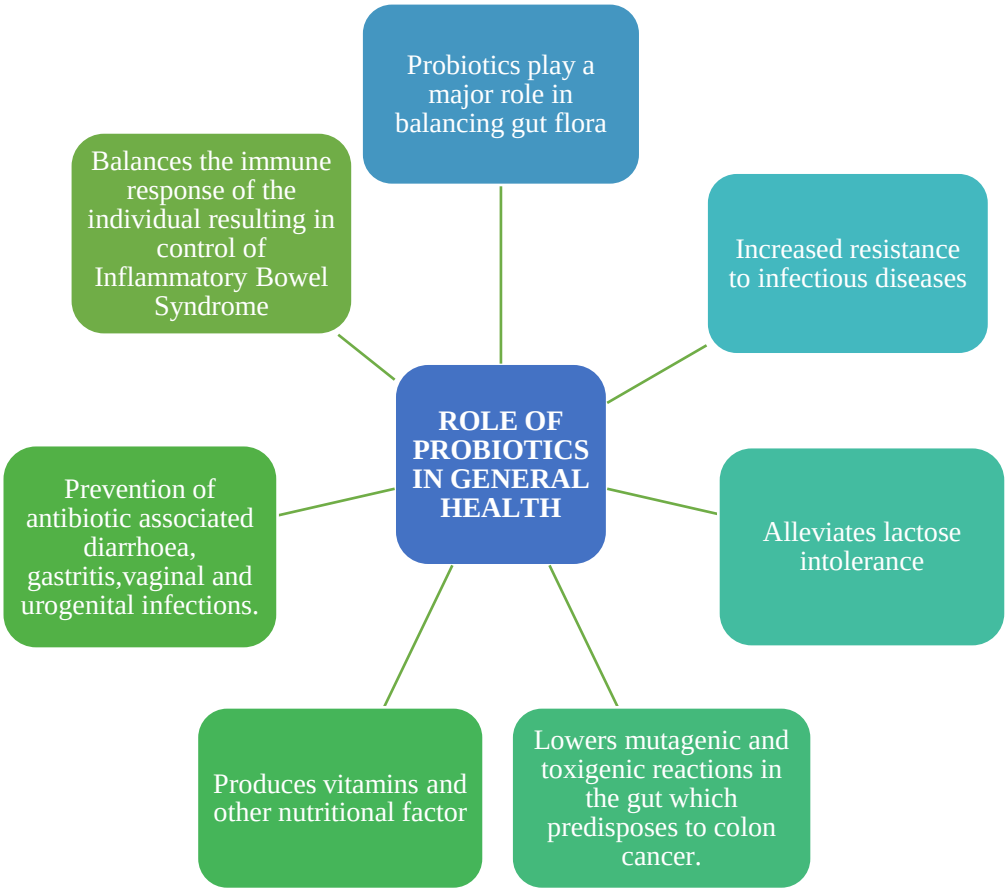

Figure- 1: Role of probiotics in general health.

Role of Probiotics in Oral Health

The oral cavity houses a great diversity of microbial species and each surface of the oral cavity is covered by numerous bacterial communication systems. Keigser et al reported the presence of more than thousand species of bacteria which may be in planktonic state or integrated into biofilms.[8] Although probiotic research in the field of dental sciences is relatively new, preliminary studies suggest their beneficial influence on maintaining oral health. The cause of oral disease is determined by a number of factors that include the proliferation of certain bacterial populations such as Streptococcus and Actinomycetes, their adherence to oral surfaces to facilitate amplified growth in dental plaque and disease-associated inflammation. Preliminary studies into probiotics have demonstrated positive results, particularly in the prevention and treatment of gingivitis, periodontitis and dental caries. The most common probiotic strains in the oral cavity include Lactobacillus and Bifidobacterium species. The probiotics helps in reducing the pathogenic oral microflora and have multiple effects in the oral cavity as depicted in Figure 2.

