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EVALUATION OF THE EFFICACY OF COATED AND NON-COATED SUTURES IN THE REDUCTION OF BACTERIAL LOAD: A SYSTEMATIC REVIEW

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ABSTRACT

Aim: To systematically evaluate the effectiveness of antimicrobial-coated sutures compared with non-coated sutures in reducing bacterial load and improving clinical outcomes following periodontal surgical procedures.

Methods: This systematic review was conducted in accordance with the PRISMA 2020 guidelines and registered in PROSPERO (CRD420251163080). Electronic databases (PubMed, ScienceDirect, Wiley Online Library, Cochrane Library, and Google Scholar) were searched for studies published between January 2000 and May 2025. Eligible studies included randomized controlled trials, controlled clinical trials, comparative observational studies, and well-designed in vitro investigations evaluating antimicrobial-coated versus non-coated sutures in periodontal surgery. Methodological quality was assessed using the Cochrane Risk of Bias 2 tool for randomized trials and a modified Newcastle–Ottawa Scale for non-randomized and in vitro studies. All eligible studies were included in the qualitative synthesis; however, quantitative meta-analysis was restricted to randomized clinical trials reporting comparable microbiological outcomes. Pooled estimates were calculated using a random-effects model and expressed as standardized mean differences (SMDs) with 95% confidence intervals (CI).

Results: Eleven studies met the inclusion criteria, comprising seven randomized clinical trials and four in vitro investigations. The studies evaluated a range of antimicrobial coatings, including triclosan, chlorhexidine, tetracycline, neem oil, and aloe vera. Qualitative synthesis demonstrated a consistent trend toward reduced bacterial colonization with antimicrobial-coated sutures, with several studies also reporting improved wound healing and postoperative comfort. Three randomized clinical trials involving 94 participants were eligible for quantitative synthesis. The pooled analysis demonstrated a moderate trend favoring antimicrobial-coated sutures (SMD = –0.68, 95% CI: –1.38 to 0.02); however, the overall effect was not statistically significant. Substantial heterogeneity was observed among the included clinical studies ($I^2 = 72\%$).

Conclusion: Antimicrobial-coated sutures demonstrate a consistent tendency to reduce bacterial colonization and may provide additional benefits in wound healing and postoperative comfort following periodontal surgery. Although the pooled clinical evidence suggests a favorable direction of effect, the available data remain inconclusive because the overall effect did not reach statistical significance and considerable heterogeneity existed among studies. Larger, well-designed randomized clinical trials employing standardized microbiological and clinical outcome measures are required to strengthen the evidence base.

KEYWORDS: Periodontal surgery; antimicrobial-coated sutures; triclosan; chlorhexidine; bacterial load; wound healing; systematic review.

INTRODUCTION

Periodontal disease is a chronic, multifactorial inflammatory condition and remains one of the most prevalent oral health problems worldwide. It is a leading cause of tooth loss, characterized by gingival inflammation, periodontal pocket formation, and progressive destruction of the supporting structures of the teeth, including connective tissue and alveolar bone.1 The primary objective of periodontal therapy is to halt disease progression, preserve the natural dentition, and restore function and comfort. While non-surgical interventions are effective for managing mild to moderate periodontitis, advanced cases often require surgical intervention such as open flap debridement for optimal clinical outcomes.1

A critical component of successful periodontal surgery is effective wound closure, which not only ensures proper healing but also minimizes the risk of microbial contamination at the surgical site.2,3 The oral cavity harbors a dense and diverse microbial population, with saliva containing approximately 7.5×10^8 microorganisms per milliliter.2 Consequently, sutures placed in this environment are continuously exposed to microbial biofilms and may act as conduits for bacterial ingress, potentially leading to persistent inflammation and surgical site infections (SSIs).2

SSIs are a significant postoperative complication, occurring in up to 10% of healthy individuals and more frequently in those with compromised immunity.4,5 Clinical manifestations include swelling, erythema, pain, exudation, abscess formation, and delayed wound healing.5 Traditional suture materials vary in composition (e.g., natural or synthetic, monofilament or braided, absorbable or non-absorbable), each exhibiting different tendencies for microbial adherence and biofilm development.6,7

To address this challenge, antimicrobial-coated sutures, for instance those impregnated with agents like triclosan or chlorhexidine have been developed.8 These sutures aim to inhibit bacterial colonization along the suture line and reduce the incidence of SSIs. While a large body of evidence, including the comprehensive systematic review and meta-analysis,9,10 has demonstrated that triclosan-coated sutures significantly reduce the incidence of surgical site infections (SSIs) across a variety of surgical disciplines, the findings are largely generalized and not specific to the periodontal context. Given the unique microbial environment of the oral cavity and the distinct healing challenges encountered in periodontal surgeries, the extrapolation of these results to periodontal procedures remains limited.

This systematic review aims to bridge the current gap in literature by evaluating and synthesizing evidence on the effectiveness of antimicrobial-coated versus conventional sutures in reducing bacterial load and postoperative infections, with a specific focus on periodontal surgical procedures, an area that has not been adequately addressed.

METHODOLOGY

Protocol Development

This systematic review was conducted in accordance with the PRISMA 2020 statement11 and registered in Prospective Registration of Systematic Review (PROSPERO) CRD420251163080.

Study Design

The present study was structured using the Participants (P), Intervention (I), Comparison (C), and Outcome (O) framework to address the research question:

“Do antimicrobial-coated sutures offer superior outcomes in reducing bacterial load and surgical site infections compared to non-coated sutures in periodontal surgeries?”

