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Comparison of bacterial colonization on absorbable non-coated suture with Triclosan- or Chlorhexidine-coated sutures: a randomized controlled study

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Abstract. – OBJECTIVE: The oral cavity is a colossal reservoir for the bacteria. The healing of tissues is compromised after flap surgery, particularly in the presence of sutures, as they can act as repositories for bacteria, ultimately leading to surgical site infections. Hence, antibacterial-coated sutures have been considered as an alternative to reduce the risk of these infections and further improve the wound healing of the tissues after flap surgery. Since minimal information is available on the effect of antibacterial-coated sutures on periodontal tissues, this study aims to clinically and microbiologically assess the antibacterial efficacy of Triclosan (TCS) and Chlorhexidine-coated sutures (CCS) on periodontal tissues compared to non-coated sutures (NCS).

PATIENTS AND METHODS: A total of 75 subjects with moderate to severe periodontitis were included in the study and randomly allocated to one of the three groups, (TCS, CCS, and NCS groups) equally. Suture removal was performed on postoperative day 8, and parameters such as wound healing and post-operative pain were evaluated. The retrieved suture samples were subjected to microbiological analysis and the bacteria were identified quantitatively and qualitatively.

RESULTS: Intragroup analysis of the wound healing index and post-operative pain for all the groups showed a significant improvement ($p<0.01$), from day 8 to day 30. Intergroup analysis of the wound healing index revealed significant wound healing ($p<0.05$) on day 15 and day 30. For post-operative pain, intergroup analyses showed significantly low pain scores ($p<0.01$) for the TCS group. Microbiologic analysis of aerobic colony counts in both anterior and posterior regions revealed significantly ($p<0.01$) least colony counts in TCS and highest colony counts in NCS groups, respectively. Although anaerobic colony counts were not statistically significant, relatively fewer colony counts were identified in the TCS group. Whereas, relatively higher anaerobic colony counts were seen in the CCS group in the anterior region and in the NCS group in the posterior region. Qualitative assessment revealed higher amounts of *Streptococcus* and *Staphylococcus* species in all the three groups (TCS, CCS, and NCS groups).

CONCLUSIONS: Antibacterial-coated sutures, particularly Triclosan-coated sutures, are effective in reducing bacterial accumulation compared to non-coated sutures. Therefore, these sutures can be effectively utilized in periodontal flap surgery.

Key Words:
Triclosan-coated sutures, Chlorhexidine-coated sutures, Culture media, Microbial colony count, Periodontal flap surgery.

Introduction

Periodontal health is considered an essential component of overall health[1]. Periodontitis is an inflammatory disease that affects the supporting

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tissues of the teeth viz., the periodontium[2]. When the disease progresses or when there is limited access to the root surfaces that harbor the plaque, a surgical approach such as access flap surgery is performed[3]. The success of this procedure depends on primary wound closure, which can be accomplished through the proper application of sutures for the stabilization of flaps with the help of suture materials[4]. Surgical site infections are one of the most common post-operative infections that occur after suturing since the suture material acts as a reservoir for the collection of microbes at the surgical site[5].

Various systemic antibiotics are being prescribed post-surgically to reduce the microbial load, specifically acting at the surgical site, aiming to prevent the chance of infections. However, antibiotic resistance is considered to be a major global health concern due to the overuse of antibiotics[6]. As a result, local delivery of antimicrobial agents is considered an alternative to eliminate the risk of antibiotic resistance and contemporarily, the use of antimicrobial-coated sutures is gaining importance[7]. Among the different types of antimicrobial-coated sutures, Triclosan and Chlorhexidine-coated sutures are commonly used. Triclosan is a broad-spectrum antibacterial agent and has anti-inflammatory properties. Chlorhexidine also has a wide range of antimicrobial activity and has been implicated in suture materials[7].

There is a shred of limited evidence regarding the use of antibacterial-coated sutures and their impact on oral tissues after periodontal surgeries. Therefore, the aim of this study is to evaluate the clinical and microbiological effectiveness of absorbable Triclosan and Chlorhexidine-coated sutures compared to absorbable non-coated sutures in patients undergoing periodontal flap surgery.

Materials and Methods

The present randomized controlled double-blinded study was approved by the institutional Ethics Committee (IEC Reference number-A-NIDS/IEC/2019004) and was registered with the Clinical Trials Registry India with registration number CTRI/2021/07/034877.

The sample size was calculated using Open Epi version 3 software with a 95% confidence interval and a statistical power of 80%. Considering the 10% attrition rate of the sample during the study, the sample size was rounded off to 25 for each group, resulting in an overall sample size of 75.

