Surgery 174 (2023) 638–646

Contents lists available at ScienceDirect

Surgery

journal homepage: www.elsevier.com/locate/surg

Can triclosan-coated sutures reduce the postoperative rate of wound infection? Data from a systematic review and meta-analysis

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ARTICLE INFO

Article history:
Accepted 9 April 2023
Available online 14 June 2023

ABSTRACT

Background: Wound infections are typical postoperative complications with considerable therapeutic consequences and high personnel and financial costs. Previous meta-analyses have shown that triclosan-coated sutures can reduce the risk of postoperative wound infection. This work aimed to update previous meta-analyses with a special focus on different subgroups.

Methods: A systematic review with meta-analysis was performed (registration: PROSPERO 2022 CRD42022344194). The search was independently performed in the Web of Science, PubMed, and Cochrane databases by 2 reviewers. A critical methods review of all included full texts took place. The trustworthiness of the evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation method. An analysis of the cost-effectiveness of the suture material was carried out.

Results: In this meta-analysis of 29 randomized controlled trials, the use of triclosan-coated suture material resulted in a significant reduction of postoperative wound infection rate (24%) (random-effects model; risk ratio: 0.76; 95% confidence interval: [0.67–0.87]). The effect was evident in the subgroups according to wound contamination class, underlying oncologic disease, and pure preoperative antibiotic prophylaxis. In the subgroup analysis by the operating department, the significant effect was visible only in the abdominal surgery group.

Conclusion: Based on the randomized controlled clinical trials reviewed, triclosan-coated sutures reduced postoperative wound infection rates in the main study and most subgroups. Additional costs of up to 12 euros for the coated suture material appear to be justified to generate an economic benefit for the hospital by reducing postoperative wound infections. The additional socioeconomic benefit of reducing wound infection rates was not investigated here.

Introduction

Postoperative wound infections are still a common complication of surgical procedures. They are associated with increased morbidity and mortality, prolonged hospitalization times, and an increased likelihood of reoperation.[1] In Europe, the incidence of this complication is estimated to be 0.6% to 10.1%, depending on the type of surgical procedure. For hip arthroplasty, for example, the incidence is 1.1%, whereas, for colon surgery, the incidence is 8.7%.[2] The incidence of postoperative wound infection is also expected to increase due to the predicted increase in surgical procedures, especially in the orthopedic elective field.[3]

The risk factors predisposing to postoperative wound infection can be divided into patient-related (eg, comorbidities, patient age, obesity) and procedure-related risk factors.[4] Some of these risk factors are difficult to influence. Therefore, the focus of research is to find solutions for the risk factors that can be influenced to reduce the incidence of wound infections.

Bacteria, especially *Staphylococcus aureus*, which can be found on the skin, in the gastrointestinal tract, or in the urogenital tract, have a major influence on wound infections.[4] Among other things, these bacteria can attach to the suture material and form a biofilm.[5] This can now form immunity to local and systemic antibiotics. The suture material can be coated with an antimicrobial agent to prevent this postoperative complication. One such agent is triclosan

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https://doi.org/10.1016/j.surg.2023.04.015
0039-6060/

(5-chloro-2-[2,4-dichlorophenoxy] phenol). Triclosan has been successfully used in consumer products such as toothpaste and soaps for >40 years.[6]

In vivo and in vitro studies have demonstrated the efficacy of triclosan-coated sutures against *Staphylococcus aureus*, *Staphylococcus epidermidis*, and their methicillin-resistant strands MRSA and MRSE.[7,8] Since then, several randomized controlled trials and meta-analyses have been conducted and published addressing the effectiveness of triclosan-coated sutures in preventing postoperative wound infections. These come to different conclusions, so the benefit of triclosan-coated sutures has not yet been definitively proven.[9,10]

The present work aimed to provide an update regarding the randomized controlled clinical trials available to date regarding the efficacy of triclosan-coated sutures in reducing the risk of postoperative infection and to summarize them in a recent meta-analysis. Because previous meta-analyses have demonstrated the efficacy of triclosan-coated sutures, particularly in contaminated procedures,[9] and to form a homogeneous basis of the studies analyzed, this analysis should be limited to procedures from the "clean" and "clean-contaminated" range. An additional new focus of this work was the differentiated investigation of various subgroups. The plan was to identify differences in using the triclosan-coated suture material appropriately.

In addition to the pure meta-analysis of postoperative wound infections, this work aimed to cast an eye on the cost situation. Special suture material is often associated with additional costs for a clinic. However, because postoperative wound infections represent an enormous cost factor for a clinic, more expensive material can still be worthwhile if wound infections can be reduced as a result. This factor was evaluated using exemplary data from our clinic.

Method

A systematic review with meta-analysis was performed. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement was used for quality assurance.[11,12] The study protocol of the review was registered (PROSPERO 2022 CRD42022344194).