P (Population): Patients undergoing periodontal surgical procedures

I (Intervention): Use of antimicrobial-coated sutures (e.g., triclosan-, chlorhexidine-coated)

C (Comparator): Use of non-coated (conventional) sutures

O (Outcomes): Reduction in bacterial load, incidence of surgical site infections (SSIs), and improvement in clinical wound healing parameters

Eligibility Criteria

Studies were considered eligible for inclusion if they were published in English between January 2000 and May 2025, compared antimicrobial-coated sutures with non-coated sutures specifically in periodontal surgical settings, and reported outcomes related to bacterial load, surgical site infections (SSIs), and/or clinical wound healing such as inflammation, wound dehiscence, or healing scores. Eligible study designs included randomized controlled trials (RCTs), controlled clinical trials, comparative observational studies, and well-designed in vitro experimental investigations comparing antimicrobial-coated and non-coated sutures. Both quantitative outcomes, such as microbial counts and healing index scores, and qualitative assessments relevant to suture performance were accepted for analysis. Studies were excluded if they were published in languages other than English, released prior to 2000, or categorized as narrative reviews, systematic reviews, meta-analyses, editorials, letters to the editor, abstracts without full-text availability, or animal studies. Well-designed in vitro investigations evaluating antimicrobial-coated and non-coated sutures under standardized experimental conditions were considered eligible because they provide mechanistic evidence regarding bacterial adhesion, biofilm formation, and antimicrobial efficacy, complementing the available clinical evidence. Additionally, studies that did not report relevant clinical or microbiological outcomes or lacked appropriate statistical descriptors (e.g., mean and standard deviation) were excluded from the final review.

Search Strategy

An electronic database search was conducted to retrieve relevant literature published between January 2000 and May 2025. The lower time limit was selected because antimicrobial-coated sutures represent a relatively recent development in periodontal surgery, with clinically relevant investigations emerging predominantly after 2000. Earlier studies primarily focused on conventional suture materials without antimicrobial coatings and were therefore unlikely to address the objectives of the present review while increasing retrieval of non-relevant records. The following databases were searched: PubMed, Science Direct, Wiley Online Library, Cochrane Library, and Google Scholar.

To maintain a targeted and efficient search strategy, the Google Scholar search was restricted to the first 100 results, as ranked by its internal relevance algorithm. This limitation is supported by several considerations. Google Scholar prioritizes studies based on factors such as citation frequency, publication prominence, and author influence, which typically ensures that the most pertinent literature appears early in the results. Moreover, evidence suggests that the relevance and methodological quality of articles decline substantially beyond the top 200 search results.12 This approach aligns with recommendations from established sources like the Cochrane Handbook, which advises prioritizing relevance in high-volume search environments.13

The search strategy included relevant keywords and MeSH terms such as:

“Periodontal Surgery,” “Sutures,” “Antibiotic-Coated Sutures,” “Non-Coated Sutures,” “Wound Healing,” “Surgical

Wound Infection," "Biofilm," and "Postoperative Complications."
These terms were combined using Boolean operators (AND, OR) to enhance the sensitivity and specificity of the search. Manual hand-searching of high-impact journals in periodontology and oral surgery was also performed. Additionally, reference lists of included and excluded articles were screened to identify any overlooked studies.

Screening Process
Two independent reviewers (initials CP and AW) carried out a comprehensive screening of the identified studies to assess their relevance. The screening was executed in two stages. In the first phase, titles and abstracts of all retrieved articles were examined, and those not meeting the inclusion criteria were excluded. During the second phase, the same reviewers independently assessed the full texts of potentially eligible articles. Discrepancies in selection were resolved through discussion, and in cases where consensus could not be reached, a third reviewer was consulted to make the final decision. Ultimately, all three reviewers reached agreement on the included studies. Where clarification was needed, corresponding authors of the studies were contacted via email. The inter-rater agreement was evaluated using Cohen's kappa coefficient, with a value exceeding 0.80, indicating strong consistency between the reviewers.

Data Extraction
Data were extracted independently for each included study and summarized under the following variables: name of the author(s), country of origin, year of publication, study sample size, type of study design, outcomes assessed, specific parameters measured, and overall conclusions.

Evaluation of Methodological Quality
The methodological quality of included studies was evaluated using design-appropriate tools. Randomized controlled trials (RCTs) were appraised with the Cochrane Collaboration's Risk of Bias (RoB 2) tool14 across its standard domains, implemented via Review Manager (RevMan) software. Non-randomized studies were assessed using a modified Newcastle-Ottawa Scale (NOS), which considers sample representativeness, comparability between groups, exposure ascertainment, outcome measurement, and clarity of statistical analysis. All assessments were conducted independently by two reviewers (CP and AW), with disagreements resolved through discussion. The results were summarized in a color-coded heat map to depict domain-specific and overall risk of bias across study designs.

Statistical Analysis
Owing to fundamental methodological differences between laboratory-based and clinical investigations, only clinical studies were considered eligible for quantitative pooling. In vitro studies were synthesized descriptively. Where applicable, statistical analyses were conducted using RevMan 5.3. The standardized mean difference (SMD)15 was employed as the summary measure, and statistical significance was determined at a threshold of $p < 0.05$.

Assessment of Heterogeneity
Quantitative analysis of heterogeneity using Cochrane's Q test and the I^2 statistic16 could not be performed due to the diverse nature of the included studies. Variability in outcome reporting, measurement units, and absence of consistent effect sizes and variance data precluded the possibility of statistical pooling or formal heterogeneity testing.

