ORIGINAL RESEARCH

Evaluation of Microbial Adherence on Antibacterial Suture Materials during Intraoral Wound Healing: A Prospective Comparative Study

Ayisha Moonnam Kandathil[1], Sachin Aslam Aslam[2], Roshni Abidha[3], Mathew Pynummoottil Cherian[4], Sooraj Soman[5], Manju Sudarsanan[6]

Abstract

Aim: To assess the efficacy of antiseptic-coated silk sutures with triclosan-coated polyglactin 910 suture in reducing bacterial colonization after oral surgical procedures.

Materials and methods: The patients who required multiple sutures after surgical procedures in the mandible were the study subjects. The sites of suturing were divided into three groups. Group A – surgical site receiving black-braided silk suture (control group). Group B – surgical site receiving triclosan-coated Polyglactin 910 suture (experimental group). Group C – surgical site receiving antiseptic-coated silk suture (experimental group). Evaluation was done on the 3rd postoperative and 7th postoperative day. Microbial adherence was evaluated by microbiological study.

Results: The mean comparison of microbial count between 3rd and 7th post-op day in the three groups shows an increased microbial colonization in the control group when compared with the experimental groups. The combined mean microbial adherence in the three groups showed microbial count in the uncoated silk suture (group A) as 10.35 ± 3.74, triclosan-coated suture (group B) as 6.28 ± 2.17 and iodoform + calendula oil-coated suture (group C) as 7.1 ± 2.02 which is statistically significant ($p < 0.05$).

Conclusion: The present research concluded that the pomade-coated silk suture is as efficient as triclosan-coated VICRYL PLUS Polyglactin 910 sutures in reducing the bacterial colonization in intraoral wound healing.

Clinical significance: The pomade (iodoform + calendula oil) may be advocated in the field of oral and maxillofacial surgery for impregnating the suture materials which act as an antiseptic agent and a promoter of wound healing which is easily accessible and also cost-effective.

Keywords: Antiseptic-impregnated sutures, Bacterial adherence, Triclosan-coated sutures, Wound healing.

The Journal of Contemporary Dental Practice (2023): 10.5005/jp-journals-10024-3553

Introduction

In the practice of oral and maxillofacial surgery, surgeons always try to achieve a sound wound healing. The appropriate wound closure after any surgical procedure includes a sequence of complex biological processes. To achieve an acceptable esthetic and functional outcome, a good closure and stabilization of re-approximated wound edges are inevitable. Wound healing takes place in two mechanisms, that is, primary and secondary intention.[1] The tissues approximated by surgical sutures or adhesives with minimal loss of tissues are said to heal by primary union. Sutures play an important role after every surgical intervention, allowing the tissues to hold in apposition until the wound has healed sufficiently to be self-supportive and functions primarily to maintain wound closure and to promote wound healing during the time when the wound is most vulnerable.[2] The wound healing process can be affected by suture type, suturing technique, the amount of suture material used, and the amount of tension in the suture, and can be a provence of surgical wound contamination that results in the adherence of bacteria and acts as a means of channeling of bacteria to oral tissues. Therefore, they must avoid or limit bacterial adhesion and proliferation to those parts exposed to oral fluids, thereby avoiding contamination inside the wound.

The bacterial adherence is variable and is dependent not only on the suture structure and specific microbial species but also on the of suture materials' chemical composition.[3] Today, various suture materials are commercially available, and it is essential in surgical practice to be aware of the basic properties of suture materials as it forms one of the principles of practising oral surgery and therefore maximize the outcome of any surgical procedure. Among natural suture materials, many surgeons consider silk suture as the standard of performance superior in handling characteristics and also because of the low-cost factor.[4]

Pérez et al.[5] studied the clinical and microbiological impact of an antibacterial suture (Monocryl® Plus) in the surgical removal of 3rd molar on the use of sutures with impregnation of antibiotics and concluded that the antibacterial sutures showed a lesser presence of microorganisms in terms of preventing surgical site infections by reducing the colonization of bacteria. The antimicrobial efficacy is high for the sutures when impregnated with pomade which contained a combination of antibacterial solutions while comparing