All 85 patients who reported to the Department of Periodontology in Anil Neerukonda Institute of Dental Sciences, between June 2020 and November 2021 were screened for eligibility. The patients in the age group of 20-60 years, without any history of usage of non-steroidal anti-inflammatory drugs (NSAIDs) and antibiotics for the past 3 months, with good general health, with an intraoral probing pocket depth of ≥5 mm after phase I periodontal therapy, and those who signed the informed consent were included in the study. Those who were smokers, who were immunocompromised, those with poor oral hygiene, pregnant and lactating women, and those who were known to be allergic to Triclosan and Chlorhexidine were excluded from the study. Before the commencement of the study, written information about the purpose and the procedure of the study was given to the patients and consent was obtained. The study was then approved by the Institutional Ethical Committee. Initial phase I therapy was performed for the selected patients and were re-evaluated after four weeks to assess the probing pocket depth. Of these patients, 75 patients with probing depths of ≥5 mm were selected and enrolled for the study. Based on random allocations, patients were divided into three equal groups i.e., experimental group (Group A- patients receiving Triclosan-coated, braided, polyglactin 910 absorbable sutures-MITSU AB and Group B- patients receiving Chlorhexidine-coated, braided, polyglactin 910 absorbable sutures-MITSU C+), and control group (Group C-patients receiving non-coated braided polyglactin 910 absorbable sutures-MITSU) (Figures 1-3).

A double-blinded protocol was followed throughout the study, in which both the subjects and the researcher were unaware of the type of suture material being used. Initially, all three types of suture materials (Triclosan-coated sutures, Chlorhexidine-coated sutures, and non-coated sutures) were placed in opaque envelopes by a third person who was aware of all the three groups in the study. One envelope was randomly selected by the researcher at the time of flap surgery. Flap surgery was performed for all the 75 patients under aseptic conditions. The direct loop suturing was done with one of the pre-determined suture materials, namely Triclosan-coated sutures (TCS), Chlorhexidine-coated sutures (CCS), and non-coated sutures (NCS). Post-operative instructions were given, and antibiotics were not prescribed. Warm water rinse was advised for 1 min, twice daily.

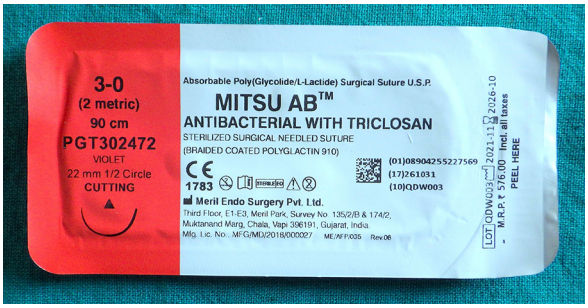

Figure 1. Triclosan-coated absorbable suture.

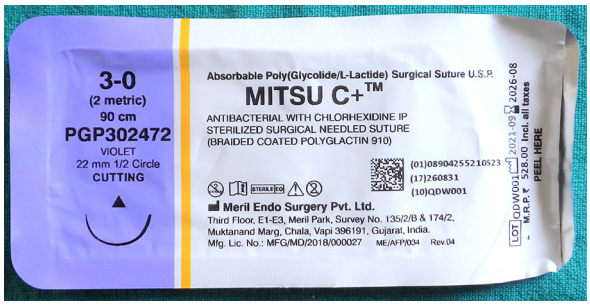

Figure 2. Chlorhexidine-coated absorbable suture.

The suture removal was done on the 8th postoperative day, and the suture materials from anterior and posterior regions were immediately processed for the further microbiological evaluation of quantitative (colony counts of aerobic and anaerobic bacteria) and qualitative (frequency of aerobic bacteria in suture samples collected from anterior and posterior regions) assessment in a sterile thyoglycolate medium containing vials (Figure 4).

The clinical parameters evaluated were the wound healing index by Landry and Turnbull[8] and post-operative pain scores by Mc Caffery and Beebe et al[9]. on postoperative days 8, 15 and 30.

During microbiological processing, the suture materials containing vials were incubated at 37°C and then the medium was inoculated onto agar plates using carpet culture (Figure 5). The agar plates were further incubated for aerobic culture in a biological incubator and for anaerobic culture in a Gas Pak jar at 37°C (Figure 6) and opened after 48 hours. Colony counts were calculated based on semi-quantitative analysis. All the colonies were further processed for preliminary tests like differential staining. Aerobic and anaerobic bacterial colonies were further classified based on colony morphology, hemolysis and swarming on culture plates, Gram reaction, morphology, and motility (Figure 7). In addition, frequencies of bacterial colonies were also observed.

The results were evaluated statistically using the following methods: inter-group comparison of wound healing index, postoperative pain, and colony forming units (CFUs) were performed using the Kruskal-Wallis test. An intra-group comparison of wound healing index and post-operative pain was carried out using the Friedman test. In the intergroup comparison of colony-forming units (CFUs) for aerobic and anaerobic bacteria in anterior and posterior regions, the significance between the two groups was evaluated using the Bonferroni test.