DATA SYNTHESIS
All included studies were narratively synthesized and then evaluated for quantitative pooling based on similarity of design, outcomes, and statistical reporting.
Although 11 studies met the inclusion criteria for the systematic review, quantitative synthesis was restricted to randomized clinical trials reporting comparable quantitative microbiological outcomes. Three studies provided extractable numerical data on bacterial load (colony-forming unit [CFU] counts or equivalent microbiological measures) suitable for meta-analysis. In vitro investigations were not included in the quantitative synthesis because they evaluate antimicrobial efficacy under controlled laboratory conditions that are not directly comparable with patient-based clinical outcomes. These studies were therefore synthesized descriptively. Owing to the anticipated clinical and methodological heterogeneity among the included trials, a random-effects model was used for the meta-analysis.
For each study, Standardized Mean Differences (SMDs) with corresponding 95% confidence intervals (CI) were calculated. The SMD approach was selected because the included trials reported bacterial counts using different scales, measurement units, and microbial quantification methods (e.g., CFU/cm, CFU/mL, aerobic vs anaerobic counts, CLSM-based quantification). Negative SMD values were interpreted as favoring coated sutures, reflecting the direction where lower bacterial counts indicate better antimicrobial performance.
Heterogeneity was quantified using the I^2 statistic, Cochran's Q test, and Tau^2. A qualitative synthesis was also performed for all 11 studies to integrate evidence on wound healing, biofilm characteristics, patient-reported outcomes, zone of inhibition assays, and species-level microbial assessments.

RESULTS
Study Selection
After eliminating duplicates (n=87) from an initial pool of 557 studies, the titles and abstracts of all included studies were screened, resulting in the exclusion of 311 articles. Of the 159 remaining articles retrieved for full-text review, 13 could not be obtained. The remaining full-text articles were assessed for eligibility, and those not meeting the inclusion criteria

were excluded. These were either review articles or articles not pertaining to periodontal surgical procedures. Ultimately, 11 studies met the inclusion criteria and were included in the qualitative synthesis, while five studies were included for quantitative analysis as depicted in Figure 1 below.

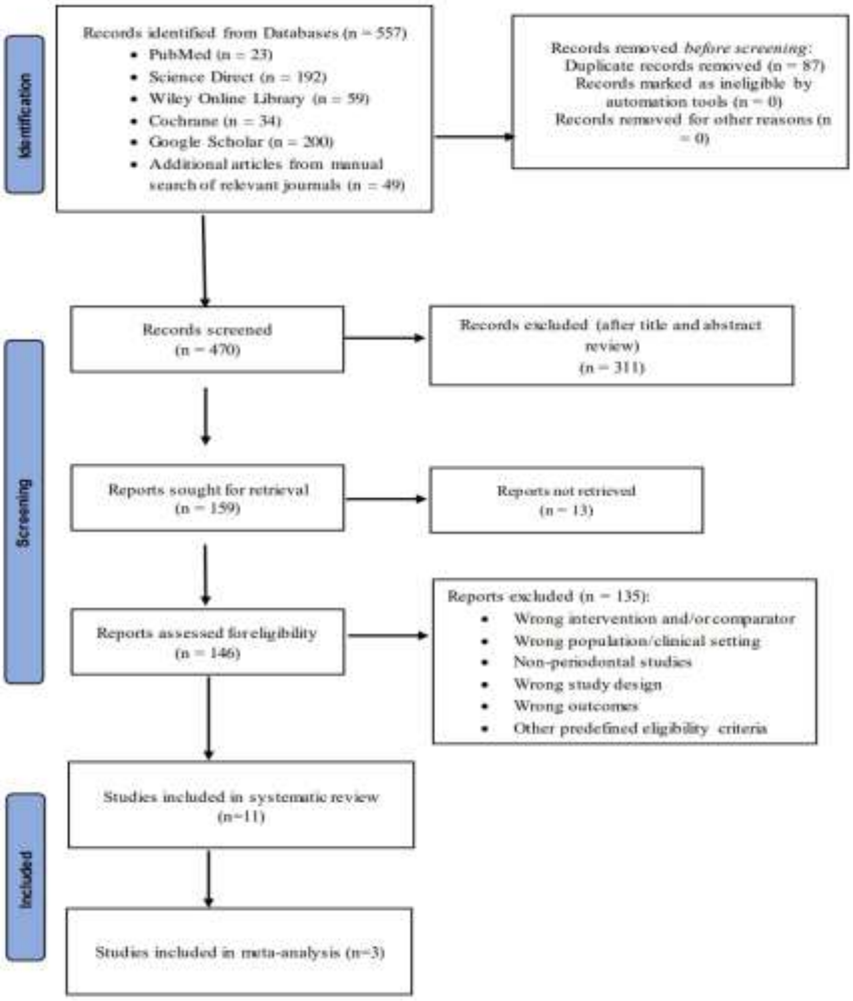

Figure 1: PRISMA Flow diagram

Table I: Search Strategy for different databases

Description of Included studies

Pubmed Search String	("coated"[All Fields] OR "coating"[All Fields] OR "coating s"[All Fields] OR "coatings"[All Fields]) AND ("suturability"[All Fields] OR "suturable"[All Fields] OR "sutural"[All Fields] OR "suturation"[All Fields] OR "suture s"[All Fields] OR "sutured"[All Fields] OR "sutures"[MeSH Terms] OR "sutures"[All Fields] OR "suture"[All Fields] OR "suturing"[All Fields]) AND (("periodontal"[All Fields] OR "periodontally"[All Fields] OR "periodontically"[All Fields] OR "periodontics"[MeSH Terms] OR "periodontics"[All Fields] OR "periodontic"[All Fields] OR "periodontitis"[MeSH Terms] OR "periodontitis"[All Fields] OR "periodontitides"[All Fields]) AND ("surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields]))
Science Direct	(((coated sutures) AND (antibiotic coated suture)) AND (periodontal surgery)) AND (non coated suture)
Google Scholar	https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&as_ylo=2000&as_yhi=2025&q=%5Bcoated-sutures%5D*%5Bperiodontal+surgery%5D&btnG=
Wiley Online Library	Anywhere: ("periodontal surgery") AND ("antibiotic-coated sutures" OR "triclosan") AND ("non-coated suture")
Cochrane Library	Title, Abstract, Keywords: "coated suture" AND "periodontal surgery"

A total of eleven studies meeting the inclusion criteria, comprised of eight studies that were conducted in India and one each from Iran, Egypt, and the Netherlands. The body of evidence included four in-vitro investigations and seven randomized controlled trials. Across these studies, a range of suture-coating materials was examined, including triclosan, chlorhexidine, tetracycline, neem oil, and aloe vera. Although the specific methodologies varied, most studies focused on quantifying bacterial load through colony-forming unit (CFU) counts, while others additionally evaluated biofilm structure, zones of inhibition, clinical healing indices, post-operative pain, and microbial species profiling (Table 2).

