

Evaluation of Antibacterial Effectiveness of Antiseptic Ointments on the Suture Material's Bacterial Colonization at the Impacted Third Molar Site: An *In Vitro* Study

Karishma Rathor¹, Sthitaprajna Lenka², Susmita Nayak², Ramesh Nagarajappa³, Shakti Rath^{4*}, Swagata Sahoo², Ananya Bej², Karan Baruah²

¹Department of Public Health Dentistry, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India, ²Department of Oral and Maxillofacial Surgery, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India, ³Department of Public Health Dentistry, The Oxford Dental College, and Hospital, Bangalore, Karnataka, India, ⁴Department of Microbiology and Research, Central Research Laboratory, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India. *Corresponding Author's Email: dr.shaktirath@gmail.com

Abstract

This study aimed to assess the efficacy of several antiseptic ointments by evaluating the development of microorganisms on the suture material, the amount of post-surgical discomfort, and the degree to which the operated wounds heal after administration of various ointments. We studied 30 patients with impacted lower third molar who underwent trans alveolar extraction. Mersilk was selected for suturing of the operated site, and before suturing, three types of ointments, hexigel, neomycin, and metrogyl, were applied to the suture material. Patients were instructed not to use any antimicrobial toothpaste or mouthwash for one week. After seven days, the sutures were removed and sent for microbiological evaluation. The results showed a significant reduction in the number of microorganisms, post-operative discomfort, and swelling of the face postoperatively. Isolated bacteria showed minimum growth around the suture with hexigel ointment with CFUs/ml ($\approx 22 \times 10^8$), and with Metrogyl gel showed the maximum amounts of CFUs/ml ($\approx 61 \times 10^8$) followed up with Neomycin ointment group CFUs/ml ($\approx 40 \times 10^8$). The p-value for Degree of Healing is greater than 0.05, with no significant difference between the three types of antiseptic ointment relating to Degree of Healing. The lowest pain score was due to Hexigel, and the maximum was found to be due to neomycin. As all types of suture material can lead to infection at the surgical wound, after surgical extraction, the use of antiseptic ointments like Hexigel that contains chlorhexidine before the suturing can give us better healing of the wound with less pain and swelling.

Keywords: Antiseptic Ointments, Bacterial Colonization, Mersilk, Third Molar, Tran's alveolar Extraction.

Introduction

The mandibular third molar teeth are the most impacted, affecting 33% of the population. Frequently observed complications of impacted teeth necessitate their extraction. Indications for 50% of tooth extraction are pericoronitis; the remaining 50% are pain, orthodontic conditions, and association with pathological conditions. Surgical extraction of 3rd molar teeth is the most common procedure for oral surgery (1). Sutures play a critical role in wound healing after any surgical intervention, allowing tissue approximation to be detached by any trauma due to surgery or accident, promoting primary healing, and controlling bleeding. Hence, we should choose suture material with care (2). Since the involved body tissues are different from other parts of the

body in terms of speech, mastication, and swallowing, as well as the constant presence of saliva and abundant vascularisation, suture materials used in oral and maxillofacial surgeries behave differently from those used elsewhere in the body (3). The most frequently used suture material in third molar surgery is braided natural silk sutures, size 3-0/4-0. Due to its ability to retain tensile strength, excellent knot security, appropriate tissue response, and economic value, this material is favoured. Also, handling this suture material is easy because of its wax and silicone coating that reduces tissue damage. They are also used in gastrointestinal and cardiovascular surgeries and are easily absorbed by the body (4). A good suture material must limit or avoid the

This is an Open Access article distributed under the terms of the Creative Commons Attribution CC BY license (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