In intragroup analysis, the significance between the two intervals for wound healing index and postoperative pain was investigated using the Wilcoxon signed rank test; correlation for frequency of bacterial colonies was performed using Pearson's Chi-square test. In intergroup analysis, the significance between the two groups for the wound healing index and post-operative pain was determined by the Mann-Whitney U test.

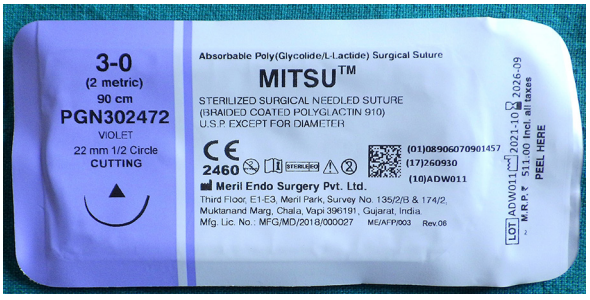

Figure 3. Non-coated absorbable suture.

Figure 4. Thyoglycolate medium containing sutures.

Statistical Analysis

The data collected was entered into an Excel sheet and subjected to statistical analysis using OpenEpi version 3 software (Atlanta, GA, USA) to generate graphs and tables.

The results were evaluated statistically using the following methods:

• Inter-group comparison of wound healing index and post-operative pain was made using the Kruskal-Wallis test (One-way ANOVA on ranks), which showed statistical significance on the 15th (p=0.029) and 30th days (p=0.023) for wound healing index and high statistical significance on 8th (p=0.00), 15th (p=0.001) and 30th (p=0.00) days for post-operative pain. The significance between the two groups for the wound healing index and post-operative pain was determined using the Mann-Whitney U test.

• Inter-group comparison of colony-forming units (CFUs) was done using the Kruskal-Wallis test (One-way ANOVA on ranks), which showed high statistical significance for colony-forming units of aerobic bacteria in anterior (p=0.00) and posterior (p=0.001) regions. In the intergroup comparison of colony-forming units (CFUs) for aerobic and anaerobic bacteria in anterior and posterior regions, the significance between the two groups was investigated using the Bonferroni test.

• Intra-group comparison of Wound healing index and postoperative pain on 8th, 15th and 30th days was made using the Friedman test, which showed high statistical significance for wound healing and also for post-operative pain in all the three groups i.e., TCS (p=0.00), CCS (p=0.00) and NCS (p=0.00). In the intragroup analysis, the significance between the two intervals for the wound healing index and post-operative pain was determined by the Wilcoxon signed rank test.

• The frequency of bacterial colonies was analyzed in all three groups. Polymicrobial colonies were highly statistically significant (p=0.00) in the NCS group and least in the TCS group. The correlation for the frequency of bacterial colonies was done using Pearson's Chi-square test.

p-value <0.05 was considered statistically significant for the analysis. p-value <0.01 was considered highly statistically significant for the analysis.

Figure 6. Anaerobic Gas Pak Jar.

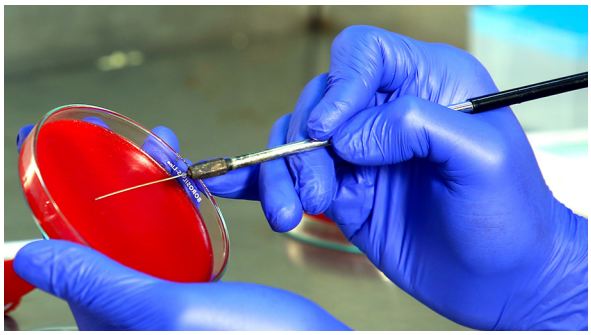

Figure 5. Inoculation of thyoglycolate medium onto agar plate.

Results

Out of 75 subjects included in the study, 44 were males with a mean age of 41.65 years and 31 were females with a mean age of 38.5 years. There were no losses to follow-ups in the study.

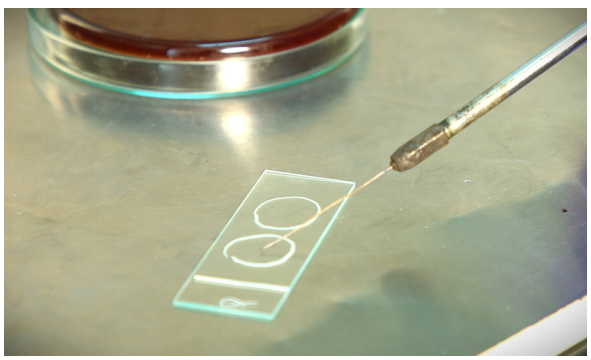

Figure 7. Colonies were inoculated onto glass slide for further microscopic evaluation by staining procedures.