Table 2 Characteristics of Included Studies

Author (s) & Year	Country of origin	Study Design	Population	Suture Type (Coated vs Non-Coated)	Antibacterial Agent Used	Primary Outcome(s)	Secondary Outcome(s)	Key Results / Findings	Conclusion	Remarks
Venema et al.17, 2011	Netherland	In vitro experimental study	Saliva from 28 healthy adult donors	Triclosan coated Vicryl Plus vs non-coated Vicryl (both polyglactin 910, 3-0)	Triclosan	Viable bacterial count (CFU/cm) on sutures; biofilm formation using CLSM	Zone of inhibition; effect of chlorhexidine-cetylpyridinium rinse on viability	No significant difference in CFUs between coated and uncoated sutures. No inhibition zone observed for salivary flora. CLSM confirmed similar live bacteria presence. Rinse reduced viable bacteria on both suture types, but more viable bacteria remained on triclosan group post-rinse ($p<0.05$).	Triclosan-coated sutures did not reduce bacterial load or biofilm compared to plain sutures. Adjunctive rinses may have greater influence on bacterial viability than suture coating.	Highlights limitations of triclosan coating in the presence of complex salivary flora. Well-controlled in vitro model with selective and total bacterial quantification and CLSM imaging.
Sethi et al.18, 2016	India	In vitro study	Saliva samples from 10 patients with chronic periodontitis (systemically healthy, non-smokers, no antibiotics in	Plain polyglactin 910 (Vicryl) - Triclosan-coated polyglactin 910 (Vicryl Plus) - Chlorhexidine-coated polyglactin 910	Triclosan, Chlorhexidine	- Total CFUs - Zone of inhibition - CLSM-based biofilm viability	- SEM-based biofilm morphology - Gram-staining for microbial flora composition	Chlorhexidine-coated sutures showed the lowest CFUs (22 ± 21), significantly less than both plain (127 ± 46) and triclosan (82 ± 41) ($p < 0.001$). Triclosan-	Chlorhexidine-coated sutures exhibited superior antibacterial and anti-biofilm performance.	High-quality in vitro model using human saliva incubated sutures. Included advanced imaging techniques (CLSM,

			last 3 months)	(Pectryl CS)				coated sutures had the largest ZOI. SEM and CLSM showed minimal biofilm on chlorhexidine, with absence of Gram-negative rods.		SEM) for biofilm assessment. Chlorhexidine coating showed superior inhibition of both CFUs and biofilm formation. No clinical correlation due to in vitro nature.
Gupta et al.8, 2017	India	Randomized Controlled Trial (Parallel group, 3-arm)	30 patients with chronic periodontitis, aged 18–45 years, pocket depth >5 mm	Group 1: CHX-coated silk; Group 2: Tetracycline-coated silk; Group 3: Plain silk (all 3-0 braided silk sutures)	Chlorhexidine, Tetracycline	CFU/mL counts from sutures on day 7 and day 15	None reported	On day 7, no significant difference between groups. On day 15, CFU/mL significantly lower in both CHX and tetracycline groups vs control. CHX: 317.3; TET: 272.8; Plain: 347.6 ($p < 0.05$)	CHX- and Tetracycline-coated sutures reduced bacterial load more effectively than uncoated sutures by day 15	Focused solely on microbiological outcome. Triple-arm design. No clinical healing parameters evaluated. Clear evidence of bacterial load reduction with medicated sutures.
Sharma et al.19, 2017	India	Randomized Controlled Trial (Pilot: Parallel-group, single-center)	10 systemically healthy patients (35–55 yrs) undergoing periodontal flap surgery	Group 1: Chlorhexidine-coated polyglactin 910; Group 2: Non-coated polyglactin 910	Chlorhexidine	CFU counts of aerobic and anaerobic bacteria on day 7	Identification of specific microbial strains isolated from sutures	No significant difference in CFUs between groups (aerobic: $p=0.29$; anaerobic: $p=0.34$); Group 1 had higher aerobic CFUs; Group 2 had higher anaerobic	CHX-coated sutures did not significantly reduce microbial load compared to uncoated; species profile varied	Small sample size (n=5/group); detailed microbial identification done; no clinical outcome measures reported