[1–6]Department of Oral and Maxillofacial Surgery, MES Dental College and Hospital, Perinthalmanna, Kerala, India

Corresponding Author: Ayisha Moonnam Kandathil, Department of Oral and Maxillofacial Surgery, MES Dental College and Hospital, Perinthalmanna, Kerala, India, Phone: +91 8589899343, e-mail: ayshamks@gmail.com

How to cite this article: Kandathil AM, Aslam SA, Abidha R, *et al*. Evaluation of Microbial Adherence on Antibacterial Suture Materials during Intraoral Wound Healing: A Prospective Comparative Study. J Contemp Dent Pract 2023;24(8):515–520.

Source of support: Nil

Conflict of interest: None

with the uncoated sutures in intraoral wound healing in the study of Cruz [6,7] et al. In this study, an antibacterial solution was prepared, composed of iodoform and calendula oil for the impregnation of sutures. The calendula oil and iodoform had proven its antibacterial properties in many literatures separately.

The purpose of the study is to appreciate an estimate count of microbial adherence on sutures by evaluating the potency of commercially available antiseptic-coated sutures with antibacterial solution impregnated sutures and also comparing both the sutures with an uncoated silk sutures. Despite black-braided silk sutures have been used for intraoral surgical operations for more than a century, due to the biofilm adhesion on them, medical professionals have recently embarked on researching alternative choices. Although antiseptic-coated suture materials are readily accessible (such as VICRYL PLUS), routine use of them cannot be justified due to the significant cost issue.

The aim of this study is to assess the efficacy of antiseptic coating (iodoform + calendula oil) on suture materials by evaluating the microbial adherence on commercially available triclosan-coated sutures with a control group of uncoated sutures in intraoral wounds.

Materials and Methods

The study was a prospective experimental study held in a period from January 1, 2021 to August 31, 2022 and was done at Department of Oral and Maxillofacial Surgery, MES Dental College. Ethical committee of MES Medical College, Perinthalmanna, has approved the ethical clearance (as per letter No. IEC/MES/63/2020 dated 07/1/2021).

The inclusion criteria comprised of patients in the age-group of >18–45 years who required intraoral multiple interrupted sutures for wound closure without any acute infections only on mandibular arch, mandibular vestibule, and floor of the mouth on the same day with minimum of three sutures. The sutures manufactured by Johnson & Johnson limited, India, were used in these patients for wound closure.

Patients suffering from systemic illness predisposing them to immunocompromised state, acute oral infections who require wound closure only in maxilla and pregnant females were excluded from the study.

The sites of suturing were divided into three groups in each patient – 36 study subjects (patients) were included.

Group A – Surgical site with black-braided silk suture (control group)

Group B – Surgical site with triclosan-coated polyglactin 910 suture (experimental group)

Group C – Surgical site with antiseptic-coated silk suture (experimental group)

All the three suture materials were used in the same patient for wound closure on the same day and the tail end of each suture was harvested and sent for microbiological evaluation on the 3rd postoperative and 7th postoperative day.

Preparation of Antiseptic-coated Suture Material

The antiseptic pomade was prepared in equal quantity by mixing iodoform (40.4%, NICE chemicals) with calendula oil (5%, Apara International). The pomade was applied to the suture thread by the surgeon immediately before the suturing. The application was done till it gets saturated with the pomade by placing the pomade between two fingers and sliding the thread between them.

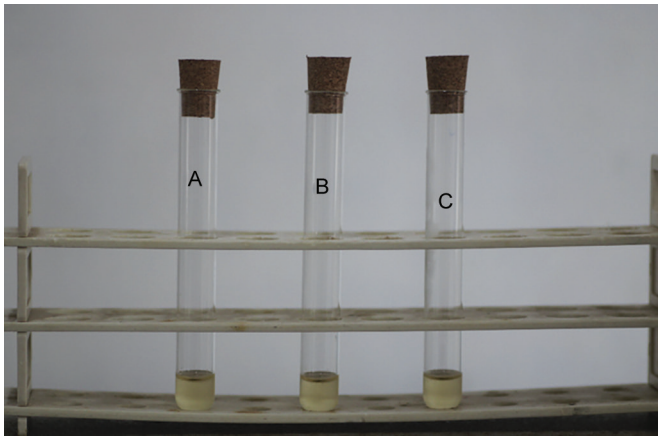

Fig. 1: Sterile test tubes with transport media for collection of suture materials

