



Anti-bacterial Efficacy of Probiotics used in Provisional Polymethyl Methacrylate Crowns against *Porphyromonos gingivalis* – An *In vitro* Study

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Aim: To evaluate the effect of Probiotic used in PMMA Temporary restorations on gingival inflammatory response by its action on the marginal gingival epithelial cells.

Materials and Methods: This is an in vitro Interventional pilot study using discs of PMMA (Group A) and PMMA incorporated with Probiotics (Group B . The effect of probiotics incorporated PMMA on strains of *Porphyromonos gingivalis* grown on culture plates will be assessed using zone of inhibition test and minimum inhibitory concentration was assessed . Data was recorded, tabulated and statistically evaluated using SPSS software.

Results: The zone of Inhibition in the Group B was (Mean = 16.30mm) is comparatively higher than that of Group A with mean value 12.92mm. Results states that among the various concentration of Probiotic Lozenges (2.5, 5, 10, 15 and 20 µg/ml) used to determine the antibacterial activity , Highest mean zone of inhibition was observed with 20 µg/ml with 16 mm, followed by 15 µg/ml with 14mm , 10 µg/ml with 9mm, 5 µg/ml with 11 mm & with the lowest inhibition observed in 2.5 µg/ml with 8mm. There is significant correlation between concentration of probiotics and its antibacterial efficacy. The increase in concentration of probiotics in the PMMA discs is directly proportional to its antibacterial efficacy against *P. gingivalis*.

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Conclusion: Thus the study proved a significant correlation between Probiotic used in PMMA Temporary crowns and reduction in gingival Inflammation at the margins of the restoration which will be beneficial when used in crowns used in patients undergoing Orthodontic treatment or Immediate Implant Loading with acrylic crowns.

Keywords: *Porphyromonas gingivalis*; probiotics; antibacterial; poly methyl methacrylate; provisional crowns.

1. INTRODUCTION

In dentistry, Provisional restoration refers to a fixed or removable prosthesis designed to enhance aesthetics, stabilization and function for a limited period of time after which it is to be replaced by a definitive prosthesis [1]. Commonly used materials for provisional restorations includes Poly methyl methacrylate (PMMA) and Poly ether ether ketone (PEEK). One of the major disadvantages of these provisional crowns is that it causes gingival inflammation/gingivitis around the soft tissue of the restoration. This ill effect is attributed to the inherent properties and surface of the PMMA material which harbours periodontal pathogens leading to biofilm formation and accumulation of plaque [2].

Gingivitis and Periodontitis are multifactorial diseases that encompasses the hard and soft tissue through microbial colonization (with or without invasion) thereby leading to inflammatory and adaptive immune responses of the host [3]. Being a gram negative anaerobe, *P. gingivalis* is one of the major pathogens associated with gingivitis [4]. If left uninterveined, gingivitis can result in chronic periodontitis, a disease that initiates with inflammation of the soft tissue and progresses to destruction of alveolar bone, ultimately resulting in tooth loss [5,6]. Lipopolysaccharide (LPS), hemagglutinins, gingipains, and fimbriae accounts to the virulence factors of *P. gingivalis*. These factors plays a vital role in the induction of immune inflammatory responses and resorption of alveolar bone [7].

The term "Probiotic", as opposed to "antibiotic", was initially proposed by Lilley and Stillwell in 1965 [8]. First probiotic species to be introduced in research was *Lactobacillus acidophilus* by Hull et al. in 1984 [8] followed by *Bifidobacterium bifidum* by Holcomb et al. in 1991.[8] In 1994, the World Health Organization deemed probiotics to be the next-most important immune defense system when commonly prescribed antibiotics are rendered useless by antibiotic resistance. According to WHO the probiotics are defined as

the live microorganisms which when administered in adequate amounts confer a health benefit on the host [8]. Some of the most well-studied probiotics include *Lactobacillus*, *Bifidobacterium*, and *Lactococcus* species that colonize the gut. These probiotics act as an adjuvant in the treatment of celiac diseases, obesity associated irritable bowel syndrome, campylobacter jejuni infection, and infant sepsis [9,10]. Commonly found in yogurts and other fermented foods, many *Lactobacillus* strains are Generally Recognized As Safe (GRAS) by the U.S. Food and Drug Administration (FDA) for the use in specific food productions.