								CFUs; distinct species distribution noted	between groups	
Karde et al.20, 2019	India	Double-blinded RCT	30 patients with chronic periodontitis undergoing flap surgery	TCS (Triclosan-coated), CCS (Chlorhexidine-coated), NCS (non-coated) polyglycolic acid sutures	Triclosan (Group A), Chlorhexidine (Group B)	Bacterial load (CFU), Biofilm presence (CLSM)	Healing index (HI), Postoperative pain (POP), Visible plaque	TCS group showed lowest bacterial counts (aerobic/anaerobic) and biofilm presence, followed by CCS; NCS had highest microbial load and visible plaque. No major difference in healing between groups.	TCS and CCS sutures reduced microbial load; TCS was most effective. Healing outcomes were comparable across groups.	RCT registered; good methodology; limited by sample size and short follow-up. Confocal microscopy supports microbiological findings.
Banodkar et al.21, 2022	India	In vitro experimental study	Saliva samples from 20 periodontitis patients	Group A: Tetracycline-coated, Group B: Triclosan-coated (Vicryl Plus), Group C: Non-coated (Vicryl); all braided 4-0 sutures	Tetracycline (Group A), Triclosan (Group B), None (Group C)	Zone of inhibition (mm) against salivary microflora	None reported	Tetracycline-coated sutures showed the highest zone of inhibition (14.45 mm), followed by triclosan (1.4 mm); non-coated showed no inhibition (0 mm). Statistically significant differences between all groups.	Tetracycline-coated sutures exhibit the greatest antibacterial efficacy among the tested groups.	Custom-coated sutures were used; clinical relevance may be limited; results strongly favor tetracycline coating in vitro.
Chaganti et al.22, 2023	India	Randomized controlled double-blinded trial	75 patients (20–60 years) with ≥5 mm probing depth post-phase I therapy	Group A: Triclosan-coated polyglactin 910 (MITSU AB); Group B: Chlorhexidine-	Triclosan (Group A); Chlorhexidine (Group B); None (Group C)	Quantitative and qualitative bacterial colonization (CFU counts, colony	Wound healing index (Landry and Turnbull), postoperative pain score (McCaff	TCS group had lowest CFU counts in both anterior and posterior regions (aerobic and anaerobic).	Triclosan-coated sutures significantly reduce microbial load, improve wound healing, and	Strong methodology with triple-arm comparison. First study comparing CHX-

			, systemically healthy, non-smokers, not allergic to CHX or triclosan	coated polyglactin 910 (MITSUC+); Group C: Non-coated polyglactin 910 (MITSU)		frequency, species identification)	ery & Beebe) on days 8, 15, and 30	Polymicrobial colonies least in TCS, highest in NCS. Wound healing and pain scores significantly better in TCS group by day 30.	lower postoperative pain compared to CHX-coated and uncoated sutures.	and triclosan-coated Vicryl directly. Consistent statistical significance across clinical and microbiological outcomes. Registered RCT with CONSORT adherence.
Kaur et al.23, 2023	India	In vitro randomized controlled trial	Subgingival plaque from periodontitis patients	Group 1: 100% Neem oil-coated silk sutures; Group 2: 50% Neem oil-coated; Group 3: Triclosan-coated (polyglactin 910, Vicryl Plus); Group 4: Uncoated silk sutures	Neem oil (100% and 50%), Triclosan	Zone of inhibition (ZOI) – length, breadth, area	None reported	100% neem oil showed significantly greater ZOI than all other groups (77.0 mm²), 50% neem oil had moderate effect (16.8 mm²), while triclosan and uncoated sutures showed no measurable inhibition. Differences were statistically significant ($P < 0.05$).	Neem oil-coated sutures (especially 100%) demonstrate strong antimicrobial activity compared to triclosan-coated and uncoated sutures in anaerobic conditions.	Evaluates novel coating (Neem oil); though in vitro, it provides evidence for suture modification using natural agents in periodontitis-specific microbial settings.
Naghsh et al.24, 2023	Iran	Randomized Clinical Trial (Split-	12 patients (age 20–40) requiring full-mouth periodo	Group 1: Monocryl (uncoated); Group 2: Monocryl Plus	Triclosan	CFU count: aerobic, anaerobic, and total	None reported	Silk sutures had significantly higher aerobic and anaerobic	Triclosan-coated and synthetic non-coated sutures had	Split-mouth design increases internal validity. Direct clinical

		mouth, single-blind)	ntal flap surgery (4 quadrants per patient)	(triclosan-coated); Group 3: Silk (non-coated); Group 4: Nylon (non-coated); All 4–0 reverse cut		bacterial colonies		bacterial colonies than triclosan-coated (Monocryl Plus), Monocryl, and Nylon (P < 0.05). No significant difference among the latter three groups.	reduced bacterial colonization compared to silk. Silk sutures promoted the highest microbial growth.	relevance to periodontal surgery context. Suitable for ROB-2 assessment.
Ahmed El Sharaki 25 2023	Egypt	Randomized Controlled Trial (Parallel design)	60 systemically healthy adults with insufficient keratinized tissue undergoing free gingival grafts	Group A: Silk (non-coated); Group B: Vicryl Plus (triclosan-coated absorbable braided polyglactin 910)	Triclosan	Graft healing (Landry index), infection rates	Patient-reported outcomes (pain, comfort, satisfaction via VAS)	Significantly better graft healing at 1-month in Vicryl Plus group ($p = 0.027$); lower (but not statistically significant) infection rates in Vicryl Plus group at all time points; significantly higher patient satisfaction in Vicryl Plus group ($p = 0.011$)	Vicryl Plus sutures showed improved healing and patient satisfaction over silk sutures; may also reduce infection risk	Focuses on free gingival grafts—not flap surgery—still relevant due to suture use in periodontal soft tissue surgery
Mitra et al.26, 2024	India	Split-mouth RCT	12 patients requiring periodontal flap surgery in ≥2 quadrants (48.67 years avg age)	Control: Non-coated 3-0 braided black silk sutures; Experimental: Aloe vera-coated 3-0 braided black silk sutures	Aloe vera extract	Early Healing Score (EHS), CFU counts from sutures	Visual Analog Scale (VAS) for pain	Aloe vera group had significantly better healing (EHS) and lower CFU counts ($P < 0.05$); no significant difference in VAS scores	Aloe vera-coated sutures improve early healing and reduce microbial load compared to non-coated silk	Well-designed split-mouth trial; used EHS and standardized microbiological assessment

Qualitative Review of Included Studies

The risk of bias across included studies varied by study design. Among the randomized controlled trials (RCTs), most studies demonstrated low risk in the domains of missing outcome data and outcome measurement. However, domains related to randomization and deviations from intended interventions showed some concerns in several studies, with one study exhibiting high overall risk of bias (Figure 2). For non-randomized studies, sample representativeness and statistical analysis were the most common domains with some concerns, whereas exposure ascertainment and group comparability were generally rated low risk (Figure 3). Overall, while a majority of studies demonstrated low to moderate risk of bias, certain methodological limitations were noted, particularly in randomization and analytical reporting.