Fig. 2: Microbial growth in the blood agar culture plate

Procedure

All the three suture materials were placed in a single patient after completion of surgical procedure. A 2 mm tail end of the suture material was harvested from each sutured sites from the patient on the 3rd and 7th postoperative days. To maintain a viable bacterial culture of the suture threads, these harvested pieces were immediately transferred to the sterile tubes (Fig. 1). Each tube contained the peptone as the carrier medium. And the test tubes were labeled and stored with ice in a thermal container before processing. To allow the deposits to form, each tube was kept in a constant mechanical flux at 12 rpm for 10 minutes. And it was removed and subjected to 10-fold dilutions. By pipetting 1 mL of the suspension and diluting it in 9 mL saline solution, first dilution of 10^{-1} was prepared and by transferring 1 mL of each dilution to obtain the next, first 10^{-1} dilution (1:10) was prepared up to 10^{-10} and the tubes were kept under constant homogenization. About 1 mL of each dilution was plated on a medium of blood agar plus defibrinated sheep blood (5 mL blood agar per 100 mL base medium). For incubation, the plates were kept under microaerophilic conditions at 37°C for 48 hours. The number of colony-forming units per mL (CFU/mL) was recorded from the culture plate with the aid of colony counter after incubation (Fig. 2). The data (number of bacterial count) were entered in the pro forma and recorded as a hard copy.

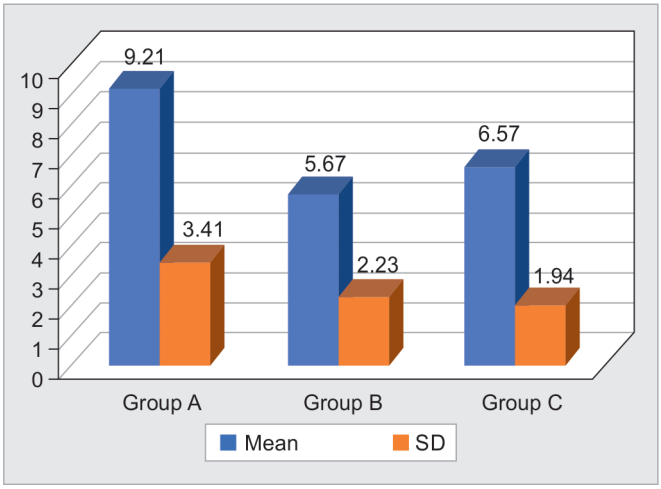

Fig. 3: Graphical representation of bacterial adherence in three groups on 3rd postoperative day

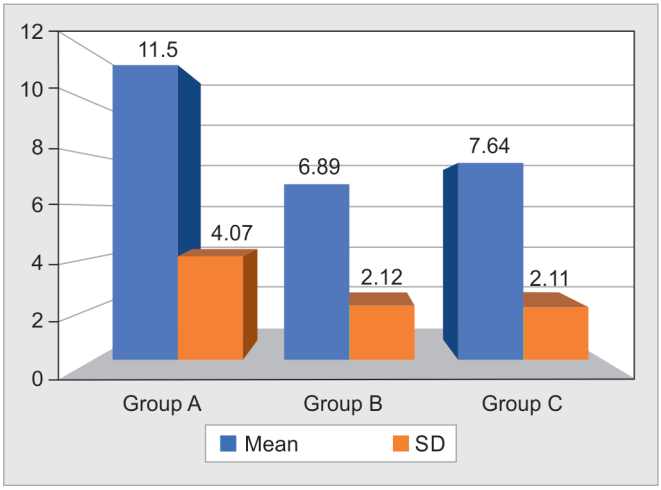

Fig. 4: Graphical representation of bacterial adherence in three groups on 7th postoperative day

Statistical Analysis

Data were analyzed using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL) and the level of significance was set at $p < 0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using Shapiro–Wilkinson test. Inferential statistics to find out the difference between the time intervals was done using Wilcoxon sign-rank test and analysis between three groups was done using Kruskal–Wallis, followed by Tukey's HSD *Post hoc* analysis to find out the difference between any two groups.