(Received 20th March 2024; Accepted 11th July 2024; Published 30th July 2024)

adhesion of bacteria and their proliferation to areas exposed to oral fluids; as a result, wound contamination is prevented. Most surgeons consider silk suture a performance standard for all-natural suture materials because of its exceptional handling abilities. Inadequate closure results in the detachment of boundaries, creating a possible entry point for bacterial infiltration, which may induce infection and fibrosis (5). Scientific evidence reveals that susceptibility to infection of host tissues is increased by the presence of suture material in the wound. It also serves as a transport media of bacteria in surgical wounds. Both anaerobic and aerobic bacteria of species *Streptococcus*, *Peptostreptococcus*, *Fusobacterium*, *Porphyromonas*, *Prevotella*, *Bacteroides*, and yeasts like *Candida albicans* can cause infections (6). Bacteria on suture materials can substantially impact how well extraction sites recover after removing third molars. Bacteria can develop infections at the extraction site, resulting in more significant pain, oedema, and slow healing. Infections can sometimes lead to the formation of an abscess, requiring additional medical attention (7, 8). The presence of microorganisms can cause an inflammatory reaction. While some inflammation is expected during healing, excessive inflammation can interfere with regular healing and cause additional discomfort. Bacterial infection can damage wound edges, causing dehiscence (reopening of the wound). This may expose the extraction site to further pollution and hinder healing. They can disturb the creation of new tissue and the closure of the wound, so interfering with the normal healing process. This can increase the time it takes for the extraction site to heal completely. Bacteria can create biofilms on suture materials. Biofilms are complex communities of bacteria resistant to drugs and the body's immune system. Biofilm production can make infections more difficult to treat and delay recovery (7, 8). The administration of oral antiseptics before the surgical intervention is efficient at suppressing microbiota and avoiding post-operative difficulties, aiding in the prevention of microorganisms spreading via the blood; as a result, there is a reduced risk for bacterial endocarditis (9). These days, of all the antimicrobial drugs practised to lower the number of microorganisms in the oral cavity, chlorhexidine gluconate is the most secure and efficient option.

Unfortunately, chlorhexidine gluconate has several negative drawbacks. It causes stains on teeth and dental prostheses and the desquamation of the oral mucosa epithelium. Assessing the antibacterial efficacy in laboratory settings, i.e., *in vitro*, is essential because it helps establish a proper treatment plan, particularly in extracting the third molar. It helps in understanding the mode of action of the antibacterial agent and further helps in reducing the resistance of the microorganism. It significantly enhances surgical outcomes and helps establish clinical guidelines and infection control protocols in such surgery (10). Rather than attempting to compare the virulence of different strains, *Staphylococcus aureus* was the source of carbuncles and wound infections (11, 12). This study aimed to assess the efficacy of several antibacterial ointments by evaluating the development of microbes on the suture thread, the amount of post-surgical discomfort, and the degree to which the operated wounds heal after administration of various ointments.

Materials and Methods

Study Population

A total of 30 patients who underwent trans-alveolar extraction of the mandibular third molar teeth in the department were included in this study. This study was conducted from December 2022 to February 2023. The study was conducted after institutional ethical clearance vide letter number SOA/IDS/IRB 2022/12-VII.

Inclusion and Exclusion Criteria

The inclusion criteria are (i) age (range of 18 to 39); (ii) availability during the study period; (iii) good general health; (iv) Throughout the trial period, there should be no ongoing or pending therapies; and (v) acceptance by the patient and commitment to the oral hygiene recommendations. None of the antiseptic mouthwash/toothpaste was to be used throughout the study period. The exclusion criteria are (i) usage of any antimicrobial mouthwash/toothpaste while sutures are still in the patient's mouth; (ii) Medical history of diabetes/degenerative disease; (iii) Habit history of smoking; (iv) poor oral health (poor periodontal status, cavities, oral pathologies, etc.; (v) application of orthodontic/prosthetic devices; (vi) allergy to amoxicillin; (vii) pregnancy/lactation.

A random assignment was made to each patient into one of the groupings after they signed informed consent forms and agreed to participate in the trial. Each selected name was allocated to one of three categories, denoted by the letters A, B, and C. Thus, three groups of ten individuals were formed. The three ointments utilised in this experiment were designated as Group A, Group B, and Group C: hexigel, metrogy gel, and neomycin.