Inclusion/exclusion criteria

The PICOS criteria were used to specify the selection criteria.[13]

- (P)opulation: patients undergoing surgery
- (E)xposure: "clean" or "clean-contaminated" operation (classified according to Centers for Disease Control and Prevention [CDC] criteria)
- (C)omparator: triclosan-coated sutures versus "normal" sutures
- (O)utcome: incidence of wound infection 30 days after the operation

Study design

Randomized controlled clinical trial (RCT).

Search strategy

The literature search was performed in the electronic databases Web of Science, PubMed, and Cochrane for the period up to July 8, 2022 (the search was performed on July 8, 2022). English-language publications with an available abstract were included. The search strands and further details can be found in the Supplementary Materials.

Study selection

Title, abstract, and full-text screening were performed by 2 independent individuals (L.D., C.O.L.). Discordances were resolved by consensus.

Data extraction

Data extraction was performed independently by 2 individuals. Study information on reference, methodology, population, exposure, outcome, and results were documented in standardized data extraction tables.

Quality assessment

For the quality assessment of the individual-included studies, an evaluation was performed using the risk of bias method. If the authors were uncertain about the assessment, the study was considered by several authors, and the assessment was made by consensus of the authors (L.D., C.O.L.).

Statistical analysis

Only studies that met the inclusion criteria and had adequate methodological quality were included in the evidence synthesis. A meta-analytical calculation of pooled effect estimates with 95% CIs was performed using a random-effects model. The risk ratio (RR) and its corresponding 95% CI were calculated here.

The heterogeneity of the studies was indicated by the I^2 statistic (0 to 40%: might not be important; 30% to 60%: may represent moderate heterogeneity; 50% to 90%: may represent substantial heterogeneity; 75% to 100%: considerable heterogeneity).[14] A supplementary χ^2 analysis was performed.

Various subgroup analyses (wound contamination class, malignant underlying disease, different surgeries, concomitant antibiotic perioperative regimen, suture material used, type of infection, risk of bias, definition of outcome with CDC) were calculated. In addition, sensitivity analyses were performed to determine the influence of individual studies on the overall outcome.

The calculations were performed using Review Manager version 5.4 (Cochrane, Memphis, TN). Additionally, a funnel plot was created in R (R Foundation for Statistical Computing, Vienna, Austria) to evaluate publication bias.[15] To test for funnel plot asymmetry, linear regression tests were used.[16] Trustworthiness was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation method.[17]

Cost analysis

The cost analysis was performed based on data from the studies of the English National Health Service[18,19] and the studies of Schmidt et al.[20] Here, the reported extensions of hospital stays due to the resulting wound infection together with the resulting additional costs per treatment case were converted to an averaged value of costs per additional treatment day. These averaged costs were converted to a still profitable additional cost factor due to the coated suture material based on the risk reduction calculated in the meta-analysis, based on an averaged suture consumption of an example operation (primary hip total joint arthroplasty implantation; consumption: 12 fascia and 12 subcutaneous sutures). A

Table I
Overview of the included studies with information on the included population, exposure, and outcome