Results

The mean age-group of this study was 26.05 ± 7.11 and number of females are more compared with males in the study. The mean value in the 3rd post-op day (POD) in group A (9.21 ± 3.41), group B (5.67 ± 2.23) and group C (6.5 ± 1.94) and the mean microbial adherence on 7th POD in group A (11.50 ± 4.07), group B (6.89 ± 2.12) and group C (7.64 ± 2.11). On overall observation (Figs 3 and 4), the microbial adherence in black-braided silk suture (group A) was more when compared with triclosan-coated Polyglactin 910 suture

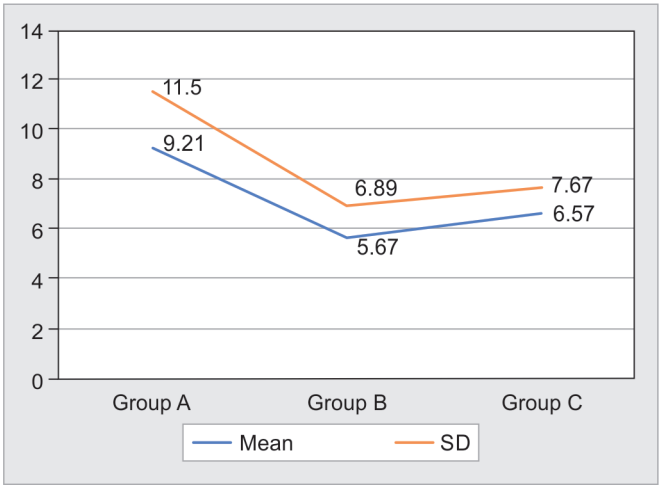

Fig. 5: Comparison of bacterial count in three groups between 3rd and 7th postoperative day

Table 1: Mean comparison between the groups and between the 3rd and 7th post-op day

	Groups	*Mean ± SD*	*p-value*
3rd POD	Group A	9.21 ± 3.41	
	Group B	9.21 ± 3.41	
	Group C	6.57 ± 1.94	
	Group A vs group B		0.0001
	Group A vs group C		0.0001
	Group B vs group C		0.30
7th POD	Group A	11.50 ± 4.07	
	Group B	6.89 ± 2.12	
	Group C	7.64 ± 2.11	
	Group A vs group B		0.0001
	Group A vs group C		0.0001
	Group B vs group C		0.52
Comparison B/W 3rd and 7th POD	Group A	2.29 ± 0.66	0.01
	Group B	1.22 ± 0.11	0.01
	Group C	1.07 ± 0.17	0.02

(group B) and antiseptic-coated silk suture (group C) and statistically significant ($p < 0.05$) on 3rd and 7th POD. The comparison between the experimental group (group B) did not show much difference in the microbial adherence on the 3rd and 7th POD and statistically non-significant ($p > 0.05$). The mean comparison of microbial count between 3rd and 7th postoperative day in the three groups shows (Fig. 5) an increased microbial colonization in the uncoated silk (group A) when compared with the antibacterial-coated sutures (groups B and C) (Table 1).

Combined comparison (Table 2) shows an increased microbial count in the uncoated silk suture (group A) when compared with the antibacterial-coated sutures (group A and group C) which is statistically significant ($p < 0.05$). When comparing the two experimental groups, group B and group C, the results do not show a significant difference in the microbial colonization. The results conclude that the pomade-coated silk suture is as efficient as triclosan-coated VICRYL PLUS Polyglactin 910 sutures in reducing the bacterial colonization in the intraoral wound healing.