Study Protocol

All patients interested in participating in the trial signed the informed consent forms. Before each surgical step, clinical and radiological characteristics were evaluated. The parameters studied were the facial landmarks (distance from the ear's tragus to the mouth, degree of eruption, distance from mandible to external corner of the eye, distance from the corner of lip to mandible, inter-incisal distance, difficulty index). Following the end of the procedure, the wound was sutured using a 3-0 milk suture, and the patient was instructed to post-operative care. Patients' clinical history was obtained on their initial visit, the technique was described, and they were allowed to participate in the study.

Post-Operative Care

The patients were informed that this gel had antimicrobial and good healing properties. The participants were prescribed a combination of Amoxicillin and Clavulanic acid with a dose of 625mg thrice for seven days and a combination of aceclofenac 100mg and paracetamol 325mg twice daily for three days. If the patient's discomfort persists after the first 3-day prescription, and if needed, the same dose of aceclofenac and

paracetamol could be administered. The sutures were removed on the 8th day postoperatively. The clinical parameters were analysed. The subjective evaluation of post-operative discomfort and healing was evaluated. The suture samples were sent to the Central research laboratory for microbiological evaluation under aseptic conditions using Amies Transport Medium. Routine microbiological analysis and biochemical tests such as gram staining, haemolysis, and sugar fermentation were done to isolate and identify the bacteria. Colony-forming units were calculated based on the number of visible colonies on an agar plate, which can be multiplied by the dilution factor to provide the CFU/ml value, e.g., 1×10^6 CFU/ml. Blood agar plates were used for *Streptococcus* species, whereas Nutrient agar was used for *Lactobacillus* species.

Results

The Mean age was 26.07 ± 3.685 ; the Minimum age was 20 years, and the Maximum age was 34 years. The isolated bacteria were identified based on gram staining, haemolysis pattern, and sugar fermentation test results (Table 2). All the isolate bacteria were gram-positive. *Lactobacillus* was isolated in the highest number, followed by *Streptococcus salivarius*, *S. mutans*, *S. milleri*, and *S. sanguis*. The results' frequencies, mean values, and standard deviations were displayed. One-way ANOVA was used to assess statistical significance, and a t-test was used to determine whether group differences in significance were present. P values were deemed significant if they were less than 0.05 (Table 3).

Table 1: Distribution of Study Subjects According to Sex, Tooth Number and Ointment Type

Variables		n (%)
Sex	Males	17 (56.7)
	Females	13 (43.3)
Tooth number	38	15 (50)
	48	15 (50)
Ointment type	Neomycin	10 (33.3)
	Hexigel	10 (33.3)
	Metrogy gel	10 (33.3)

Table 2: Biochemical Identification of Isolated Bacteria

Isolated bacteria	Gram Stain	Haemolysis	Sugar Fermentation Tests						
			Manni tol	Raffin ose	Sorbi tol	Melibi ose	Trehal ose	Argini ne	VP
<i>Lactobacillus</i>	+ve rods	ND	-ve	v	-ve	v	v	-ve	-ve
<i>Streptococcus sanguis</i>	+ve cocci	α	-ve	+ve	-ve	+ve	+ve	-ve	-ve
<i>Streptococcus milleri</i>	+ve cocci	α	-ve	-ve	-ve	+ve	+ve	+ve	+ve
<i>Streptococcus mutans</i>	+ve cocci	α	+ve	+ve	+ve	+ve	+ve	+ve	+ve
<i>Streptococcus salivarius</i>	+ve cocci	α	-ve	+ve	-ve	+ve	+ve	-ve	-ve
<i>S. pyogenes</i>	+ve cocci	β	-ve	-ve	-ve	-ve	+ve	+ve	-ve

Notes: +ve: positive; -ve: negative; V: variable; ND: Not done

Table 3: Frequency and Mean CFUs/ml of the Isolated Bacteria

Isolated bacteria	n (%)	Mean $\pm$ SD
<i>Lactobacillus</i>	9 (30)	47.78 $\pm$ 14.57
<i>Streptococcus sanguis</i>	4 (13.3)	21.00 $\pm$ 2.94
<i>Streptococcus milleri</i>	4 (13.3)	33.75 $\pm$ 18.39
<i>S. mutans</i>	4 (13.3)	51.25 $\pm$ 8.85
<i>Streptococcus salivarius</i>	8 (26.7)	43.88 $\pm$ 20.87
<i>S. pyogenes</i>	1 (3.3)	-