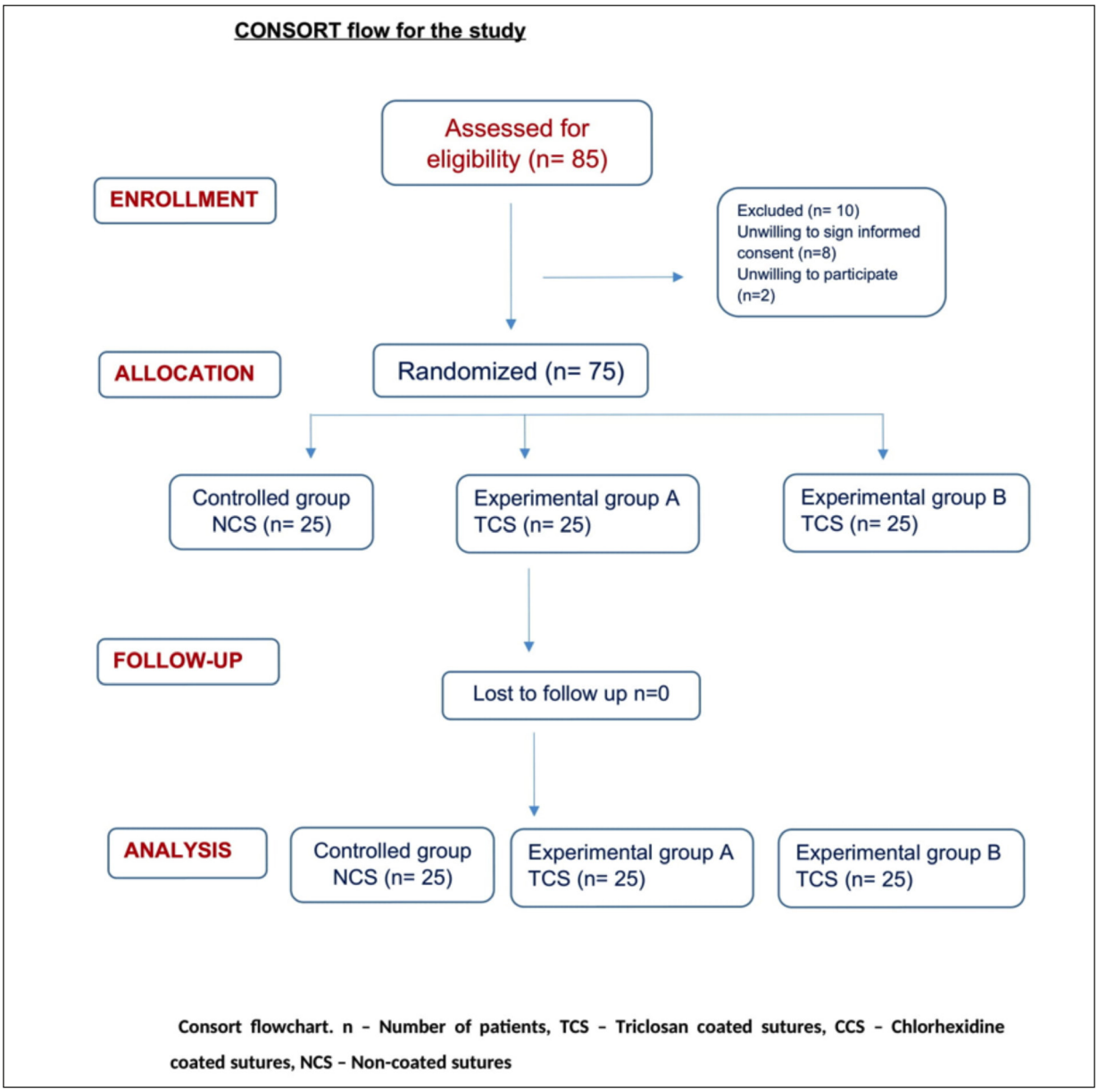

Figure 8. CONSORT flow for the study.

This data was represented in the form of a CONSORT flowchart (Figure 8).

Clinical Parameters

Wound healing index

Intragroup analysis of wound healing in all three groups on day 8, day 15, and day 30 revealed significantly better wound healing on day 30 and statistically significant improvements in wound healing from day 8 to day 30 within each group (Table I). Intergroup analysis of wound healing index on day 8 revealed no statistical significance. Whereas day 15 and day 30 revealed significantly better wound healing of the tissues in the TCS group when compared to the other two groups (Table II)

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Post-operative pain

Intragroup analysis of post-operative pain in all three groups on day 8, day 15 and day 30 revealed significantly less post-operative pain on day 30 and a gradual reduction in post-operative pain from day 8 to day 30 within each group (Table I). Intergroup analysis of postoperative pain on day 8, day 15 and day 30 revealed significantly less

Table I. Intragroup comparison of wound healing index and postoperative pain among the three groups at different intervals.