Study ID	No. of participants	No. of centers	Surgery type	Intervention versus control suture	SSI criteria	CDC wound class	Duration of follow-up	Preoperative antibiotics	Surgical layer intervention was used on
Baracs 2011	385	7	Elective colorectal surgery	PDS plus versus PDS	Not stated	Clean- contaminated	30 d	Yes	Fascia, skin
Chen 2011	241	1	Head and neck surgery (tumor ablation)	Vicryl plus versus Vicryl	Local erythematous change in sutured wound with purulent discharge, cervical wound dehiscence, or neck skin necrosis	Clean	Not stated	Yes	Subcutaneous
Diener 2014	1,185	24	Elective midline laparotomy	PDS plus versus PDS II	CDC criteria	Clean-contaminated	30 d	Yes	Fascia
Ford 2005	147	1	Pediatric surgery	Vicryl plus versus Vicryl	Not stated	Clean and clean-contaminated	80 d	No	Not specified
Galal 2011	450	1	All surgery	Vicryl plus versus Vicryl	CDC criteria	Clean, clean-contaminated, contaminated	30 d (1 year for prosthetic surgery)	Yes	All layers except skin closure
Ichida 2018	1,013	1	Gastroenterological surgery	Vicryl plus and PDS plus versus Vicryl and PDS II	CDC criteria	Clean and clean-contaminated	30 d	Yes	Fascia, peritoneum, skin
Isik 2012	510	1	Cardiac surgery	Vicryl plus versus Vicryl	CDC criteria	Clean	1 mo	Not stated	Not specified
Justinger 2013	856	1	Laparotomy	PDS plus versus PDS II	CDC criteria	Clean and clean-contaminated	2 wk after discharge	Yes	Fascia
Karbhari 2019	150	1	Elective inguinal hernia surgery	Vicryl plus versus Vicryl	Southampton wound scoring system	Clean	14 d	Yes	Subcuticular
Koujalagi 2017	60	1	Open abdominal surgery	PDS plus versus PDS II	CDC criteria	Clean-contaminated	10 d	Yes	Fascia
Lin 2018	102	1	Total knee arthroplasty	Vicryl plus versus Vicryl	CDC criteria	Clean	6 mo	Yes	Arthrotomy, fascia, subcutaneous
Mattavelli 2015	281	4	Elective colorectal resection	Vicryl plus and PDS plus versus Vicryl and PDS II	CDC criteria	Clean-contaminated	30 d	Yes	Peritoneum, fascia, skin
Miyoshi 2022	1,496	24	Elective colorectal surgery	Vicrly plus or PDS plus versus Vicryl or PDS II	CDC criteria	Clean-contaminated	90 d	Yes	Fascia
Nakamura 2013	410	1	Elective colorectal surgery	Vicryl plus versus Vicryl	CDC criteria	Clean-contaminated	30 d	Yes	All layers except skin closure
Nihr 2021	5,788	54	Abdominal surgery	Vicryl plus and PDS plus versus Vicryl and PDS II	CDC criteria	Clean-contaminated, contaminated, dirty	30 d	Yes in 89.6%	Fascia
Olmez 2019	890	1	Gastrointestinal surgery	PDS plus versus PDS II	Clinical symptoms of infection	Clean, clean-contaminated	30 d	Yes	Fascia
Rasic 2011	184	1	Colorectal surgery	Vicryl plus versus Vicryl	Not stated	Clean-contaminated	Until discharge	Yes	Peritoneum, muscle, fascia
Renko 2017	1,557	1	Pediatric surgery	Vicryl plus, Monocryl plus, PDS plus versus Vicryl, Monocryl, PDS II	CDC criteria	Clean, clean-contaminated, contaminated	30 d	Yes in 30%	Not specified
Roy 2019	110	1	Gastrointestinal surgery and thyroid surgery	PDS plus versus PDS II	CDC criteria	Clean, clean-contaminated	30 d	Yes	Not specified
Santos 2019	508	1	Saphenectomy	Vicryl plus versus Vicryl	Hyperemia and periborder cellulitis with opening of 3 cm and drainage of purulent secretion	Clean	30 d	Yes	All layers
Seim 2012	323	1	CABG	Vicryl plus versus Vicryl	Positive bacterial culture and clinical assessment	Clean	4 wk	Yes	Not specified
Sprowson 2018	2,437	3	Total knee and hip arthroplasty	Vicryl plus versus Vicryl	CDC criteria	Clean	30 d	Yes	Dependent on surgeon
Steingrimmson 2015	357	1	CABG with valve surgery	And Monocryl plus versus Vicryl and Monocryl	CDC criteria	Clean	60 d	Yes	Fascia, subcutaneous, intracutaneous

Sukeik 2019	150	1	Primary hip and knee arthroplasty	Vicryl plus versus Vicryl	ASEPSIS[29] wound scoring system	Clean	6 wk	Yes	Fascia, subcutaneous
Tabrizi 2019	320	2	Dental implant surgery	Vicryl plus versus Vicryl	CDC criteria	Clean-contaminated	28 d	Yes	Not specified
Thimour-bergström 2013	374	1	CABG ± valve surgery	Vicryl plus versus Vicryl	CDC criteria	Clean	60 d	Yes	Subcutaneous, intracutaneous
Turtiainen 2012	276	5	Nonemergency lower-limb arterial surgery	Vicryl plus and Monocryl plus versus Vicryl and Monocryl	CDC criteria	Clean	30 d	Yes	Subcutaneous, intracutaneous
Williams 2011	150	1	Mastectomy	Vicryl plus and Monocryl plus versus Vicryl and Monocryl	CDC criteria	Clean	6 wk	If considered at risk	Subcutaneous, intracuticular
Zhang 2011	101	6	Mastectomy	Vicryl plus versus Chinese silk	ASEPSIS[29] and CDC criteria	Clean	90 d	Not stated	Intradermal

ASEPSIS, **A**dditional treatment, **S**erious discharge, **E**rythema, **P**urulent exudate, **S**eperation of deep tissues, **I**solation of bacteria, **S**tay as inpatient prolonged over 14 days; *CABG*, coronary artery bypass grafting; *CDC*, Center for Disease Control; PDS, polydioxanone suture; *SSI*, surgical site infection.

baseline risk for postoperative wound infection of 10% was used for this calculation.

Results

The results of the literature search are shown in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram (Supplementary Figure S1) (see Supplementary Materials). The literature search of studies published up to July 8, 2022, resulted in 849 hits. After the removal of duplicates, 664 studies remained. As a result of the title abstract review, 36 publications were included in the full-text review. In total, 29 publications met the inclusion criteria and were included in the systematic review (Table I).[e1-e29] The list of excluded publications with source reference and reason for exclusion can be found in the Supplementary Materials (Supplementary Table SIII).

Study characteristics

A total of 29 publications were available for the evidence synthesis. Only RCTs were included. An overview of the included studies with information on the included population, exposure, and outcome can be found in Table I.