Table 4: Bacterial Load Around Different Types of Ointment

Type of Ointments	Bacterial Growth (CFUs)	p Value
Neomycin	$\approx 40 \times 10^8$ /suture	<0.05
Hexigel	$\approx 22 \times 10^8$ /suture	
Metrogyl gel	$\approx 61 \times 10^8$ /suture	
P value	<0.05	

Table 5: Pairwise Comparisons of the Bacterial Growth in Various Ointment Groups

Pairwise comparison of groups		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Neomycin	Hexigel	17.700*	3.029	.000	9.97	25.43
	metrogyl	-21.000*	3.029	.000	-28.73	-13.27
Hexigel	neomycin	-17.700*	3.029	.000	-25.43	-9.97
	metrogyl	-38.700*	3.029	.000	-46.43	-30.97
metrogyl	neomycin	21.000*	3.029	.000	13.27	28.73
	Hexigel	38.700*	3.029	.000	30.97	46.43

Hence, the analysis of variance was applied to check the significance of the difference between the mean Degree of Healing and Visual Analog pain for the Antiseptic ointment, and the results are shown in further tables. The results were expressed as total isolated bacteria's mean CFUs ($\pm$ standard deviation). The bacteria grew around Hexigel ointment and showed minimum CFUs/ml ($\approx 22 \times 10^8$). Metrogyl gel ointment showed the maximum amounts of CFUs/ml ($\approx 61 \times 10^8$), followed up by Neomycin ointment group CFUs/ml ($\approx 40 \times 10^8$) (Table 4).

Table 5 shows the degree of healing of antiseptic ointment, including Hexigel, Metrogyl Gel, and Neomycin. The significant difference in average score is tested through the analysis of variance after testing the normality test by using the Kolmogorov Smirnov test, and it shows there is no significant difference found in the degree of healing concerning Antiseptic ointment Hexigel, Metrogyl Gel and Neomycin since the p-value is more significant than 0.05.

Table 6: Hypothesis Test Summary

Sl. No	Null Hypothesis	Test	Significance	Decision
1	The distribution of the Degree of Healing is normal, with a mean of 3.20 and a standard deviation of 0.71	One-sample Kolmogorov	0.57	Retain the null hypothesis.
2	The distribution of Visual Analog pain is normal, with a mean of 2.57 and a standard deviation of 1.45	Smirnov Test	0.506	

Table 7: The Mean and Standard Deviation for the Degree of Healing

Antiseptic ointment	Degree of Healing				ANOVA	p
	N	Mean	SD	SE		
Hexigel	10	3.50	0.707	0.224	1.87	0.174
Metrogyl gel	10	3.20	0.789	0.249		
Neomycin	10	2.90	0.568	0.180		
Total	30	3.20	0.714	0.130		

Table 8: The Mean and Standard Deviation for the Visual Analog Pain

Antiseptic ointment	Visual Analog pain				ANOVA	p
	N	Mean	SD	SE		
Hexigel	10	1.00 ^a	0.816	0.258	37.96	0.001**
Metrogyl gel	10	2.70 ^b	0.675	0.213		
Neomycin	10	4.00 ^c	0.816	0.258		
Total	30	2.57	1.455	0.266		

Table 9: Duncan post-hoc test of the visual analog pain

Duncan Post Hoc Test				
Antiseptic ointment	N	Subset for alpha = 0.05		
		1	2	3
Hexigel	10	1.00		
Metrogyl gel	10		2.70	
Neomycin	10			4.00