		Wound healing index		Post-operative pain	
Groups	**Intervals**	**Mean rank**	***p****	**Mean rank**	***p****
*NCS	Day 8	1.24	0.000	3.0	0.000
	Day 15	1.92		1.96	
	Day 30	2.84		1.04	
*TCS	Day 8	1.5	0.000	3.0	0.000
	Day 15	1.56		2.0	
	Day 30	2.94		1.0	
*CCS	Day 8	1.3	0.000	2.96	0.000
	Day 15	1.7		2.02	
	Day 30	3.0		1.02	

NCS*: Non-Coated Sutures; TCS*: Triclosan Coated Sutures; CCS*: Chlorhexidine Coated Sutures; *p**: probability value.

Table II. Intergroup comparison of wound healing index and postoperative pain among the three groups at different intervals.

		p*	
Interval	**Groups**	**Wound healing index**	**Post-operative pain**
Day 8	NCS*	0.456	0.000
	TCS*		
	CCS*		
Day 15	NCS*	0.029	0.001
	TCS*		
	CCS*		
Day 30	NCS*	0.023	0.000
	TCS*		
	CCS*		

NCS*: Non-Coated Sutures; TCS*: Triclosan Coated Sutures; CCS*: Chlorhexidine Coated Sutures; *p**: probability value.

postoperative pain in the TCS group when compared to the other two groups (Table II).

Microbiological Assessment

Colony forming units (quantitative assessment)

Intergroup analysis of colony-forming units of aerobic bacteria in anterior and posterior regions showed the least colony counts for the TCS group, followed by the CCS group and highest for the NCS groups. Intergroup analysis of colony-forming units of anaerobic bacteria in the anterior region between TCS, CCS and NCS groups showed the lowest colony counts for the TCS group, followed by the NCS group and highest in the CCS group. Whereas in the posterior region, the colony counts were least for the TCS group, followed by the CCS group, and highest for the NCS group (Tables III-IV).

Colony frequency

When the frequency of bacterial colonies was observed, polymicrobial colonies were least among the TCS group, followed by the CCS with the highest frequency among NCS groups. Whereas the monomicrobial colonies were the highest among the TCS group, followed by the CCS group, and least for the NCS groups (Table V).

Qualitative assessment

Qualitative assessment of aerobic bacteria for the TCS group in anterior and posterior regions revealed the highest frequencies of *Streptococcus* and *Staphylococcus* species and the least amounts of Diphtheroids. Qualitative assessment of aerobic bacteria for the CCS group revealed the highest frequencies of Streptococcus and *Staphylococcus* species the least amounts of *Neisseria* species in the anterior region and the highest frequencies of *Streptococcus* and

Table III. Colony forming units among the three groups in the anterior region.

Colonies	Groups	Mean Rank	*p**
Aerobic bacteria in anterior region	NCS*	49.02	0.000
	TCS*	24.40	
	CCS*	40.58	
Anaerobic bacteria in anterior region	NCS*	37.68	0.623
	TCS*	35.28	
	CCS*	41.04	

NCS*: Non-Coated Sutures; TCS*: Triclosan Coated Sutures; CCS*: Chlorhexidine Coated Sutures; *p**: probability value.

Table IV. Colony forming units among the three groups in posterior region.

Colonies	Groups	Mean Rank	*p**
Aerobic bacteria in posterior region	NCS*	47.80	0.001
	TCS*	25.64	
	CCS*	40.56	
Anaerobic bacteria in posterior region	NCS*	39.94	0.816
	TCS*	36.06	
	CCS*	38.00	

NCS*: Non-Coated Sutures; TCS*: Triclosan Coated Sutures; CCS*: Chlorhexidine Coated Sutures; *p**: probability value.

Table V. Frequency of bacterial colonies in three groups (TCS, CCS, and NCS).

	Type of Microbial Colony				
Group	Poly-Microbial	Mono-Microbial	Total	Pearson Chi-Square test	*p-value (2-tailed)
TCS	11 (44%)	14 (56%)	25	18.75	0.00
CCS	22 (88%)	3 (12%)	25		
NCS	23 (92%)	2 (8%)	25		
Total	56 (74.67%)	19 (25.33%)	75		

NCS*: Non-Coated Sutures; TCS*: Triclosan Coated Sutures; CCS*: Chlorhexidine Coated Sutures; *p**: probability value.

Table VI. Frequency of aerobic bacteria in three groups (TCS, CCS, and NCS).

Bacteria	TCS*				CCS*				NCS*			
	Anterior		Posterior		Anterior		Posterior		Anterior		Posterior	
Aerobic	n*	%	n*	%	n*	%	n*	%	n*	%	n*	%
Streptococcus species	6	24%	7	28%	6	24%	7	28%	5	20%	6	24%
Staphylococcus species	6	24%	7	28%	6	24%	7	28%	5	20%	6	24%
Diphtheroids	1	4%	2	8%	-	-	1	4%	1	4%	1	4%
Klebsiella pneumoniae	4	16%	4	16%	7	28%	4	16%	5	20%	7	28%
Neisseria species	1	4%	2	8%	1	4%	-	-	1	4%	1	4%

NCS*: Non-Coated Sutures; TCS*: Triclosan Coated Sutures; CCS*: Chlorhexidine Coated Sutures; n*: number of suture samples in which species were detected.