Table 2: Combined comparison between the three groups

Groups	*Mean ± SD*	*p-value*
Group A	10.35 ± 3.74	
Group B	6.28 ± 2.17	
Group C	7.10 ± 2.02	
Group A vs group B		0.0001
Group A vs group C		0.0001
Group B vs group C		0.42

Discussion

Dental extractions are one of the minor routine procedures in oral surgery, and achieving an optimal wound healing is one of the basis of principles in oral surgery. Indeed, tooth extraction is initially perceived purely as tooth loss, but local changes arise and promote hard- and soft-tissue alterations. The process of local changes that take place in order to close the wound and restore tissue homeostasis is called "socket healing."[1–3] It includes a cascade of events which is divided into three sequential, and frequently overlapping phases, they are: inflammatory, proliferative, and modeling/remodeling.[4]

The wound healing is an external manifestation of a complex series of cellular and metabolic reactions intended to restore tissue integrity and functional capability following injury.[5,6] Wound healing comprises two mechanisms, that is, primary and secondary intention. Primary healing occurs when tissues are approximated by surgical sutures with minimum tissue loss.[7,8] When there is more extensive loss of cells, or large defects, healing takes place by secondary union.[9–11] Healing by primary intention is preferable because there is less scarring, more rapid healing, and reduced discomfort.[9,12,13] Suturing is the most common method to achieve this goal. Other biomaterials, such as adhesive glues, staples, adhesive tapes, and fibrin sealants have also been used to hasten the pace of healing.[7,14,15]

Surgical site infection (SSI) is the third most common cause of infections in surgical patients and are more frequently encountered postoperative complication in oral and maxillofacial surgery.[16,17] Two-thirds of all cases of SSI appear in the zone of the incision.[18,19] This probability is even greater in the presence of sutures.[20–22] It has been calculated that 100 Cfu would be required to cause SSI when using standard sutures.[23]

The relationship between the frequency of infection and a suture material's capacity to harbor microbes has drawn attention to the problem of microbial adhesion to various materials.[24] Numerous studies have been done to show that the multifilament sutures have higher microbiological adhesion than monofilament ones.[25] When considering the suture materials in intraoral surgical procedures, specific care should be taken as they are partially embedded in intraoral tissues and bathed in saliva, with a mean concentration of microorganisms of 7.5 X 10 8 CFU/mL.[26,27] This results in continuous wicking of microorganisms along the suture at the surgical site which results in a prolonged inflammatory response and surgical site infection (SSI).[28] In literature, various studies are conducted to create an antimicrobial suture to reduce bacterial adhesion and colonization by coating or impregnating with antibacterial substances. One such item that has been applied in various circumstances is a suture prepared of Polyglactin 910 covered with the antibacterial chemical triclosan.[29] In the present study, a pomade is prepared by coating the silk sutures and comparing the microbial adherence with the commercially available triclosan-coated vicryl sutures in intraoral wound healing.

The use of silk-braided sutures in the current study is justified by the fact that among all the natural suture materials, many surgeons regard silk as the gold standard due to its excellent pliability and widespread usage.[30] The present study showed statistically a significant difference in the microbial adherence when compared with the antiseptic-coated silk suture (experimental group) and black-braided silk suture (control group). No postoperative inflammation, allergic reactions, or infection occurred in the study. Fernando Cruz et al.[7] conducted a study to assess if an antiseptic pomade could reduce the bacterial colonization on multifilament sutures and the study concluded that the antiseptic pomade was effective in reducing bacterial colonization on silk-braided sutures which is considered to be supportive evidence to the current study.

According to the study of S Viju et al.[31] application of tetracycline hydrochloride (TCH) onto silk sutures at three different concentration and the effect of TCH concentrations on the characteristics of the silk sutures was studied with the scanning electron microscope (SEM) and found out good drug release and antimicrobial characteristics on the sutures.

In the current scenario, the microbial growth was significantly lower in the experimental groups than that of the control group. The present study employed the culturing method due to its affordability and accessibility. But not all infections are compatible with molecular systems. In the study, the microbial load on sutures was cultured, tabulating only the count of viable bacteria since culture only produces counts of bacteria that are still alive.