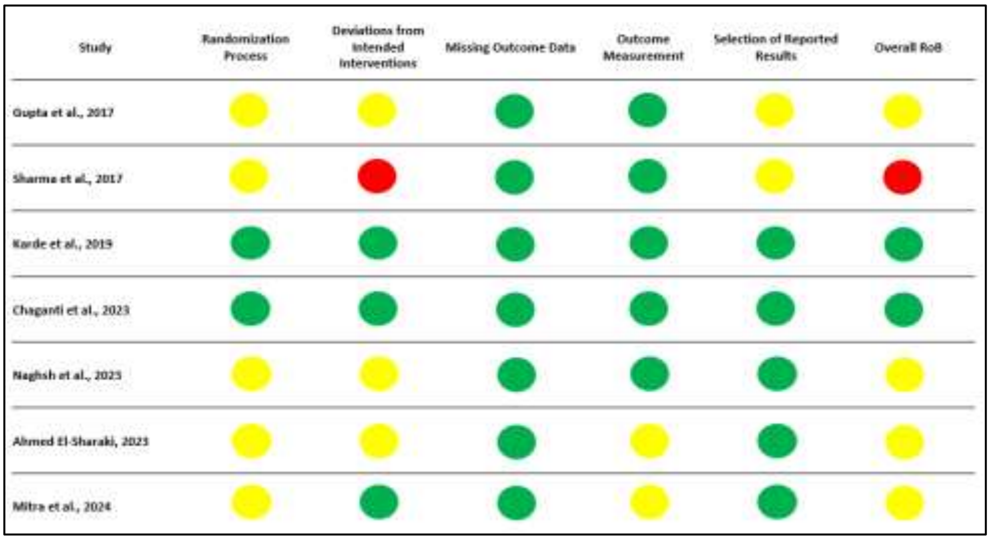

Figure 2 Risk Of Bias Analysis for RCTs

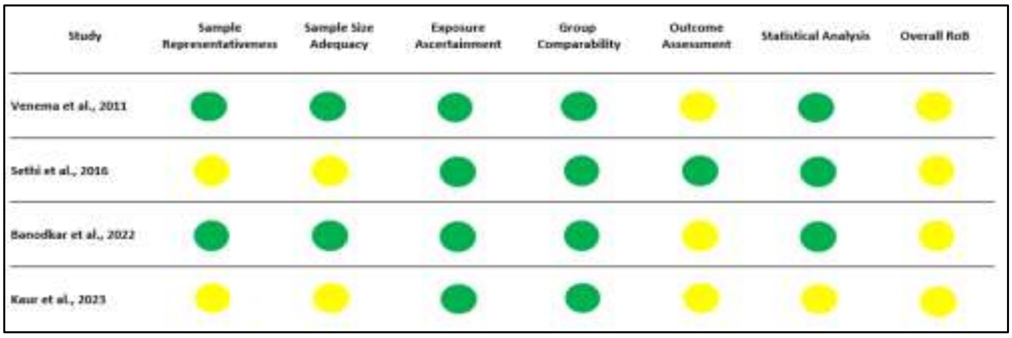

Figure 3 Risk Of Bias Analysis for Non-RCTs

Quantitative Meta-analysis

Three randomized clinical trials20,22,24 involving a total of 94 participants (47 in the antimicrobial-coated suture group and 47 in the non-coated suture group) met the criteria for quantitative synthesis. Laboratory-based in vitro studies were not included in the meta-analysis because of their fundamentally different experimental design and biological context and were instead synthesized narratively.

Using a random-effects model, the pooled analysis yielded an overall standardized mean difference (SMD) of –0.68 (95% CI: –1.38 to 0.02), indicating a moderate trend toward reduced bacterial colonization with antimicrobial-coated sutures compared with non-coated sutures (Figure 4). Although the direction of the pooled effect favored antimicrobial-coated sutures, the confidence interval crossed the line of no effect, indicating that the overall difference was not statistically significant. Therefore, the available clinical evidence suggests a favorable trend but does not provide conclusive evidence that antimicrobial-coated sutures significantly reduce bacterial colonization compared with conventional sutures.

Substantial heterogeneity was observed among the included clinical studies ($Tau^2 = 0.34$; $\chi^2 = 7.25$, df = 2, $p = 0.027$; $I^2 = 72\%$), likely reflecting differences in antimicrobial coating agents, suture materials, microbiological assessment methods, and study populations. Despite this heterogeneity, two of the three studies demonstrated reduced bacterial colonization with antimicrobial-coated sutures, while one study reported comparable bacterial counts between coated and non-coated synthetic sutures.