Staphylococcus species and the least amounts of Diphtheroids species in the posterior region. Qualitative assessment of aerobic bacteria for the NCS group in anterior and posterior regions revealed the highest amount of *Streptococcus* and *Staphylococcus* species and *Klebsiella pneumoniae* and the least amount of Diphtheroids and *Neisseria* species (Table VI).

Discussion

Periodontitis is believed to be due to the result of altered equilibrium between the controlled host activity and patho-microbionts in the oral cavity[10]. This disease is polymicrobial in nature and is modified by various host-modifying conditions towards plaque accumulation like oral hygiene, smoking, diabetes, stress etc[11]. In India[12], the prevalence rate of chronic periodontitis is 42%. Heitz-Mayfield et al[13], in a systematic review, compared various treatment options for chronic periodontal disease and stated that flap surgery, along with scaling and root planning, has shown an effective reduction of probing pocket depth, and gingival inflammation in deeper pockets. After performing the flap surgery, the flaps are approximated closely with the help of surgical suture materials to stabilize the flaps for uneventful wound healing.

The bacteria present in the oral cavity colonize in the form of biofilm over the tooth surface. Predominantly *Actinomyces* species colonize over the supragingival tooth surface. Subgingival biofilms are unique, as they are associated with both tooth and underlying tissue. Predominant species sub-gingivally, include red (e.g.: *P. gingivalis*, *T. denticola, T. forsythia*) and orange (e.g.: *P. intermedia*) colored complexes apart from *Actinomyces* species[14]. This environment of the oral cavity with enormous bacteria poses a greater challenge, particularly after flap surgery, as the employment of sutures colonizes the bacteria over them and may trigger inflammation at the surgical site and is considered one of the risk factors for *surgical site infections*[15]. The aqueous oral environment serves as a confounding factor, which increases the chance of the wicking action of bacteria through the suture thread, along with intraoral fluids[16].

In general, the post-operative complications account for about 30%[17]. Of these, surgical site infections are most commonly discussed and their incidence is estimated to be 2-5% and 20% of all healthcare-associated infections[18]. In the case of periodontal therapy, the prevalence of postsurgical complications is reported[19] to be 2.09%, among which post-operative infections are commonly discussed. Surgical site infections (SSI), previously called surgical wound infections, are defined as infections that occur within 30 days after surgery, affecting the incision or tissues at the surgical site. There may be an increased chance of virulence for SSI owing to the bacterial contiguity with suture material in the oral cavity. According to Owens and Stoessel[20], the risk of surgical site infection is considered to be increased when microorganisms exceed 10^5 per gram of tissue, and in the presence of sutures, even fewer organisms may be required to induce infection. Bacteria commonly associated with these infections include *S. aureus, S. epidermidis, E.coli*, MRSA (Methycillin Resistant *Staphylococcus Aureus*), MRSE (Methycillin Resistant *Staphylococcus Epidermidis*), *K. pneumonia*, etc.

Thus, in order to prevent microbial colonization over suture materials to reduce bacterial resistance and also the chance of infections, various antibacterial coatings have been developed in recent times, like Triclosan, Chlorhexidine, polyhexamethylene biguanide, and octenidine.

Triclosan (5-chloro-2-(2,4-dichlorophenoxy)-phenol) has been in use in dental hygiene for 40 years without any dysbiosis and cross resistance[21]. Triclosan is said to be safe, and no resistance is offered when used in suture materials and gets eliminated from blood in approximately 3.8 days. Triclosan safety and biocompatibility have been evaluated in Vicryl plus (polyglactin 910) antibacterial sutures, containing 472 µg/m of triclosan, with a lower concentration of 270 µg/m in EU countries. For polydioxanone suture (PDS) plus and monocryl plus, it is 2,360 µg/m (maximum exposure of 0.09 mg/kg body weight/day). The maximum single daily exposure to Triclosan from Vicryl Plus is 12% of daily exposure from various over-the-counter and personal care products[22]. Moreover, it is considered to be non-cytotoxic and non-carcinogenic, as no evidence of carcinogenic property was observed in chronic toxicity studies[23,24]. The toxicity of Triclosan is considered to be low due to rapid metabolism, excretion, lack of accumulation over time, and low exposure levels[25].

Chlorhexidine is a bisbiguanide and has been considered a gold standard due to its bactericidal and bacteriostatic properties. Hence, its use as an antibacterial coating has been considered, in order to decrease bacterial colonization and thereby improve the wound healing[26].

In the present study, intragroup analysis of the wound healing index for all three groups showed statistically significant ($p<0.01$) improvement in mean scores from day 8 to day 30, indicating improvement in wound healing on day 30, when compared to day 8 and day 15.