Results of the critical methods evaluation

Varying levels of overall bias risk were found. Two studies showed a risk that could be rated very low (green signs only), and another 7 showed a low risk (1 yellow or 1 red sign, the rest only green). Only 6 studies showed a very high overall bias risk (at least 3 signs red). The remaining 14 studies showed a medium risk (Figure 1).

Results of all included studies

The 29 studies included in this meta-analysis yielded a total number of 17,607 patients. Of these, 1,657 (9.41%) suffered a postoperative infection.

Considering all included studies, using triclosan-coated sutures reduced the risk of postoperative wound infection by 24%, calculated using the random-effects model (RR: 0.76; 95% CI: [0.67–0.87]; Figure 2). χ^2 analysis and I^2 statistics showed small to moderate heterogeneity between studies ($I^2 = 33\%$; $P = .05$; Figure 2). The incidence of postoperative wound infection among the studies varied from 1.48% to 36.67%.

Results on different subgroups

Table II shows the stratified pooled incidence of postoperative wound infection incidence estimates categorized into subgroups.

Wound contamination class

In this subgroup analysis, only those studies were included in which the wound contamination class was classified using CDC criteria. A total of 27 studies met this criterion; 16 studies were assigned to the “clean surgery” subgroup, and 11 were sorted into the “clean-contaminated surgery” subgroup.

In the “clean surgery” group, the use of triclosan-coated sutures reduced the risk of postoperative wound infection significantly by 22% (RR: 0.78; 95% CI: [0.66–0.94]; $I^2 = 0$, $P = .48$). In the “clean-contaminated surgery” group, the risk of postoperative wound infection was reduced significantly (RR: 0.72; 95% CI: [0.59–0.88]; $I^2 = 42\%$; $P = .07$; Supplementary Figure S3).

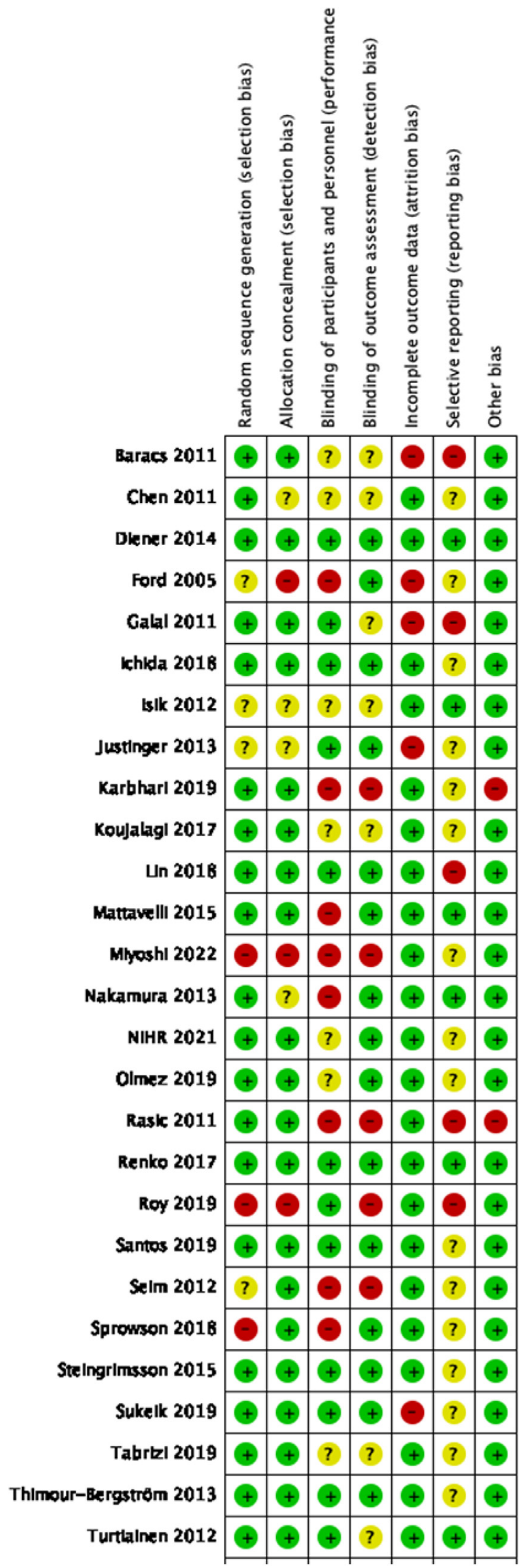

Figure 1. Results of the critical methods evaluation of the included studies.

Underlaying malignancy

Six studies provided data from surgeries performed for underlying oncologic disease. These were largely colorectal carcinomas ($n = 3$) or breast cancers ($n = 2$). One study was based on patients with neck cancer.

In this subgroup, the use of triclosan-coated sutures reduced the risk of postoperative wound infection significantly by 32% (RR: 0.68; 95% CI: [0.50–0.92]; $I^2 = 4\%$; $P = .39$; Supplementary Figure S4).