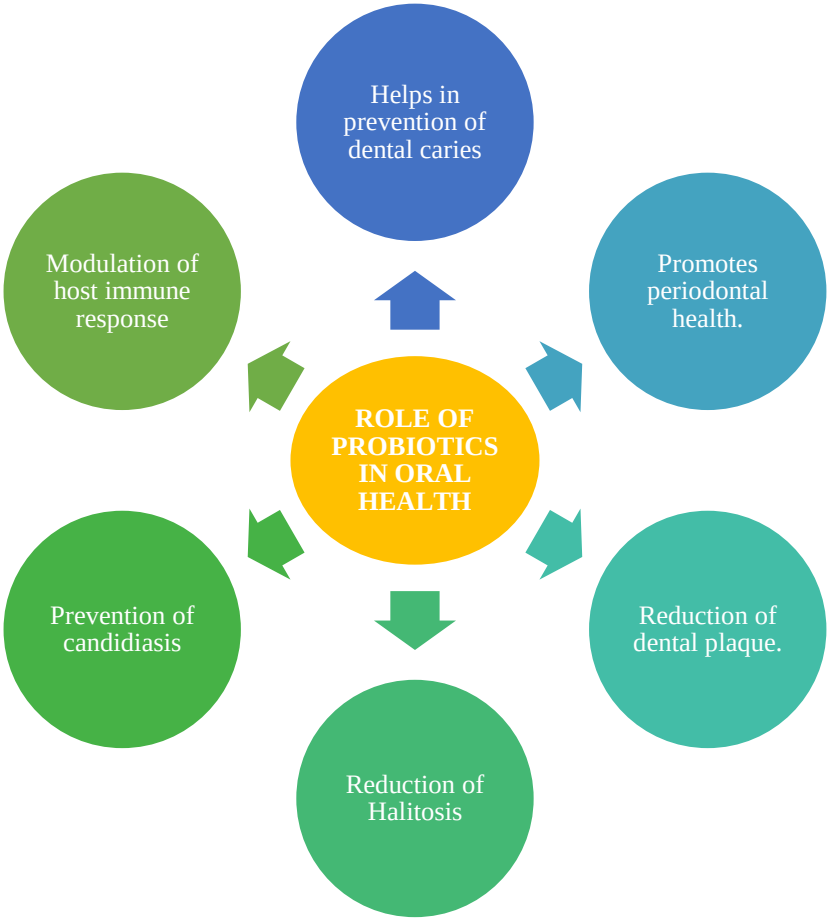

Figure- 2: Role of probiotics in oral health.

Keeping in mind the pathogenesis of oral diseases, a probiotic bio-therapeutic for the prevention and treatment of oral diseases should fulfil certain requirements. A successful therapeutic should target the etiologic factors, for dental caries therapeutics, focus should lie in the reduction of causative organisms such as S. mutans and reduction of dental plaque. For gingivitis and periodontitis, the mechanism of action of therapeutics should focus on diminution of dental plaque, reduction of number of periodontal pathogens such as the red complex and modulation of host immune response by controlling the release of inflammatory cytokines which may slow the destruction of supporting tissues. As for oral candidiasis, the main focus should lie in the reduction of Candida counts in the mouth as the primary etiology is dysbiosis.

A number of human clinical trials have reiterated the potential of probiotics as biotherapeutics for the prevention and treatment of oral diseases. [9]

Probiotic Biotherapeutics in Dental Caries

Major factors associated with caries development include poor oral hygiene, content of specific carbohydrates in the diet, dental biofilm formation etc. Even though all these factors have to intervene for dental caries to develop, microbiological factors are still the leading cause of this disease. Bacteriotherapy is therefore believed to have a significant impact in the prevention of disease. Previous literature has proven that by inhibiting cariogenic bacteria and enhancing commensal microbes in the oral cavity through frequent use of probiotic supplements have greatly lowered the incidence of caries. Probiotics act through various mechanisms including buffering the salivary pH, production of bacteriocin and enzymes (dextranase, mutanase, and urease), competing for adhesion and colonization on tooth surfaces.[10]

Mechanism of Action of Probiotic Bacteria in Prevention of Dental Caries

Dental caries is multifactorial in origin and the most commonly involved organisms are streptococcus mutans (MS). S. mutans is an acidogenic bacteria and rapidly metabolizes carbohydrates resulting in lowering of pH in oral cavity leading to disturbance in hemostasis of the oral microbial community.[6] Streptococcus mutans act as initiators and lactobacilli as secondary invaders which results in caries progression. The process of tooth caries ensues by the progression of adhesion, co-aggregation and secondary colonisation. One of the important mediators that promote adherence are the biofilms. Adhesion has been evaluated in vitro by counting the number of bacteria that adhere to saliva-coated hydroxyapatite (HA) and oral epithelium. Comparable to the early tooth colonizer streptococcus sanguis, lactobacillus rhamnosus showed the greatest levels of adhesion among probiotic strains.[11] Lactobacilli are known to play an important role in the maintenance of human health by simulating a native immunity and protection against infection of the pathogenic bacteria. Lactobacillus species strain GG is an effective probiotic as it produces organic acids, hydrogen peroxide, bacteriocins and adhesion inhibitors against streptococcus species.