The use of probiotic *Lactobacillus* and *Lactococcus* species is just beginning to be explored in the oral cavity [8,11,12]. Metchnikoff was the first to state that probiotics could provide a health benefit. Based on his study among Bulgarian population, he stated that probiotics in the form of fermented milk containing viable bacteria had a positive effect on the lifespan of the individuals [13]. These incidences paved way for a new concept of probiotics in medicine and dentistry [14].

Effect of probiotic against certain oral pathogens are well established by previous studies. Probiotics induce cidal or static inhibition of growth of pathogens through production of bacteriocins [14]. Probiotics also has the ability to modify the surrounding environment by altering the pH and/or the oxidation–reduction potential, which may compromise the ability of pathogens to become established. This anti-bacterial property of Probiotic is thus used in the current study to minimise the gingival pathogens around the provisional crowns. Thus, the aim of the study is to evaluate the Antibacterial efficacy of Probiotics incorporated in chemically activated Poly methyl methacrylate discs against the periodontal pathogen *Porphyromonas gingivalis*.

2. MATERIALS AND METHODS

Acrylic discs of 6mm diameter and 2mm thickness according to ISO standardisation is

fabricated using Chemically activated Poly methyl methacrylate [PMMA]. It is to be noted that the same material is used for fabrication of provisional crowns in our day to day practice. Commercially available probiotic lozenges were used in our study. This contained *Lactobacillus casei* Shirota = 6.5×10^6 , *L.sporogenes* = 10×10^6 and *Bifidobacterium* species = 2×10^6 according to the manufacturer. The discs were separated into two groups namely A and B with 12 samples in each group. Group A is the control group that consists of discs without probiotic coating whereas group B is the test group which is to be immersed in probiotic solution for 48 hrs at 37°C.

The study consists of two parts:

Comparing antibacterial efficacy between Group A (Control): Discs without Probiotic [15] + Group B (Test): Discs immersed in Probiotic lozenges [15] against *P. gingivalis*.

Evaluation of Minimum inhibitory concentration of Probiotic against *P. gingivalis* among 5 different concentrations (2.5, 5, 10, 15 and 20 µg/mL)

The periodontopathic bacterial strains *P. gingivalis* ATCC33277 was grown in half-strength brain heart infusion (BHI) broth. The bacteria are grown at 37°C in an anaerobic medium. The disc diffusion method was used to determine the antibacterial activity. The antimicrobial activity was determined using BHI agar medium supplemented with 5% defibrinated sheep blood, and the optical density (OD) of the bacterial inoculum was adjusted to 0.1 at 600 nm (0.5 McFarland standard). On a blood agar plate, the bacterial inoculum suspension (100 µL) was swabbed uniformly. This plate was then allowed to dry for 5 min. Various concentrations of extracts (2.5, 5, 10, and 20 mg/mL) at 20 µL were loaded onto a 6 mm sterile disc. The disc loaded with extracts in both the groups, A and B (3 each /petri dish) was placed on the surface of the medium., The compound loaded was then

allowed to diffuse for 5 min, and the plates were incubated at 37°C for 48 h. The inhibition zones at the end of the incubation, formed around the loaded disc were measured with a transparent ruler (in mm). This experimental study was performed in 4 petri dishes to accommodate the sample size of 12 in each group. The probiotic extract prepared in five different concentrations with dilution as follows: 2.5, 5, 10, 15 and 20 µg/mL. The PMMA discs were made as explained earlier and immersed in different concentration of probiotic for 48 hrs at 37°C and these discs were inoculated into *P. gingivalis* cultured plates. Incubation of 48 hrs at 37°C was carried out. The zone of inhibition found around the discs was measured using a transparent ruler. The values thus obtained from all the discs are noted and tabulated. 96-well plate microdilution method using these 5 concentrations was used to assess the Minimal inhibitory concentration (MIC). The lowest concentration at which no growth was observed was defined as MIC (µg/mL). Acquired Data was tabulated and analysed statistically.

3. RESULTS

Preliminary screening for antibiotic activity of probiotics against *P. gingivalis* was done using disc diffusion method. In this method, zone of inhibition represents the diameter of the area around the discs that is free of microbial growth of *P. gingivalis* measured in millimetres. The first part of the study results comparing the antimicrobial efficacy between two groups: One with probiotic discs and other without probiotic discs is stated in Table 1 and Fig. 5. Results of microscopic evaluation comparing the Zone of inhibition in Group A (12) and Group B (12) suggests that the zone of inhibition around Group B mean value of 20.30mm is comparatively higher than that of Group A with mean value 12.92mm. There was growth of colonies close to the discs in Group A (PMMA discs without Probiotics) as evident in the Fig. 4 below.