Despite the histological and microbiological differences in surgical sites (skin vs mucosa), exposure to food particles and constant secretion of saliva, and also an environment influenced by breathing process, all of which can have an ablative effect on the efficiency of the antibacterial suture materials; the existing study has proved the above-mentioned results and showed that pomade impregnated silk sutures can decrease the bacterial load in the oral surgical site when compared with the uncoated silk sutures and also as efficiently as triclosan-coated vicryl sutures. The study showed a difference in the microbial adherence when compared with the 3rd and 7th postoperative day among the three groups and no incidence of infections are reported.

The study also provided conclusive evidence that the microbial load could not be totally eradicated from the suture, keeping the potential risks connected with sutures despite the antiseptic coating. Therefore, there is a need for more research on the microbial adhesion and methods to prevent biofilm formation on sutures in intraoral settings.

Although coated sutures are expensive, the antibacterial impregnated sutures utilized in this study can be used for routine procedures. It has been demonstrated that an antiseptic coating of the suture material made of iodoform and calendula oil as active ingredients has long-lasting efficiency in microbiologic control and is free from any negative effects on oral tissues. Iodoform, an effective germicidal agent with anti-infective properties, was one of the key components in the pomade that was prepared. Iodine is the active ingredient in the process of this property.[32] Calendula oil, the second component, has the triterpenoids present which are thought to be the drug's most potent anti-inflammatory ingredients. The fardiol monoester among them seems to be the principal that most directly relates to the drug's action.[33–37] However, for nearly a century, these elements have been employed

independently or in combination in a variety of medical specialties, mainly in endodontics and pediatric dentistry.

The main drawback in our study was that because the cultures were done in microaerophilic settings, pathogenic aerobes were not taken into consideration. More accurate results can be obtained via analysis employing cutting-edge molecular methods, scanning electron microscopy, and confocal laser microscopy. The effectiveness of this antiseptic pomade as a suture covering should thus be further examined by a sizeable research sample analyzing its clinical effects, microbiology, and economic advantages.

Conclusion

There was a significant reduction in the microbial adherence and colonization in antiseptic-impregnated silk sutures compared with uncoated silk sutures. The mean bacterial colony count of conventional black-braided silk suture was found to be 2.64 times higher than the antiseptic-impregnated black-braided silk sutures. The mean bacterial count of impregnated black-braided silk suture was found to be only 0.9 times higher than the triclosan-coated Polyglactin 910 sutures. The impregnated silk sutures were as efficient as commercially available antiseptic-coated sutures while comparing the microbial adherence during intraoral wound healing.