Table 7 shows that the p-value for Degree of Healing is greater than 0.05; no significant difference was found between the three types of antiseptic ointment relating to Degree of Healing. The above hypothesis test of the Kolmogorov Smirnov test is used to test the variance analysis's normality and the significance of the difference in mean score for more than two groups, such as three different antiseptic ointments in our study. The results show that the normal condition is satisfied for the degree of healing and visual analogue pain, and the results are given in Table 6 and Table 7. Table 6 shows the degree of healing of antiseptic ointment, including Hexigel, Metrogyl Gel, and Neomycin. The significant difference in average score is tested through the analysis of variance after testing the normality test by using the Kolmogorov Smirnov test, and it shows there is no significant difference found in the degree of healing concerning Antiseptic ointment Hexigel, Metrogyl Gel and Neomycin since the p-value is more significant than 0.05

Table 8 shows the visual analog pain concerning antiseptic ointments, such as Hexigel, Metrogyl Gel, and Neomycin. The significant difference in average score is tested through the analysis of variance after testing the normality test by using the Kolmogorov Smirnov test, and it shows there is a highly significant difference found in the Visual Analog pain concerning Antiseptic ointment Hexigel, Metrogyl Gel and Neomycin since the p-value is less than 0.01. Further, the Duncan Post Hoc Test is used to test the significance of the ointment. There is a significant difference among all three antiseptic ointments regarding visual analogue pain, as shown in Table 9.

Discussion

This study assessed the antibacterial effect of three antiseptic ointments on sutures following the trans alveolar extraction of the impacted lower third molar tooth. Data on the degree of healing and post-surgical pain were also evaluated. Microbiological tests showed that none of the antiseptic ointments effectively decreased the number of germs or fungi. In the same way, none of the items helped with the pain or swelling in the face after surgery. It was found that people who used hexigel ointment mended faster than people who used other ointments. Molecular mechanisms that could account for the discrepancies in antibacterial efficacy among different antiseptic

ointments. Preventing post-operative infections in dental and medical surgery helps prevent complications such as prolonged pain, swelling and other systemic infections that impact the patient's quality of life. It also helps faster recovery and reduces hospitalization, lowering mortality rates. Additionally, healthcare costs are reduced significantly, and surgical outcomes are enhanced. Prevention of post-operative infections increases the patient's trust towards the healthcare provider and the healthcare organization, which avoids any further regulatory or legal issues. Finally, it significantly reduces the emergence of antibiotic resistance, which is quite common in post-operative infections (13, 14).

Pons-Vicente *et al.* 2011 bacterial adherence on a Teflon-coated polyester suture was slightly inferior to the silk suture, but the expected differences were not seen (10). Ercan *et al.* 2018 said sutures treated with non-thermal atmospheric plasma inhibit *S. aureus* and *Escherichia coli* colonisation (15). Sutures are partly embedded in tissue and partially bathed in saliva, with a mean concentration of around 7.5×10^8 microorganisms/ml. Sutures applied in the gingiva and oral mucosa may thus cause protracted tissue reactions due to the constant influx of microbial contamination along the suture channel (16-20). Compared to the above studies, we did not find colonisation of any gram-negative organism or *S. aureus*, a gram-positive bacterium. Different antiseptic ointments were used in those studies (16-20).

Durdey and Bucknall, 1984 found that multifilament sutures produce more prolonged tissue responses and harbour more bacteria than monofilament sutures. However, many surgeons prefer multifilament sutures because monofilament sutures are more challenging to handle, have poor knot security and sharp edges that irritate the oral mucosa (21). According to Garg *et al.*, 2022, suture materials can cause bacterial infections. Adhesion of the microbes can be reduced by using adjunctive measures that can improve the wound healing process and effectively reduce the microbes' adherence around the suture materials, such as chlorhexidine (22). Like the above studies, our study used hexigel (a chlorhexidine-based ointment) to control pathogenic bacteria effectively.

Zorrilla *et al.*, 2020, concluded that no antiseptic ointments tested resulted in significant bacterial population reductions. Similarly, none of the ointments improved post-operative discomfort or oedema of the face. There was more effective healing in patients treated with chlorhexidine ointment than those prescribed metrogyl or neomycin ointment (17). Similar to the above studies, hexigel gave better results in our study. Further, Cruz *et al.*, 2013, concluded that using antiseptic pomade to coat the suture effectively reduced microbial adhesion on multifilament braided silk suture material (23). Edmiston *et al.* 2006, found a considerable reduction in adherence of gram-negative and gram-positive bacteria and reduced microbial viability to antibacterial-coated sutures (24).