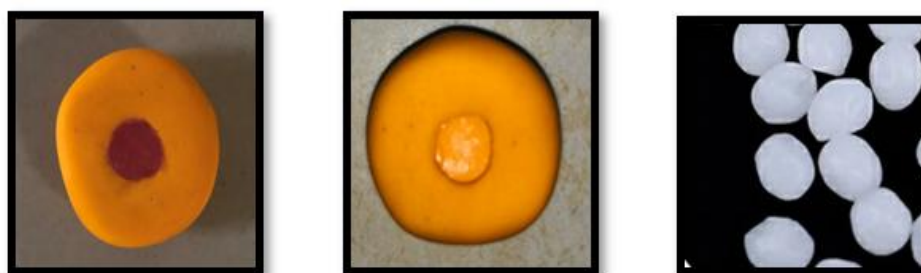


Fig. 1. Represents Procedure for fabrication of discs made up of Polymethyl methacrylate



Fig. 2. Represents A. Culture plate with evident *P. gingivalis* growth and B. Acrylic disc (Both group A and B) incorporated into the culture plate

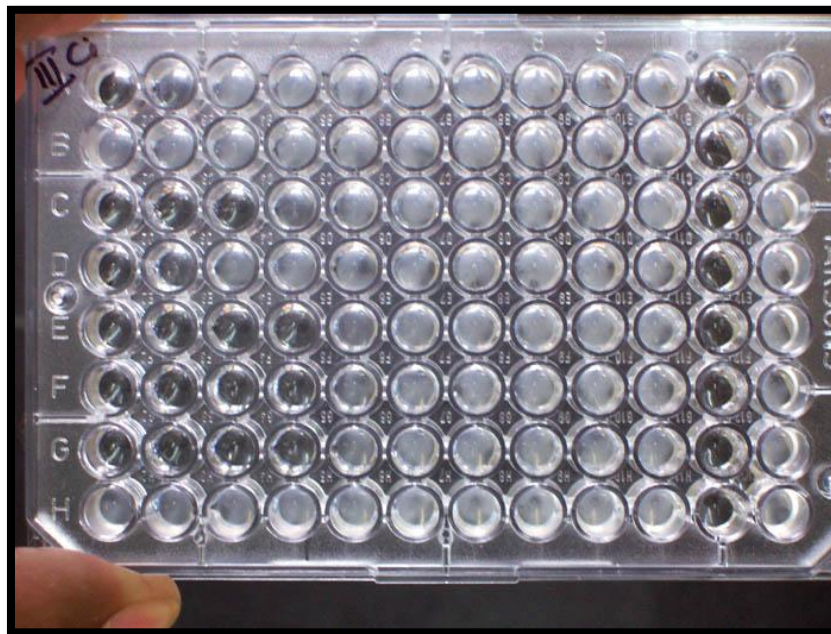


Fig. 3. Represents the 96 well Microdilution method used for assessing the minimum inhibitory concentration

The second part of the study compared antibacterial efficacy of various concentrations of probiotics against *P. gingivalis*. Results states that among the various concentration of probiotic lozenges (2.5, 5, 10, 15 and 20 $\mu\text{g/ml}$) used to determine the antibacterial activity , Highest mean zone of inhibition was observed with 20 $\mu\text{g/ml}$ with 16 mm, followed by 15 $\mu\text{g/ml}$ with 14mm , 10 $\mu\text{g/ml}$ with 9mm, 5 $\mu\text{g/ml}$ with 11 mm & with the lowest inhibition observed in 2.5 $\mu\text{g/ml}$ with 8mm as shown in Fig. 7 . There is

significant correlation between concentration of probiotics and its antibacterial efficacy. The increase in concentration of probiotics in the PMMA discs is directly proportional to its antibacterial efficacy against *P. gingivalis*.

The minimum inhibitory concentration (MIC) was determined by using various concentrations ranging from 7.5 to 100 $\mu\text{g/ml}$ by microdilution method and the results stated that the MIC of Probiotic against *P. gingivalis* was found to be 25 $\mu\text{g/ml}$.