Discipline

The included studies were differentiated according to the underlying surgical specialty (abdominal surgery, orthopedic surgery, pediatric surgery, breast surgery, cardiac and vascular surgery). Pooled effect estimates for the endpoint wound infection were determined for each subgroup. A significant reduction in the postoperative wound infection rate was found only for the abdominal surgery subgroup (RR: 0.75, 95% CI: [0.61, 0.91]; $I^2 = 56\%$; $P = .09$; Supplementary Figure S5). The data from the other disciplines showed a tendency for the coated suture material to cause postoperative wound infections to occur less frequently without achieving significance.

Antibiotics regime

In this subgroup, we differentiated whether antibiotic administration was preoperative only or preoperative and postoperative. Here, a significant reduction of the wound infection rate was shown by the use of triclosan-coated sutures in the first group (RR: 0.73, 95% CI: [0.58, 0.93]; $I^2 = 55\%$; $P = .02$; Supplementary Figure S6).

Suture material

Considering the suture material used, significant risk reductions of the postoperative wound infection rate were shown for the coated braided suture Vicryl (RR: 0.74, 95% CI: [0.59, 0.93]; $I^2 = 0\%$; $P = .49$) and the coated monofilament suture polydioxanone suture (PDS) (RR: 0.70, 95% CI: [0.51, 0.95]; $I^2 = 58\%$; $P = .04$). This effect was not visible when braided and monofilament sutures (Vicryl and Monocryl or Vicryl and PDS) were used together (Supplementary Figure S7).

Type of infection

Considering the type of postoperative wound infection, 10 studies differentiated between deep and superficial infection. There was a significant risk reduction (RR: 0.71, 95% CI: [0.55–0.91]; $I^2 = 0$; $P = .52$) for the deep infection. Although there was no significance for the reduction of superficial infections in this subgroup (RR: 0.82, 95% CI: [0.58–1.16]; $I^2 = 64\%$; $P = .003$), the result remained significant for all infections in these 10 studies (RR: 0.78, 95% CI: [0.62–0.97]; $I^2 = 46\%$; $P = .02$) (Supplementary Figure S8).

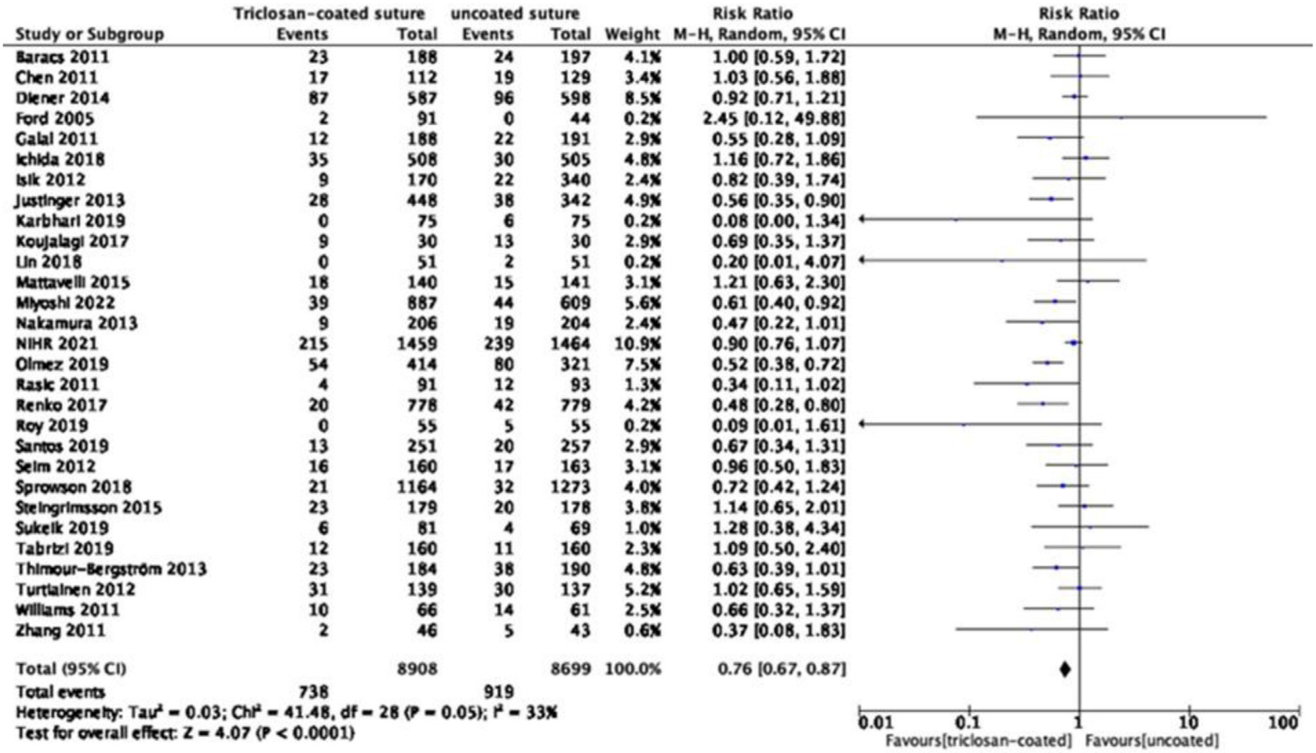

Figure 2. Considering all included studies together, using triclosan-coated sutures reduced the risk of postoperative wound infection by 24%. *M-H*, Mantel-Haenszel.