Probiotics should be installed in the oral cavity for a specified period of time in order to exhibit its actions. They should adhere to the oral tissues for them to establish a cariostatic effect and thus should be part of biofilm to fight against cariogenic bacteria. The development of levels of secretory immunoglobulins in saliva of newborns has been studied under physiological conditions and after artificial colonisation with non-pathogenic, probiotic bacterial strain of Escherichia coli. The early colonization of E. coli was able to activate immune system to produce specific antibodies and immunoglobulins.[12] Thus, it was proved by various studies that early colonisation of infants with probiotic bacteria had a significant improvement in the overall immune system. Various mechanism of action of probiotics in prevention of dental caries have been depicted in figure-3.

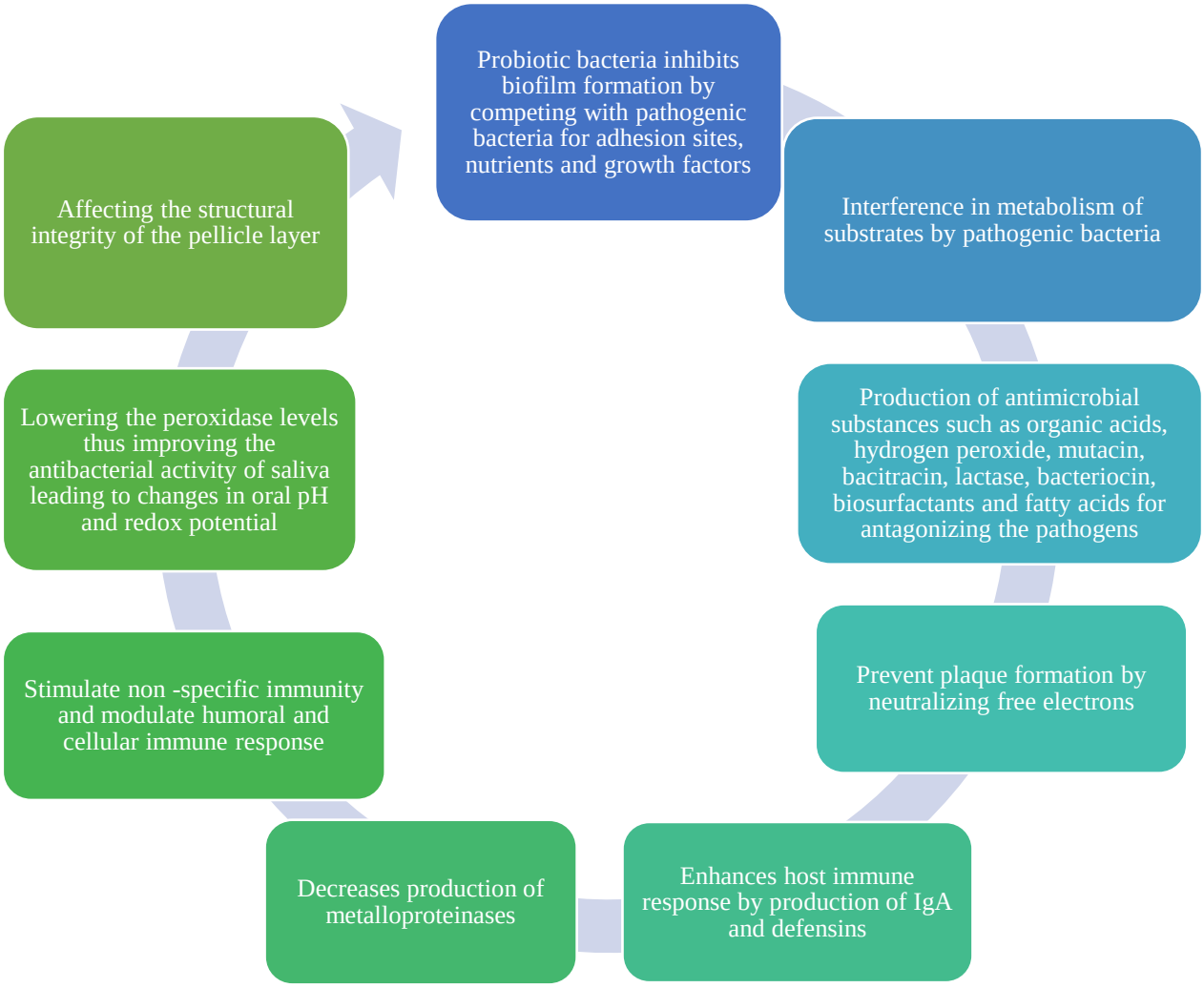

Figure-3: Mechanism of action of probiotic bacteria in prevention of dental caries.