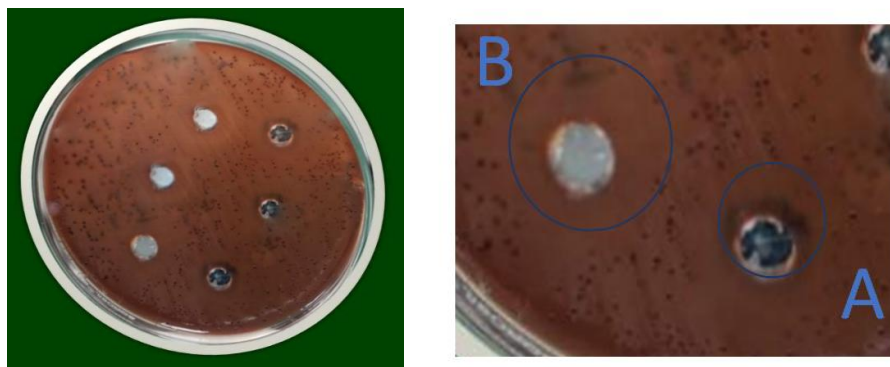


Fig. 4. Represents a. Culture plate with discs of both group A and B incorporated into it after incubation; b. Zone of Inhibition around the Discs of Group A (without Probiotics) and Group B (With Probiotics)

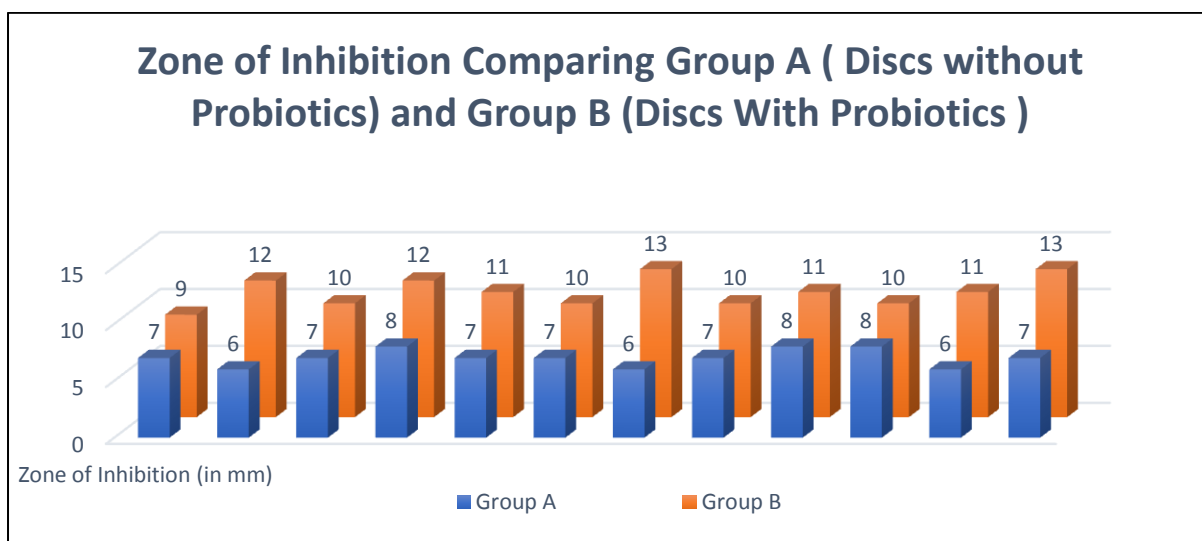


Fig. 5. Represents graphical representation of comparison of Antibacterial efficacy of Group A (discs without probiotics) and B (Discs with Probiotics) against *P. gingivalis*

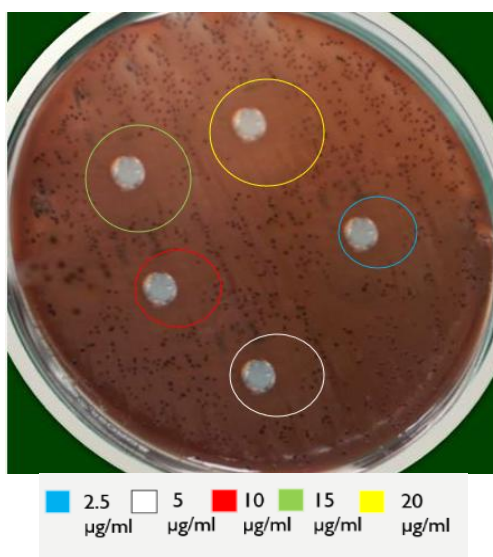


Fig. 6. Represents zone of inhibition of Probiotics in various concentrations against *P. gingivalis*