One of the significant reasons antiseptic ointments become ineffective is the formation of oral biofilms, which restrict the entry of antiseptic ointments to the targeted site (6). Further, the pH of the patient's oral cavity can play a significant role in the effectiveness of the antibiotic ointment (14, 15). Sometimes, there is a discrepancy in the application of ointment due to patients' ignorance or lack of proper instructions from the healthcare provider. In some instances, prior infection history or lack of knowledge about a patient's allergies to certain antibiotics can also play a significant role in the inefficiency of the antibiotic ointment. Lastly, resistance mechanisms such as antibiotic efflux pumps and the presence of antibiotic resistance strains can also reduce the effectiveness of such antiseptic ointments. Hence, dentists and surgeons should use the above data to reduce the use of broad-spectrum antibiotics and minimise the risk of resistance. This also helps generate a cost-effective treatment protocol and innovation of new antibacterial agents and alternative treatment protocols. Such data contribute to the personalized medicine approach, where treatments will be customized according to the patient's specific infection characteristics (6, 12-15).

Conclusion

The results of the microbiological tests indicated that none of the antiseptic ointments examined exhibited a reduction in bacterial or fungal populations that met the desired criteria. Similarly, none of the gels showed a significant decrease in post-operative discomfort or facial oedema. It was found that healing was better in patients treated

with hexigel ointment than those treated with other ointments; therefore, this must be considered while performing disimpaction of lower 3rd molars.

Abbreviation

Nil.

Acknowledgement

We thank the higher authorities of IDS and SOA University for their support and encouragement.

Author Contributions

KR, SPL, and SR conceptualised and designed the study. SN, SS, AB, and KB collected the samples, conducted the study, and collected the data. SR, KR, and SPL analysed the data, interpreted the results, and drafted the manuscript. RN did the statistical analysis. All the authors critically evaluated the final manuscript.

Conflicts of Interests

Nil.

Ethics Approval

The study was conducted after institutional ethical clearance vide letter number SOA/IDS/IRB 2022/12-VII.

Funding

None.

References

1. Santosh P. Impacted Mandibular Third Molars: Review of Literature and a Proposal of a Combined Clinical and Radiological Classification. *Ann Med Health Sci Res.* 2015;5(4):229-34.
2. Byrne M, Aly A. The Surgical Suture. *Aesthet Surg J.* 2019 Mar 14;39(S2): S67-S72.
3. Selvi F, Cakarar S, Can T, Kirli Topcu Sİ, Palancioglu A, Keskin B, et al. Effects of different suture materials on tissue healing. *J Istanb Univ Fac Dent.* 2016;50(1):35-42.
4. Sala-Pérez S, López-Ramírez M, Quinteros-Borgarello M, Valmaseda-Castellón E, Gay-Escoda C. Antibacterial suture vs silk for the surgical removal of impacted lower third molars. A randomized clinical study. *Med Oral Patol Oral Cir Bucal.* 2016;21(1): e95-102.
5. Parrini S, Bovicelli A, Chisci G. Microbiological Retention on PTFE versus Silk Suture: A Quantitative Pilot Study in Third Molar Surgery. *Antibiotics (Basel).* 2023 Mar 13;12(3):562.
6. Rath S, Bal SCB, Dubey D. Oral Biofilm: Development Mechanism, Multidrug Resistance, and Their Effective Management with Novel Techniques. *Rambam Maimonides Med J.* 2021;12(1):e0004.