Table II
Stratified meta-analysis of the incidence of postoperative wound infection after surgery

Subgroups	No. of studies	No. of total patients	No. of postoperative wound infection	Pooled incidence (%)	Risk ratio, (95% CI)	Heterogeneity test	
						I^2 (%)	Q test *P* value
Wound contamination class							
Clean surgery	16	6,495	475	7.17	0.78 (0.66–0.94)	0	.48
Clean-contaminated surgery	11	7,112	874	12.29	0.71 (0.59–0.88)	42	.07
Underlying malignancy							
	6	2,214	172	7.77	0.68 (0.50–0.92)	4	.39
Discipline							
Abdominal surgery	12	9,572	1,136	11.87	0.75 (0.61–0.91)	56	.009
Orthopedic surgery	3	2,689	65	2.42	0.76 (0.47–1.24)	0	.47
Pediatric surgery	2	1,692	64	3.78	0.54 (0.23–1.23)	9	.29
Breast surgery	2	216	31	14,35	0.60 (0.31–1.16)	0	.56
Cardiac and vascular surgery	6	2,348	262	11.16	0.86 (0.68–1.08)	0	.56
Antibiotics regime							
Preoperative	9	6,618	652	9.85	0.73 (0.58–0.93)	55	.02
Preoperative and postoperative	10	2,277	246	10.8	0.77 (0.57–1.03)	24	.22
Risk of bias							
High-quality RCTs	7	5,270	508	9.64	0.84 (0.67–1.06)	43	.14
Other RCTs	22	12,337	1,149	9.31	0.73 (0.62–0.85)	29	< .0001
Definition of outcome with CDC							
CDC	20	14,796	1,340	9.06	0.78 (0.69–0.90)	26	.12
Other	9	2,811	1,657	11.28	0.74 (0.54–1.02)	39	.11
Suture material used							
Vicryl	13	5,849	307	5.25	0.74 (0.59–0.93)	0	.49
PDS	6	3,265	457	14.00	0.70 (0.51–0.91)	58	.04
Vicryl and monocryl	4	1,134	189	16.67	0.85 (0.63–1.14)	20	.29
Vicryl and PDS	3	4,217	552	13.09	0.94 (0.81–1.10)	0	.46
Type of infection							
Superficial infection	10	9,114	422	4.63	0.82 (58–1.16)	64	.003
Deep infection	10	9,114	242	2.66	0.71 (0.55–0.91)	0	.52

CDC, Center for Disease Control; PDS, polydioxanone suture; RCT, randomized controlled trial.

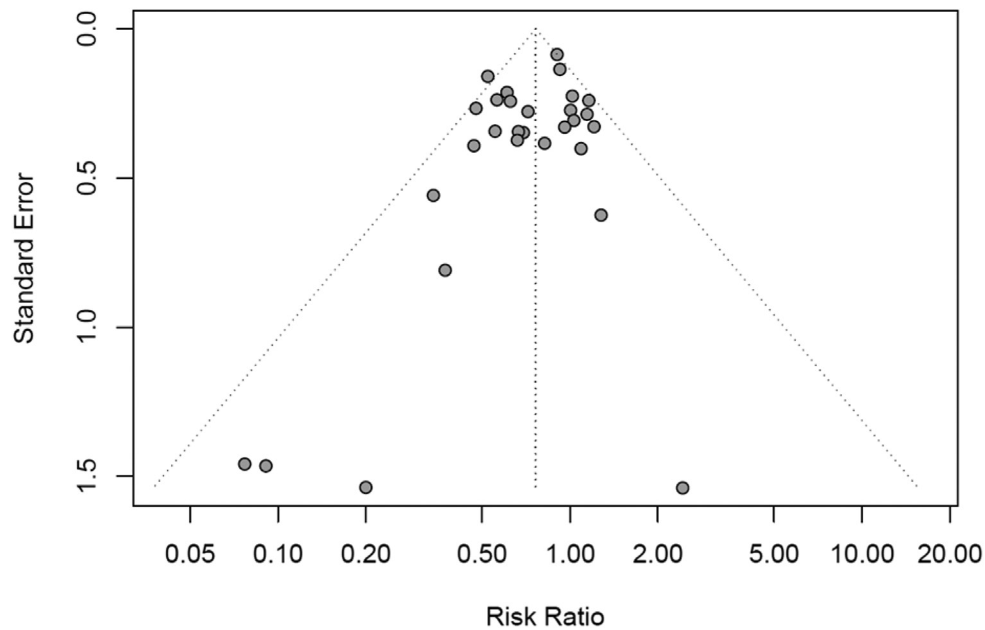

Figure 3. Funnel plot of the included studies in this meta-analysis for the incidence of postoperative wound infection.