Table 1. Zone of inhibition around the disc (Diameter in mm)

	Disc 1	Disc 2	Disc 3	Disc 4	Disc 5	Disc 6	Disc 7	Disc 8	Disc 9	Disc 10	Disc 11	Disc 12	Mean
Group A	7	6	7	8	7	7	6	7	8	8	6	7	12.92308
Group B	9	12	10	12	11	10	13	10	11	10	11	13	20.30769

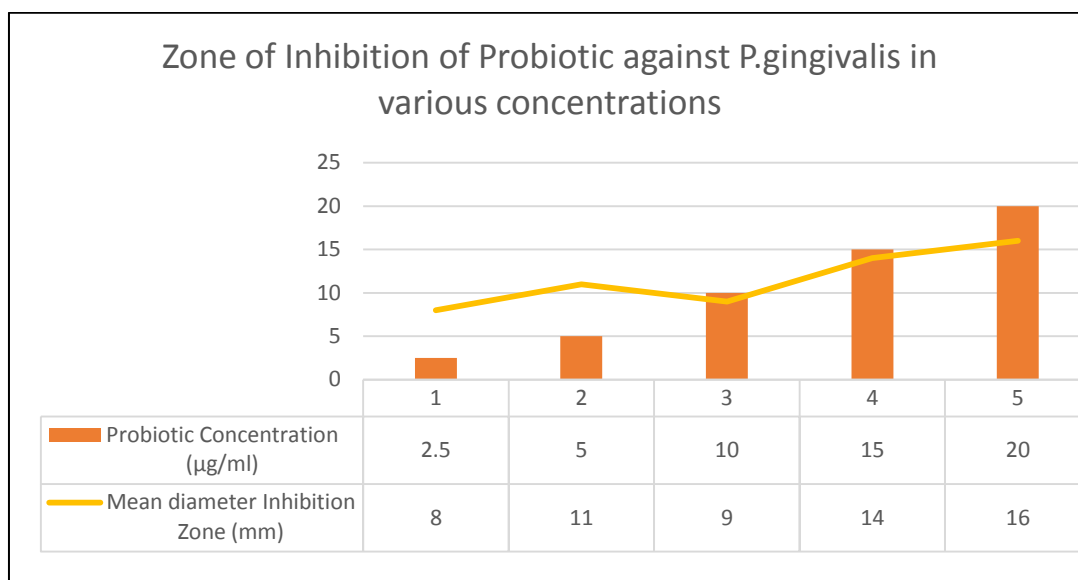


Fig. 7. Represents graphical correlation between zone of inhibition and Increasing concentration of Probiotic

4. DISCUSSION

Probiotic has been used for its gastro intestinal benefits for a long time. The effect of probiotics in promoting general health was extensively studied over the past few years. The mechanism of action of probiotic species against several other pathogens is by one or more of the following mechanisms:

- a. Exclusion and competition with potential pathogens for nutrients and epithelial cell adhesion,
- b. Production of antimicrobial substances against periodontal pathogenic organisms,
- c. Immune-modulations, and
- d. Enhancement of the mucosal barrier function.
- e. Immunomodulatory action of the probiotics regulates anti-inflammatory and proinflammatory cytokine production [16].

P. gingivalis is a Red complex pathogen and the most common bacterium involved in the onset of gingivitis and chronic periodontitis. *P. gingivalis* causes a microbial shift of the oral cavity, allowing for uncontrolled growth of the commensal bacterium [17]. To evade the host immune response, *P. gingivalis* has many ways. These include invasion by using gingipain proteases, which is a capsular polysaccharide responsible for neutrophil recruitment.

There is evidence of gingival inflammation around the crevice of the temporary crowns

made up of PMMA when they are used for more than 7 to 10 days. Goug et al. [14] in his study, found that the microbial analysis of the long-standing temporary crowns showed presence of periodontal pathogens with *P. gingivalis* being predominant bacterium.