On the 8th postoperative day, although there was no statistical significance, the wound healing index score was relatively higher for the Triclosan-coated sutures (TCS) group, indicating better wound healing with Triclosan when compared to other sutures. This is in accordance with the study conducted by Kruthi et al[27], which stated that, on the 6th postoperative day, although not statistically significant, slightly better wound healing at the surgical site was observed with Triclosan-coated sutures when compared to non-coated sutures. Intergroup analysis on day 15 and day 30 after surgery revealed significant wound healing ($p<0.05$) in the patients who received Triclosan-coated sutures. This may be due to an initial decrease in bacterial count that adhered to this suture material, which may have favored wound healing in the TCS group. In addition, the immunomodulatory effect of Triclosan may be favorable for wound healing, as healing factors like Hydroxyproline and Transforming growth factor-β (TGF-β) were observed during the wound healing process. The bactericidal activity of Triclosan also helps in the disruption of cell membranes. These actions of Triclosan are seen against most of the bacteria, which minimize the risk of surgical site infections that may help in better wound healing[28].

The result of intergroup analysis in the present study is in contrast with the study conducted by Karde et al[7], where no statistically significant difference in wound healing was observed when Triclosan-coated sutures were compared to Chlorhexidine and non-coated sutures. The result in this study is also in contrast with the study conducted by Etemadi et al[29], where no antibacterial effect was observed with Triclosan-coated sutures 7 days after surgery, as bacteria accumulated were like that of silk sutures. However, larger sample sizes are required in the future to analyze the effect of Triclosan on wound healing.

In the present study, intragroup analysis of postoperative pain scores in TCS, CCS and NCS groups revealed a statistically significant ($p<0.01$) decrease in pain scores in all the groups, from day 8 to day 30, indicating the lowest pain score on day 30.

Intergroup analysis (TCS, CCS, and NCS groups) of postoperative pain on day 8, day 15 and day 30 revealed a statistical significance ($p<0.01$), with the lowest pain scores for TCS group, followed by the CCS group. The highest pain score was observed in the NCS group, indicating decreased post-operative pain with Triclosan-coated sutures. This could be due to the antibacterial nature of the Triclosan-coated suture that reduces the bacterial accumulation on these sutures, which may further decrease the inflammation, thereby reducing the pain scores. This is in accordance with the study by Ford et al[30], who stated that when Triclosan-coated sutures were used, decreased postoperative pain was observed when compared to non-coated sutures. Krishnan et al[31] reported a relatively higher incidence of postoperative pain on day 7 in patients who received Chlorhexidine coated sutures, whereas Mohan et al[32] reported a decreased postoperative pain on day 7 among patients who received Chlorhexidine-coated sutures and stated that it might be due to the use of antibiotics after surgery.

When intergroup analysis of colony forming units (CFU) was assessed upon microbial culture, a significantly smaller number of aerobic bacteria ($p<0.01$) in anterior and posterior regions was observed for TCS, indicating that Triclosan could effectively decrease bacterial adherence in the surgical site. This result is in accordance with the study conducted by Karde et al[7], who stated that colony counts for aerobic bacteria were less in Triclosan-coated sutures, followed by Chlorhexidine-coated sutures and high in non-coated sutures. Similarly, another study conducted by Kruthi et al[27], compared Triclosan-coated sutures with non-coated sutures. The authors stated that bacterial adherence was significantly less on Triclosan-coated sutures than on non-coated sutures. Also, Ford et al[28], in a randomized controlled trial, reported that decreased post-operative pain was observed when compared to non-coated sutures due to decreased bacterial adherence on Triclosan-coated sutures. Similarly, Jayaindhraeswaran et al[33] compared Triclosan-coated sutures with silk sutures and stated that 87.3% mean bacterial reduction was observed in Triclosan-coated sutures. Various systematic reviews and meta-analyses[34-36] also compared the efficacy of Triclosan-coated sutures with other non-coated sutures and inferred that these sutures demonstrated a significant beneficial effect in the prevention of surgical site infections after surgery. Ahmed et al[37], in their systematic review and meta-analysis, stated that the risk of developing surgical site infections was signifi-

cantly less in subjects where Triclosan-coated sutures were used. Wang et al[38], in their systematic review containing 17 randomized controlled trials, also reported that when Triclosan-coated sutures were used, there was a decrease in the rate of surgical site infections by 30%.

The result for colony-forming units identified in the anterior region in the present study is in contrast with the study conducted by Pelz et al[39], in which a higher number of bacteria, particularly pathogens, were identified upon Triclosan-coated sutures. Tabrizi et al[40], in a randomized controlled trial, compared the use of Triclosan-coated sutures with non-coated sutures in oral surgery and stated that Triclosan-coated sutures did not effectively reduce bacterial accumulation and that these sutures have no effect on reducing the incidence of surgical site infections.