7. Piednoir E, Robert-Yap J, Baillet P, Lermite E, Christou N. The Socioeconomic Impact of Surgical Site Infections. *Front Public Health*. 2021; 9:712461.
8. Mohan N, Gnanasekar D, Tk S, Ignatious A. Prevalence and Risk Factors of Surgical Site Infections in a Teaching Medical College in the Trichy District of India. *Cureus*. 2023;15(5):e39465.
9. Kamiński B, Błochowiak K, Kołomański K, Sikora M, Karwan S, Chlubek D. Oral and Maxillofacial Infections-A Bacterial and Clinical Cross-Section. *J Clin Med*. 2022;11(10):2731.
10. Gajic I, Kabic J, Kekic D, *et al.* Antimicrobial Susceptibility Testing: A Comprehensive Review of Currently Used Methods. *Antibiotics (Basel)*. 2022;11(4):427.
11. Yaman D, Paksoy T, Ustaoglu G, Demirci M. Evaluation of bacterial colonization and clinical properties of different suture materials in dentoalveolar surgery. *J Oral Maxillofac Surg*. 2022;80(2):313-326.
12. Routray S, Rath S, Mohanty N. Prevalence of methicillin-resistant *Staphylococcus aureus* isolated from saliva samples of patients with oral squamous cell carcinoma. *J Oral Res* 2019; 8(1):30-36.
13. Pons-Vicente O, López-Jiménez L, Sánchez-Garcés MA, Sala-Pérez S, Gay-Escoda C. A comparative study between two different suture materials in oral implantology. *Clin Oral Implants Res*. 2011;22(3):282-288. doi: 10.1111/j.1600-0501.2010.01993.x.
14. Kaga A, Ikeda T, Tachibana K, *et al.* An innovative oral management procedure to reduce postoperative complications. *JTCVS Open*. 2022; 10:442-453.
15. Garrido L, Lyra P, Rodrigues J, Viana J, Mendes JJ, Barroso H. Revisiting Oral Antiseptics, Microorganism Targets and Effectiveness. *J Personalized Med*. 2023; 13(9):1332.
16. Ercan UK, İbiş F, Dikyoğlu C, Horzum N, Karaman O, Yıldırım Ç, Çukur E, Demirci EA. Prevention of bacterial colonization on non-thermal atmospheric plasma treated surgical sutures for control and prevention of surgical site infections. *PLoS One*. 2018 Sep 5;13(9): e0202703.
17. Rodríguez Zorrilla S, Blanco Carrión A, García García A, *et al.* Effect of antiseptic gels in the microbiologic colonization of the suture threads after oral surgery. *Sci Rep*. 2020;10(1):8360. doi: 10.1038/s41598-020-65007-y.
18. Selvig KA, Biagiotti GR, Leknes KN, Wikesjö UM. Oral tissue reactions to suture materials. *Int J Periodontics Restorative Dent*. 1998;18(5):474-487.
19. Parirokh M, Asgary S, Eghbal MJ, Stowe S, Kakoei S. A scanning electron microscope study of plaque accumulation on silk and PVDF suture materials in oral mucosa. *Int Endod J*. 2004;37(11):776-781.
20. Otten JE, Wiedmann-Al-Ahmad M, Jahnke H, Pelz K. Bacterial colonization on different suture materials--a potential risk for intraoral dentoalveolar surgery. *J Biomed Mater Res B Appl Biomater*. 2005;74(1):627-635.
21. Durdey P, Bucknall TE. Assessment of sutures for use in colonic surgery: an experimental study. *J Royal Soc Med* 1984; 77(6): 472-477.
22. Garg J, Rg SM, Sinha S, Gambhir S, Abbey P, Jungio MP. Antimicrobial Activity of Chlorhexidine and Herbal Mouthwash Against the Adherence of Microorganism to Sutures After Periodontal Surgery: A Clinical Microbiological Study. *Cureus*. 2022;14(12): e32907.
23. Cruz F, Leite F, Cruz G, Cruz S, Reis J, Pierce M, Cruz M. Sutures coated with antiseptic pomade to prevent bacterial colonisation: a randomised clinical trial. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2013;116(2): e103-9.
24. Edmiston CE, Seabrook GR, Goheen MP, Krepel CJ, Johnson CP, Lewis BD, Brown KR, Towne JB. Bacterial adherence to surgical sutures: can antibacterial-coated sutures reduce the risk of microbial contamination? *J Am Coll Surg*. 2006;203(4):481-9.