Sensitivity analysis

A sensitivity analysis was performed to determine the influence of individual studies on the pooled data and to confirm the stability of the meta-analysis. In the risk of bias sensitivity analysis, a study was considered high quality if rated as an unclear risk in no more than 1 category and high risk in no category. In this analysis of the 7 studies rated as high quality, no significant difference was shown between the triclosan-coated sutures to normal sutures (RR: 0.84, 95% CI: [0.67, 1.06]; $I^2 = 43\%$; $P = .10$; Supplementary Figure S9).

In addition, a sensitivity analysis was calculated regarding the definition of the outcome. Studies that did not use the CDC criteria to define postoperative wound infection were excluded. This analysis shows that for the studies that used the CDC criteria to define postoperative outcomes, the results in the meta-analysis were significant (RR: 0.78, 95% CI: [0.68, 0.90]; $I^2 = 28\%$; $P = .12$; Supplementary Figure S10).

Finally, an analysis of funding and conflict of interest was performed. Here, the results were all found to be significant, regardless of whether there was funding or conflict of interest (COI) (studies without funding/COI: RR: 0.76, 95% CI: [0.65, 0.90]; $I^2 = 41\%$; $P = .03$; studies with funding/COI: RR: 0.77, 95% CI: [0.63, 0.95]; $I^2 = 10\%$; $P = .05$; Supplementary Figure S11).

Publication bias and trustworthiness of the evidence

The confidence of the evidence on the association between the use of triclosan-coated sutures and the incidence of postoperative wound infection was rated as moderate based on the Grading of Recommendations, Assessment, Development, and Evaluation assessment. A slight point deduction was made for the risk of bias; therefore, the rating “high” was not given.

No evidence of publication bias was found (visually symmetrical shape of funnel plot, Figure 3). Egger’s regression test for funnel plot asymmetry yielded a P value of .091.

Cost analysis

Studies by the English National Health Service (Coello et al[18], Jenks et al[19]) were able to determine an increase in inpatient stay of 9 to 11 days per wound infection at postoperative wound infection rates of 10% to 12.8%, associated with additional case costs of 3,450 to 5,760 euros per case with postoperative wound infection. Schmidt et al identified a 24-day increase in hospital length of stay with an additional cost of approximately 13,400 euros per postoperative wound infection for patients undergoing orthopedic procedures (hip and knee arthroplasty) in their 2015 study.[20]

These data give a mean cost per day of prolongation of hospital stay of an average value of 488.41 euros/d (Coello et al 383.30 euros/d, Jenks et al 523.60 euros/d, Schmidt et al 558.30 euros/d).

For example, the primary hip or knee prosthesis implantation operation needs 12 fascia and 12 subcutaneous sutures for wound closure (own data).

From this, it can be concluded that even with a risk reduction of 24% determined in this meta-analysis and a baseline risk of 10% for postoperative wound infection (ie, wound infection can be prevented in 1 in 42 patients), even more, expensive material costs for the coated sutures of up to 12 euros would be justified to still achieve a cost saving on average.

Discussion

In this meta-analysis, 29 publications from randomized controlled clinical trials were examined to determine whether triclosan-coated sutures can reduce the rate of postoperative wound infections. With this work, existing, older meta-analyses were updated. In addition, the focus was placed on subgroup analyses to highlight existing benefits in individual applications.

The study showed that using the triclosan-coated suture material significantly reduced the postoperative wound infection rate, both in the overall analysis of all studies and in some subgroup analyses. The positive effect was evident in the subgroups subdivided according to wound contamination class (“clean-contaminated surgery" or "clean surgery") and in the subgroup of use with underlying oncologic disease. When differentiating according to the antibiotic regimen used, only the group with pure preoperative antibiotic prophylaxis showed a significant risk reduction. In the subgroup analysis by the operating department, the significant effect was seen only in the abdominal surgery group. There was no significant advantage for orthopedic, pediatric, breast, or cardiac and vascular surgery, but these subgroups contained very few studies. The data are, therefore, not very meaningful but showed a clear tendency for the coated suture material to cause postoperative wound infections to occur less frequently without achieving significance.

Our subgroup analysis clearly shows that there are special indications ("clean-contaminated surgery" or "clean surgery," underlying oncologic disease) in which the use of triclosan-coated suture material provides a benefit in care for the patient. Even if the subgroup of superficial infections did not significantly reduce the likelihood of postoperative wound infection, the result remains significant across the totality of infections (superficial and deep infection). These results are partially comparable with data from older meta-analyses, supplemented by the new results of the subgroup analysis.