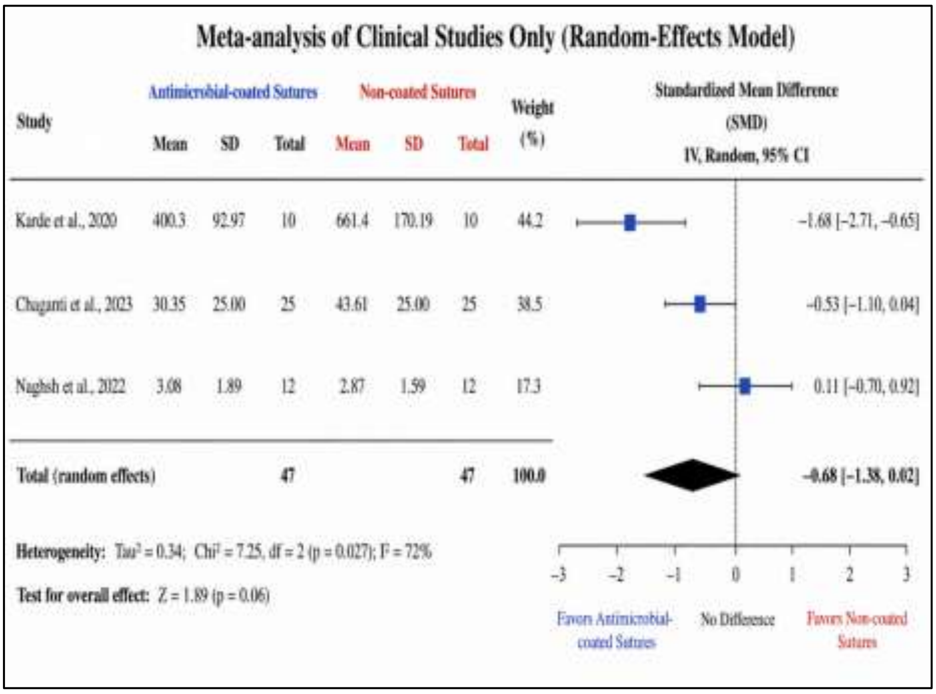

Figure 4 Forest plot of the meta-analysis of thestudies included in this review, comparing coated sutures vs non-coated sutures.

Study-level Patterns

Among the individual clinical studies, Karde et al.20 reported the greatest reduction in bacterial load with antimicrobial-coated sutures, particularly triclosan-coated materials, compared with conventional sutures. Chaganti et al.22 similarly demonstrated lower bacterial colonization together with improved wound healing and reduced postoperative pain in patients receiving triclosan-coated sutures. In contrast, Naghsh et al.24 observed no significant difference between triclosan-coated and synthetic non-coated monofilament sutures, although both performed significantly better than conventional silk sutures. Collectively, these findings suggest a consistent clinical trend favoring antimicrobial-coated sutures for reducing bacterial adherence, although the magnitude of benefit varied across studies.

Narrative Synthesis

The qualitative synthesis comprised all eleven included studies, including four in vitro investigations and seven randomized clinical trials. The in vitro studies were evaluated descriptively to provide mechanistic evidence regarding antimicrobial activity, whereas the quantitative synthesis was restricted to clinical studies. When considering all eleven included studies, additional themes emerged regarding the performance of specific antimicrobial coatings. Triclosan-coated sutures demonstrated context-dependent efficacy, performing well in several randomized clinical trials, particularly those by Karde et al.20, Chaganti et al.22, and Ahmed El Sharaki25, but less consistently in in-vitro salivary biofilm models reported by Venema et al.27 and Sethi et al.28 Chlorhexidine-coated sutures consistently exhibited strong antibacterial activity, often surpassing triclosan in reducing bacterial colonization and biofilm formation, as demonstrated by Sethi et al.28 and Gupta et al.8 Tetracycline-coated sutures produced the largest zones of inhibition in in-vitro investigations by Banodkar et al.21 and also reduced bacterial counts in the clinical trial by Gupta et al.8 Natural coating agents, including neem oil and aloe vera, showed promising antimicrobial and wound-healing properties in studies by Kaur et al.23 and Mitra et al.26, suggesting their potential as biocompatible alternatives. Several randomized clinical trials also reported improvements in wound healing, reductions in postoperative discomfort, and greater patient satisfaction associated with coated sutures, particularly those by Chaganti et al.22, Ahmed El Sharaki25, and Mitra et al.26

The qualitative synthesis included eleven studies comprising in-vitro experiments, split-mouth trials, and parallel-arm randomized controlled trials. Most investigations evaluated triclosan-coated, chlorhexidine-coated, antibiotic-impregnated, or naturally coated sutures against their non-coated counterparts, with outcomes assessed between 24 hours and 30 postoperative days. Across the available evidence, coated sutures generally demonstrated a biological trend toward reduced microbial colonization; however, the magnitude and consistency of this effect varied across studies conducted by Venema et al.27, Sethi et al.28, Karde et al.20, Chaganti et al.22, Naghsh et al.24, Ahmed El Sharaki25, and Mitra et al.26, reflecting differences in experimental settings, coating materials, and microbiological assessment methods.

From the 11 studies that were included in the qualitative synthesis, spanning in-vitro experiments, split-mouth trials, and parallel-arm randomized controlled designs. Most investigations evaluated triclosan-coated, chlorhexidine-treated, or antibiotic-impregnated sutures against their non-coated counterparts, with outcomes measured between 24 hours and 15 postoperative days. Across the narrative evidence base, coated sutures generally demonstrated a biological trend toward reduced microbial colonization; however, the magnitude and consistency of this effect varied widely between experimental settings.

Only three studies reported sufficiently comparable quantitative parameters for inclusion in the meta-analysis. When pooled, coated sutures showed a directional advantage, with negative effect sizes indicating lower bacterial load compared

to non-coated sutures. Individual studies contributed varying weights to the model, reflecting differences in precision and sample size. Although the pooled estimate favored coated materials, the confidence intervals overlapped the line of no effect in some studies, hinting at underlying heterogeneity and the influence of laboratory vs. clinical environments.
Taken together, the results suggest that while antimicrobial coatings may attenuate bacterial adhesion, the effect is neither universal nor uniform, more pronounced in controlled in-vitro conditions and comparatively modest in clinical settings where salivary flow, tissue fluids, and host factors introduce complexity.