Effect of Probiotic Bacteria on Caries Risk Factors

A limited studies has been carried out with caries development as an outcome while more have been focused on control of caries-related risk factors or so-called surrogate outcomes. These studies have mainly been short-term and the majority of them have demonstrated the capacity to reduce MS counts in saliva and/or plaque. It has been found that probiotics demonstrate the ability to reduce MS counts in saliva and/or plaque and have effect on salivary buffering capacity in the short-term administration.[13]

Current Status of Probiotic Biotherapeutics for Dental Caries

The initiation of dental caries can be caused due to the accumulation of dental plaque on oral surfaces. The goals for successful prevention of dental caries by a therapeutic are to inhibit the proliferation of pathogens such as S. mutans, to inhibit its adherence to the oral surfaces and to inhibit oral biofilm formation. The first study investigating probiotics for the inhibition of oral streptococci was performed by Meurman et al., in 1995. They performed an in vitro study and demonstrated the ability of LGG to inhibit oral streptococcus sobrinus.[14]

In a more recent study, Caglar et al. investigated the inhibitory potential of the probiotic strain L. reuteri ATCC 55730 on S. mutans proliferation. This group demonstrated a reduction of S. mutans following probiotic consumption, highlighting the potential of L. reuteri for dental caries prevention. Another

clinical trial demonstrated that LGG, incorporated in milk, reduced dental caries in a population of 3-4 year old children. The results demonstrated that the LGG treatment group had a lower incidence of dental caries associated with reduced S. mutans counts when compared to the control group. This further confirmed LGG's ability to prevent childhood caries, proposing additional potential as a dental caries therapeutic. [15,16]

Shortcomings and Future Aspects of Probiotics as Dental Biotherapeutics

Probiotics, unlike antibiotics can be used to treat and prevent oral diseases as a natural and long-term approach. Results from current researches appear optimistic that probiotics can become successful dental caries bio-therapeutics, however, few limitations and shortcomings need to be addressed. Current studies have demonstrated the potential of probiotic bacteria, but primarily with a focus on L. rhamnosus ATCC 53103 (GG) and a few L. reuteri strains. However, more probiotic bacteria should be screened for the inhibition of oral disease causing organisms. Meticulous effort is needed to screen a variety of probiotic strains for limiting oral pathogens. Initial screening of these bacteria should be followed by mechanistic studies that explore the reasoning for the observed effects of those probiotic bacteria. Well-planned studies should focus on the different aspects of oral disease and investigate each factor with probiotic treatment. For example, nutrient competition by probiotic bacteria, probiotic bacteriocin production for the inhibition of oral pathogens, co-aggregation of probiotic bacteria with oral pathogens and probiotic attachment to oral tissue should be investigated vividly.[17]

Moreover, probiotic bacteria have been shown to have the potential to secrete antibacterial substances. Further screening should be based on the probiotic release of such substances. More vivid research investigating the inhibitory activity of probiotic bacteria due to the release of antibacterial compounds should be confirmed by inactivating or blocking the release of probiotic antibacterial substances. Moreover, most studies attempting to elucidate probiotic inhibition of oral biofilm; have done so in mixed cultures. For a clear understanding of probiotic specific inhibition, pathogenic biofilms should be kept separate from the probiotic treatment. Again, a lack of established protocols limits such studies. In addition, further studies are needed to clarify the mechanisms of action.

Future Aspects

Innovative probiotic products that focus on oral health represent a new category of goods that go well beyond traditional over-the-counter remedies. With the changing lifestyle and feeding habits, globally, it is anticipated that rise in oral diseases will be proportional to other lifestyle diseases. Finding strains from locally produced fermented foods like kefir, curd, etc., and doing thorough clinical testing can help produce innovative probiotics with the required outcomes. These organic strains can lessen our reliance on chemically based interventions for maintaining dental health on a regular basis and preventing illness. Similarly, for serious oral diseases genetically modified microbes may open up a whole new dimension to the concept of probiotics in the near future. The strain can be modified to encompass biofilm formation, bacteriocin production etc. Host oral microbiota characterization can also be a possibility in the near future to understand the underlying conditions. This can assist in selecting a course of action or medication to tip the scales in favor of the beneficial bacteria. Nevertheless, since any product that is beneficial for oral health care must be used on a daily basis, probiotics may be added to toothpaste, mouthwash, chewing gum, sugar-free candies for youngsters, and other goods.[18] In certain western nations, some of these products are already over-the-counter, while in others, their popularity is growing quickly.

Conclusion

Research has demonstrated that probiotics directly suppress oral pathogens and alter the oral microenvironment, which prevents the pathogens from colonizing the mouth further. Indigenous probiotic preparations have also been shown to significantly prevent or reduce dental caries when administered continuously for a few weeks. Most of the studies indicates towards daily consumption of probiotics to produce the intended effects, such as inhibiting pathogens, growth of indigenous species and maintaining the pH balance Therefore, probiotics can be adopted as a novel approach to prevent the demineralization of enamel and improve oral health. Research to unravel the mechanisms of possible probiotic action and long-term clinical trials are further needed before including them into daily oral-health regimen.

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