Interestingly, a World Health Organization guideline from 2016 also recommends using triclosan-coated sutures.[21] It refers to the data of 2 meta-analyses from 2013 and 2014, which, analogous to our study, showed a benefit for the coated suture material.[22,23] At that time, the second work could even underline the proven positive effect of the first work in the field of "clean," "clean-contaminated," and "contaminated surgery." The wound contamination class classification according to CDC was used here, as in our work. Although the subgroup of "contaminated surgery" was already excluded from the exclusion criteria in our work, we could observe the benefit similarly, even though our investigated population was significantly larger (29 instead of 15 included RCTs).

Other studies showed divergent results to ours when differentiated by the type of suture material used (Vicryl versus PDS filament).[24] Here, the triclosan-coated PDS filament suture failed to significantly reduce the postoperative wound infection rate compared with the non-coated variant. In contrast, braided coated sutures significantly reduced the wound infection rate compared to uncoated braided sutures. This may be because with a suture with a rather large surface, as is the case with the braided suture, the effect of the triclosan is more effective, as more bacteria can adhere to this large surface than with a smaller, smooth monofilament surface. Although this aspect was not specifically investigated in this paper, we could show equally significant risk reductions in our analysis when using the coated braided suture material and the coated PDS filament suture variant. This effect was insignificant when using "mixed" sutures (Vicryl and Monocryl or Vicryl and PDS). This will be the basis of further research.

In addition to the pure reduction in the rate of postoperative wound infections due to special suture material and the associated improvement in patient comfort, the financial aspect of this risk minimization should not be ignored.

The cost analysis carried out here showed a still profitable additional possible cost factor of up to 12 euros for the coated suture material because saving postoperative wound infections also saves treatment costs. Of course, this analysis is very exemplary. The additional treatment days resulting from postoperative wound infection and thus the costs incurred vary greatly depending on the surgical procedure/specialty (Coello average 9 days extension of hospital stay due to an occurring postoperative wound infection for the average of all surgical procedures; Jenks 11 days extension of hospital stay due to an occurring postoperative wound infection major surgical procedures; Schmidt 24 days extension of hospital stay due to an occurring postoperative wound infection in hip and knee arthroplasty).[18–20]

Especially in orthopedic surgery, postoperative wound infections entail very high additional material costs because parts of the artificial joints usually have to be replaced during surgical revisions for infection control. These implants represent a major cost factor, which is confirmed by the data from Schmidt et al. They identified additional costs of approximately 13,400 euros per postoperative wound infection for patients undergoing orthopedic procedures (hip and knee arthroplasty) in their 2015 study.[20] Data on additional costs resulting from postoperative wound infections vary in the international literature, adjusted for Germany in 2016, between 926 and 65,114 euros.[25]

Additionally, the direct correlation of the costs arising from a postoperative wound infection with those arising from the coated suture material is not easy to determine. On the one hand, the costs for the suture material are not the same everywhere because not every hospital pays the same price for the suture material due to the current structure of purchasing pools and the resulting negotiable prices for materials. Second, the risk of developing postoperative wound infection varies depending on the surgical procedure and patient-specific risk factors. Because meta-analyses such as this one include data from many different studies and generally do not include the prolongation of hospital stays due to infection, the cost reduction can only be estimated. Based on online prices for suture material, the coated sutures could be less expensive than the non-coated variant.[26] Due to this, each application would pay off, even if there was no wound infection rate reduction. Due to the proven reduction, the cost savings are thus considered even higher than the savings due to the suture prices per se. In this respect, using the coated suture material would be recommended.

The assumption that triclosan-coated sutures could be harmful or dangerous has been refuted several times.[27,28] Nevertheless, even the coated sutures are only one part of an overall package that should and can reduce the postoperative wound infection rate.

Our meta-analysis has advantages and disadvantages: for example, one advantage is that it represents an overall analysis across different surgical arenas and specialties. All RCTs with the definition "clean" or "clean-contaminated" operation (CDC criteria) were included. In addition, subgroup analyses were performed and presented.

Study limitations

Limitations are that not all studies were completely blinded, which could still influence the results. In addition, industrially sponsored studies were included. However, the sponsored study with the most participants did not show any benefit of the coated suture material compared to the conventional suture material. In addition, no difference was found between this study and the non–financially supported studies in the subgroup analysis. Therefore, a bias due to industry funding seems unlikely.

In conclusion, the following conclusions can be drawn from our systematic review of clinical practice. The use of triclosan-coated suture material in "clean" and "clean-contaminated" surgery is recommended based on the data of this meta-analysis to reduce postoperative wound infection rates. Additional costs of up to 12 euros for the coated suture material are justified (at least based on the patient's consumption data) to generate an economic benefit for the hospital by reducing postoperative wound infections. This does not include the overall economic benefit that would have to be added due to the prevention of lost working hours, consequential damages, and similar things.

Funding/Support

This research did not receive any specific funding from any agencies in the public, commercial, or not-for-profit areas.

Conflict of interest/Disclosure

The authors have no conflicts of interests or disclosures to report.

Supplementary materials

Supplementary material associated with this article can be found in the online version, at [10.1016/j.surg.2023.04.015].

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