DISCUSSION

This systematic review highlights a recurring and biologically plausible trend: antimicrobial-coated sutures demonstrate a general tendency to reduce microbial colonization compared with their non-coated counterparts. Although the pooled quantitative analysis of clinical studies did not demonstrate a statistically significant difference, the overall direction of effect favored antimicrobial-coated sutures, suggesting a moderate clinical benefit in reducing bacterial colonization. The accompanying qualitative synthesis, which incorporated both clinical and in vitro evidence, further supports the biological rationale that antimicrobial coatings may reduce bacterial adhesion and biofilm formation on suture materials. This aligns with the broader understanding that sutures in the oral cavity, continuously bathed in saliva and exposed to complex polymicrobial biofilms, act as potential reservoirs for bacterial adherence and dissemination following periodontal surgery.22,29–31

The variability observed across studies can be attributed to several interconnected factors. First, not all antimicrobial coatings perform equivalently. Chlorhexidine and tetracycline coatings have frequently reported to produce superior bacterial suppression compared with triclosan, reflecting differences in chemical substantivity and spectrum of activity.32 Triclosan, despite its historic safety profile and widespread clinical use,27,28,33,34 showed inconsistent performance, particularly in in-vitro salivary biofilm models where microbial diversity and metabolic interactions may blunt its bacteriostatic effect.

Second, methodological heterogeneity contributed substantially to the variability observed across the included studies. Differences in microbiological assessment techniques, including colony-forming unit (CFU) enumeration, aerobic versus anaerobic culture methods, and confocal laser scanning microscopy, introduced methodological diversity despite the use of standardized mean differences to facilitate comparison across studies. Consistent with established evidence synthesis methodology, laboratory-based in vitro investigations were not pooled with clinical trials because these study designs evaluate fundamentally different biological conditions. While in vitro studies provide valuable mechanistic insights into antimicrobial activity, bacterial adhesion, and biofilm inhibition under controlled experimental settings, they do not account for host immune responses, salivary dynamics, wound healing processes, or other patient-related factors that influence clinical effectiveness. Accordingly, the in vitro evidence was synthesized descriptively and used to complement, rather than quantitatively influence, the clinical findings. This methodological distinction also helps explain the observed differences between study designs, with in vitro investigations generally demonstrating more pronounced reductions in bacterial load under standardized laboratory conditions, whereas clinical trials tended to report more modest improvements within the complex intraoral environment, where biological and mechanical factors may attenuate the antimicrobial effects of coated sutures.

The nature of the suture substrate itself also plays an important role. Synthetic monofilament sutures showed lower bacterial adherence compared with braided materials such as silk, which possess capillarity and surface irregularities that promote microbial retention. Several included studies reaffirmed that silk consistently harbors higher bacterial loads than both coated and non-coated synthetic sutures, emphasizing that coating efficacy must be interpreted in the context of baseline material characteristics.8,23,25,26

Although the primary focus of this review was bacterial load, several clinical trials suggested that reduced microbial adherence may translate into improved early healing and reduced postoperative inflammation. Studies evaluating triclosan-coated sutures, in particular, noted better wound healing indices and lower discomfort scores, consistent with previous studies35,36 describing triclosan's bactericidal and potential immunomodulatory actions. However, findings were not uniform; some authors reported negligible or inconsistent benefits, highlighting the need for larger, well-controlled trials to clarify the true magnitude of clinical effect.

The broader surgical literature has frequently demonstrated reduced surgical site infection (SSI) rates with antibacterial-coated sutures, including several meta-analyses showing significant benefits of triclosan-coated sutures in high-risk surgical fields.9,37 While the present review supports the general trend of reduced microbial colonization, the pooled analysis of clinical studies demonstrated only a non-significant trend favoring antimicrobial-coated sutures. This finding should be interpreted alongside the qualitative evidence, which consistently demonstrated reduced bacterial adhesion and improved antimicrobial performance across several laboratory and clinical investigations. The comparatively modest clinical effect may reflect the uniquely polymicrobial, enzyme-rich, and dynamic environment of the oral cavity, where host-related factors substantially influence postoperative wound healing and bacterial colonization.

Strengths and Limitations

This review is strengthened by its comprehensive search strategy, adherence to PRISMA 2020 guidelines, inclusion of diverse antimicrobial coating materials, and the integration of both laboratory and clinical evidence. A further strength is the methodological separation of quantitative and qualitative evidence, with only clinically comparable studies included in the meta-analysis while in vitro investigations were synthesized descriptively. The principal limitations include the small number of clinical studies available for quantitative synthesis, substantial clinical and methodological heterogeneity, variations in antimicrobial coating agents and suture materials, and inconsistent microbiological outcome measures across studies. These factors limited the precision of the pooled estimates and reduced the certainty of the overall clinical evidence.

Overall Interpretation
Taken together, the qualitative evidence consistently indicates that antimicrobial-coated sutures, particularly those coated with chlorhexidine, tetracycline, neem oil, and aloe vera, reduce bacterial colonization and may promote improved early wound healing. However, when the evidence was restricted to randomized clinical trials suitable for quantitative synthesis, the pooled effect demonstrated only a moderate, non-significant trend favoring antimicrobial-coated sutures. These findings suggest that although antimicrobial coatings exhibit promising biological activity, the magnitude of their clinical benefit remains uncertain and requires confirmation through larger, methodologically robust randomized controlled trials employing standardized outcome measures.

CONCLUSION
The findings of this systematic review indicate that antimicrobial-coated sutures exhibit promising antimicrobial properties and may reduce bacterial colonization following periodontal surgery. Qualitative evidence from both clinical and in vitro investigations consistently supports the biological potential of antimicrobial coatings to inhibit bacterial adhesion and biofilm formation. However, quantitative synthesis restricted to randomized clinical trials demonstrated only a moderate, non-significant trend favoring antimicrobial-coated sutures over conventional sutures. Consequently, while antimicrobial-coated sutures appear to be a promising adjunct for improving the microbial environment of periodontal surgical wounds, the current clinical evidence remains insufficient to support definitive recommendations for their routine use. Future well-designed, adequately powered randomized controlled trials with standardized microbiological and clinically relevant outcome measures are needed to establish their true therapeutic benefit.

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