When CFUs for anaerobic bacterial counts were observed in anterior and posterior regions, they were not statistically significant ($p>0.05$), but they were identified in the least numbers on Triclosan-coated sutures. In contrast, the highest counts were observed in Chlorhexidine-coated sutures and non-coated sutures in anterior and posterior regions, respectively. By this, it can be inferred that the least anaerobic bacterial count accumulation is seen on Triclosan-coated sutures. The least adherence of bacteria on Triclosan-coated sutures compared to Chlorhexidine-coated sutures could be due to its immunomodulatory, bactericidal, and bacteriostatic properties. However, an increased adherence of anaerobic bacteria on Chlorhexidine-coated sutures may be due to insufficient drug concentration present in the suture[7]. Similarly, the study conducted by Gaur et al[26], compared Chlorhexidine-coated sutures with non-coated sutures and stated that Chlorhexidine-coated sutures did not effectively decrease the total oral pathogens, and hence these coated sutures did not offer any advantage in intraoral surgery.

The result for CFUs for anaerobic bacteria in the present study is in contrast with the study conducted by Sharma et al[41], who stated that anaerobic bacterial count was lower on Chlorhexidine-coated sutures than on non-coated sutures. The result in the present study is also in contrast with the study conducted by Krishnan et al[31], who stated that the Chlorhexidine-coated sutures showed reduced infection rates than Triclosan-coated sutures, indicating less bacterial colonization on Chlorhexidine-coated sutures.

Hence, it can be inferred that, in the present study, both aerobic and anaerobic bacterial counts were significantly less in the group that received Triclosan-coated sutures (TCS) than the other two groups (CCS and NCS). Also, there is no significant difference in bacterial colonization in the anterior and posterior regions. Masini et al[42] stated that there was a significant reduction in bacterial count when Triclosan-coated sutures were used when compared to non-coated sutures. Wang et al[38], in a systematic review and meta-analysis, stated that Triclosan-coated sutures significantly reduced the risk of bacterial colonization on suture materials, thus aiding in reducing the risk of surgical site infections.

In the present study, all three suture groups significantly ($p<0.05$) exhibited polymicrobial colonies. The frequency of polymicrobial colonies involving 2 or more bacteria for TCS, CCS and NCS groups was 44%, 88% and 92%, respectively. By this, it can be inferred that there is a reduced frequency of polymicrobial colonies in the TCS group which is a relevant finding with respect to wound healing and antibiotic resistance when compared to the other two groups. However, further studies should be conducted in the future to determine the bacterial interactions in antibacterial-coated sutures.

In the present study, Qualitative assessment of aerobic bacteria in anterior and posterior regions showed that the highest amounts of *Streptococcus* and *Staphylococcus* species were identified in all three groups. In addition to these species, *Klebsiella pneumoniae* was identified as one of the highest quantities in the NCS group.

The identification of these species could be compared to the study conducted by Karde et al[7], where gram staining identified Streptococci, Staphylococci, *Actinomyces*, *E.coli*, and *Pepto Streptococcus* species. Janani and Kumar[43] stated that Triclosan-coated sutures inhibit the bacteria involved in surgical site infections i.e., *Staphylococcus Aureus*, *Staphylococcus Epidermidis*, *Escherichia coli* and *Klebsiella pneumonia*. Ford et al[30] stated that Triclosan-coated sutures significantly reduced colonization of *Staphylococcus Aureus*, *Staphylococcus Epidermidis* and methicillin-resistant variants of these microbes. In contrast, a study conducted by Venema et al[44] evaluated *in-vitro* adherence of bacteria on Triclosan-coated sutures and stated that these sutures showed no bacterial inhibition zone with *Streptococcus* species.

Limitations of the Study

The limitations of the present study may be related to the limited sample size and the use of qualitative methods for assessing anaerobic

bacteria, which may not provide the most precise results. However, studies with larger sample sizes may be required in the future to evaluate the exact role of antibacterial-coated sutures in periodontal surgery. Since most of the periodontopathic bacteria involved in periodontitis are anaerobic in nature, analysis of these bacteria using polymerase chain reaction (PCR) involving 16s r RNA analysis and performing the antibiotic sensitivity tests to identify susceptible bacteria, may be beneficial in the future.

Conclusions

The use of Triclosan-coated sutures in the present study showed decreased aerobic and anaerobic bacterial counts on these sutures, when compared to chlorhexidine-coated and non-coated sutures, thus decreasing the risk of surgical site infections. This reduction in bacterial counts also helped in improving wound healing and decreasing post-operative complications, thereby reducing the unnecessary use o\f systemic antibiotics following periodontal flap surgery.

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Conflicts of Interest
The authors declare that they have no competing interests.

Informed Consent
Informed consent was obtained from all subjects involved in the study.

Ethics Approval
The study was approved by the Ethical Committee of Anil Neerukonda Institute of Dental Sciences (ANIDS/IEC/2019004; 18.11.19).

Data Availability
Data sets will be provided on request by the authors.

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