References

1. Andersson L, Kahnberg KE, Pogrel MA, editors. Oral and Maxillofacial Surgery. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex , PO198SQ, United Kingdom; 2012.
2. Hupp JR, Tucker MR, Ellis E. Contemporary Oral and Maxillofacial Surgery-E-book. Elsevier B.V. Registered Office: Radarweg 29, 1043 NX Amsterdam, The Netherlands, Registered in The Netherlands; 2013.
3. Araújo MG, Silva CO, Misawa M, et al. Alveolar socket healing: What can we learn? Periodontology 2000. 2015;68(1):122–134. DOI: 10.1111/prd.12082.
4. Chhabra S, Chhabra N, Kaur A, et al. Wound healing concepts in clinical practice of OMFS. J Maxillofac Oral Surg 2017;16(4):403–423. DOI: 10.1007/s12663-016-0880-z.
5. Pérez SS, Ramírez ML, Borgarello MQ, et al. Antibacterial suture vs silk for the surgical removal of impacted lower third molars. A randomized clinical study. Medicina oral, patología oral y cirugía bucal. Ed. inglesa. 2016;21(1):11. DOI: 10.4317/medoral.20721.
6. National Nosocomial Infections Surveillance (NNIS) report, data summary from October 1986–April 1996, issued May 1996. A report from the National Nosocomial Infections Surveillance (NNIS) System. Am J Infect Control. 1996;24:380–388. PMID: 8902113.
7. Cruz F, Leite F, Cruz G, et al. Sutures coated with antiseptic pomade to prevent bacterial colonization: a randomized clinical trial. Oral surgery, oral medicine. Oral Pathol Oral Radiol 2013;116(2):e103–e109. DOI: 10.1016/j.oooo.2011.12.016.
8. King RC, Crawford JJ, Small EW. Bacteremia following intraoral suture removal. Oral Surg Oral Med Oral Pathol 1988;65:23–28. DOI: 10.1016/0030-4220(88)90185-5.
9. Cruz M, Castro JM. Effectiveness of iodoform antiseptic pomade in the control of bacterial dental implant-abutment interface contamination: a randomized clinical trial. Clin Int J Oral Sci. 2001; 14(1):1–4. Available from: https://www.researchgate.net/publication/260071444_Effectiveness_of_Iodoform_Antiseptic_Pomade_in_the_Control_of_Bacterial_Dental_Implant-Abutment_Interface_Contamination_A_Randomized_Clinical_Trial.
10. Masini BD, Stinner DJ, Waterman SM, et al. Bacterial adherence to suture materials. J Surg Educ 2011;68(2):101–104. DOI: 10.1016/j.jsurg.2010.09.015.
11. Deliaert AE, Van den Kerckhove E, Tuinder S, et al. The effect of triclosan-coated sutures in wound healing. A double blind randomised prospective pilot study. J Plastic, Reconstr Aesthet Surg 2009;62(6):771–773. DOI: 10.1016/j.bjps.2007.10.075.
12. Pelz K, Todtmann N, Otten JE. Comparison of antibacterial-coated and non-coated suture material in intraoral surgery by isolation of adherent bacteria. Annals of Agricultural and Environmental Medicine. 2015;22(3):551–555. DOI: 10.5604/12321966.1167733.
13. Venema S, Abbas F, Van de Belt-Gritter B, et al. In vitro oral biofilm formation on triclosan-coated sutures in the absence and presence of additional antiplaque treatment. J Oral Maxil Surg 2011; 69:980–985. DOI: 10.1016/j.joms.2010.02.030.
14. Storch M, Perry LC, Davidson JM, et al. A 28-day study of the effect of Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 suture with triclosan) on wound healing in guinea pig linear incisional skin wounds. Surgical Infections. 2002;3(S1):s89–98. DOI: 10.1089/sur.2002.3.s1-89.
15. Ming X, Nichols M, Rothenburger S. In vivo antibacterial efficacy of MONOCRYL plus antibacterial suture (Poliglecaprone 25 with triclosan). Surgical Infections. 2007;8(2):209–214. DOI: 10.1089/sur.2006.004.
16. Sh ME, Rahgozar S, Tajmiri G, et al. Microbiological evaluation of the antibacterial Vicryl suture in the mandibular third molar surgery. J Oro-fac Sci 2022;14:120–127. DOI: 10.4103/jofs.jofs_131_22.
17. Hoshino S, Yoshida Y, Tanimura S, et al. A study of the efficacy of antibacterial sutures for surgical site infection: a retrospective controlled trial. Int Surg 2013;98(2):129–132. DOI: 10.9738/CC179.
18. Sewlikar SA, Pillai RS, Mahajan NS, et al. Triclosan coated sutures: an overview of safety and efficacy in reducing risk of surgical site infection. Int Surg J 2016;2(1):1–7. DOI: 10.5455/2349-2902.isj20150201.
19. Tabrizi R, Mohajerani H, Bozorgmehr F. Polyglactin 910 suture compared with polyglactin 910 coated with triclosan in dental implant surgery: randomized clinical trial. Int J Oral Maxillofac Surg 2019;48(10):1367–1371. DOI: 10.1016/j.ijom.2019.01.011.
20. Guo J, Pan LH, Li YX, et al. Efficacy of triclosan-coated sutures for reducing risk of surgical site infection in adults: a meta-analysis of randomized clinical trials. J Surg Res 2016;201(1):105–117. DOI: 10.1016/j.jss.2015.10.015.
21. Chu CC, Williams DF. Effects of physical configuration and chemical structure of suture materials on bacterial adhesion: a possible link to wound infection. Amer J Surg 1994;147(2):197–204. DOI: 10.1016/0002-9610(84)90088-6.
22. Wright KJ, Barbosa SV, Araki K, et al. In vitro antimicrobial and cytotoxic effects of Kri 1 paste and zinc oxide-eugenol used in primary tooth pulpectomies. Pediatric dentistry. 1994;16(2):102–106. PMID: 8015949.
23. Rothenburger S, Spangler D, Bhende S, et al. In vitro antimicrobial evaluation of Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 with triclosan) using zone of inhibition assays. Surg Infect 2002;3(S1):s79–87. DOI: 10.1089/sur.2002.3.s1-79.
24. Moore LE. Evaluation of the Risks Associated with Long-Term Use of Cationic Antimicrobials. The University of Manchester (United Kingdom); 2005.
25. Barbolt TA. Chemistry and safety of triclosan, and its use as an antimicrobial coating on Coated VICRYL Plus Antibacterial Suture (coated polyglactin 910 suture with triclosan). Surg Infect 2002;3(S1):s45–53. DOI: 10.1089/sur.2002.3.s1-45.
26. Parirokh M, Asgary S, Eghbal MJ, et al. A scanning electron microscope study of plaque accumulation on silk and PVDF suture materials in oral mucosa. Int Endodont J 2004;37(11):776–781. DOI: 10.1111/j.1365-2591.2004.00873.x.
27. Banche G, Roana J, Mandras N, et al. Microbial adherence on various intraoral suture materials in patients undergoing dental surgery. J Oral Maxillofac Surg 2007;65(8):1503–1507. DOI: 10.1016/j.joms.2006.10.066.
28. Mortazavi M, Mesbahi M. Comparison of zinc oxide and eugenol, and Vitapex for root canal treatment of necrotic primary teeth. Int J Paediat Dent 2004;14(6):417–424. DOI: 10.1111/j.1365-263X.2004.00544.x.