There are only fewer experimental evidences exploring probiotic incorporated in PMMA temporary crown material in preventing gingival inflammation caused by *P. gingivalis*. Probiotic lozenges were selected as the material of choice in the present study as it contains Lactobacillus casei Shirota, Lactobacillus sporogenes and Bifidobacterium spp as the main constituents. The effect of probiotic tablets on gingivitis and different grades of periodontitis were studied by Grudianov et al. [18]. His study results suggested that probiotic treatment resulted in better microbiota normalization than control group. Krasse et al. [19] through his study suggested that, patients with moderate to severe gingivitis who were given L. reuteri formulations of probiotics, had reduced plaque and gingivitis scores compared to a placebo group. also confirmed the plaque inhibitory effect of probiotics was also proved by Vivekananda et al. [20].

The anti-inflammatory effects of probiotics were also suggested by Riccia and colleagues [21] through a study. It evaluated the effect of Lactobacillus brevis in a group of patients with chronic periodontitis. A significant reduction in salivary levels of prostaglandin E2 (PGE2) and

matrix metalloproteinases (MMPs) was observed in their results. The authors suggested that the beneficial anti-inflammatory effects of *L. brevis* is attributed to its ability to prevent the production of nitric oxide and PGE2. [21] Socransky et al. [22] stated that *Lactobacillus* probiotic strain has been used for its inhibitory action against periodontal pathogens through acid release. Another study by Silva et al. [23] suggests that *Lactobacillus* has the ability to produce different antimicrobial components. As stated by the author, these components include organic acids, hydrogen peroxide, low molecular weight antimicrobial substances, adhesion inhibitors and

bacteriocins. Recently, Köll et al. [24] characterized 22 strains of orally isolated lactobacilli to prove its antimicrobials activities on oral pathogens including pathogenic bacteria. This is in accordance with our in vitro study that suggests that, Probiotic at 20 µg/ml concentration has shown maximum antibacterial activity. Even at 2.5 µg/ml the current study proves inhibition in growth of *P. gingivalis*. Hence, it is clearly evident that probiotics can serve the purpose of being an adjuvant in PMMA crowns to increase its antibacterial efficacy against *P. gingivalis* thus preventing gingival inflammation.

Table 2. Reviews of literature

Author	Year	Probiotics Used in the Study	Study Statement	In Accordance / not in Accordance With Present Study
Socransky et al. [22]	1998	<i>Lactobacillus</i>	<i>Lactobacillus</i> is one of the important probiotic strain that has been used and the inhibitory action against periodontal pathogens by the production of acid.	Yes
Silva et al. [23]	1987	<i>Lactobacillus</i>	<i>Lactobacillus</i> can produce different antimicrobial components including organic acids, low molecular weight antimicrobial substances, hydrogen peroxide, bacteriocins, and adhesion inhibitors.	Yes
Köll et al. [24]	2008	22 Strains of Orally active probiotic	<i>Lactobacillus salivarius</i> were shown to suppress the growth of <i>Aggregatibacter actinomycetemcomitans</i> , <i>P. gingivalis</i> , and <i>Prevotella intermedia</i>	Yes
Matsuoka et al. [25]	2006	<i>L. salivaris</i>	The oral administration of probiotic tablets containing <i>L. salivarius</i> to healthy subjects significantly reduced the number of <i>P. gingivalis</i> in the saliva and subgingival plaque.	Yes
Irshad et al. [17]	2012	Bifidobacterium	<i>In vitro</i> invasion and survival of <i>Porphyromonas gingivalis</i> not inhibited by oral Bifidobacterium tablets in gingival fibroblasts cell lines	No
Vivekananda et al. [20]	2010	Prodentis Lozenges	The usage of Prodentis in chronic periodontitis patients had a reduction in a number of <i>P. gingivalis</i> , <i>A. actinomycetemcomitans</i> , and <i>P. intermedia</i> .	Yes

5. CONCLUSION

The present *in vitro* study confirms that probiotic used with Chemically activated PMMA has a significant antimicrobial effect against *P. gingivalis*. The minimum inhibitory concentration of probiotic against *P. gingivalis* is found to be 20µg/ml according to the present study. Hence, probiotics incorporated in PMMA is found to reduce the gingival inflammation by acting against *Porphyromonas gingivalis*. Limitations of the study includes, this being an *in vitro* study it cannot replicate the natural oral environment and its exact complex micro flora. Also, cytotoxicity and half-life of probiotics has to be considered when it is used in oral environment. Further clinical trials are required to provide a strong evidence for the use of probiotics in PMMA as a constituent.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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