29. Grigg TR, Liewehr FR, Patton WR, et al. Effect of the wicking behavior of multifilament sutures. Journal of Endodontics. 2004;30(9):649–652. DOI: 10.1097/01.don.0000121617.67923.05.
30. Ford HR, Jones P, Gaines B, et al. Intraoperative handling and wound healing: controlled clinical trial comparing coated VICRYL® Plus antibacterial suture (coated polyglactin 910 suture with triclosan) with Coated VICRYL® suture (coated polyglactin 910 suture). Surgical infections. 2005;6(3):313–321. DOI: 10.1089/sur.2005.6.313.
31. Viju S, Thilagavathi G. Characterization of tetracycline hydrochloride drug incorporated silk sutures. J Textile Institute. 2013;104(3):289–294. DOI: 10.1080/00405000.2012.720758.
32. Kuga MC, Faria G, So MV, et al. The impact of the addition of iodoform on the physicochemical properties of an epoxy-based endodontic sealer. J Appl Oral Sci 2014;22(2):125–130. DOI: 10.1590/1678-775720130052.
33. Preethi KC, Kuttan R. Wound healing activity of flower extract of Calendula offlcinalis. J Basic Clin Physiol Pharmacol 2009;20(1):73–80. DOI: 10.1515/jbcpp.2009.20.1.73.
34. Sortino F, Lombardo C, Sciacca A. Silk and polyglycolic acid in oral surgery: a comparative study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105(3):e15–e18. DOI: 10.1016/j.tripleo.2007.09.019.
35. Marzo G, Loffredi R, Marchetti E, et al. In vitro antibacterial efficacy of Vicryl Plus suture (coated Polyglactin 910 with triclosan) using zone of inibition assays. Oral implantol 2008;1(1):43–48. PMID: 23285335.
36. Ming X, Rothenburger S, Nichols MM. In vivo and in vitro antibacterial efficacy of PDS plus (polidioxanone with triclosan) suture. Surg Infect 2008;9(4):451–457. DOI: 10.1089/sur.2007.061.
37. Justinger C, Moussavian MR, Schlueter C, et al. Antibiotic coating of abdominal closure sutures and wound infection. Surgery 2009;145(3):330–334. DOI: 10.1016/j.surg.2008.11.007.