Concise Clinical Review

Characteristics of Suture Materials Used in Oral Surgery: Systematic Review

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ABSTRACT

Background: The aim of this review was to evaluate the most used suture materials with regards to their inflammatory response, their bacterial adhesion, and their physical properties when used to close oral wounds.

Methods: Four databases (PubMed, Scopus, Dentistry & Oral Sciences, and OVID) were searched to retrieve relevant studies from January 1, 2000, to January 31, 2020.

Results: Out of the 269 articles, only 13 studies were selected as they were relevant and met the systematic review's protocol. These studies showed that almost all suture materials studies (catgut, polyglycolic acid [PGA] sutures, nylon, expanded polytetrafluoroethylene, and silk sutures) caused bacterial adherence and tissue reaction. In nylon and chromic catgut, the number of bacteria accumulated was lowest. Silk and nylon were found to be more impacted than catgut and PGA in terms of physical characteristics such as tensile strength. PGA, on the other hand, was said to be the most susceptible to knot unwinding.

Conclusions: Following an oral surgical operation, all sutures revealed varied degrees of irritation and microbial accumulation. Nonresorbable monofilament synthetic sutures, however, exhibited less tissue response and less microbial accumulation.

Introduction

Despite the vast range of suture materials available, there are many situations in which specific suture materials are used to repair tissue and assist oral wound healing. Clinicians must understand the nature of suture materials due to the importance of specific oral cavity characteristics such as the presence of saliva, distinct biota, high vascularisation, mastication, and swallowing. "The aim of wound closure is to assist efficient healing and the return to function, as well as maintain the esthetics of the surgical site."[1] As a result, careful choice of the suture material, as well as the needle diameter and technique employed are of utmost importance. These variables allow for proper stability of the surgical flaps, which results in patient comfort.

In addition to high tensile strength and low tissue reactivity, ideal features of a suture material include sterility, uniform thickness, flexibility for simple handling, and the ability to retain knot security, as well as low inflammatory response to promote healing.[2] Suture materials are broadly classified according to the degradability into absorbable and nonabsorbable; according to their source into natural or synthetic, their coating into coated or uncoated, dyed or undyed; and last, according to their structure into monofilament or polyfilament.[3] Absorbable sutures such as catgut and polyglycolic acid (PGA) are mostly used in internal tissues; absorption is usually caused by the enzymatic degradation of natural sutures or by hydrolysis of synthetic materials, as opposed to non-absorbable sutures, like nylon and silk, which are preferably used for tissues that need stabilisation for a longer periods and must be removed by the operator.[2] Monofilament

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suture material is made of a single strand which provides less tissue resistance and less likely to harbour microorganisms than multifilament sutures. However, crushing of the suture can lead to undesirable and premature suture failure. As reported, silk is one of the most cost-effective suture materials currently used.[4] However, the primary drawback of this type of suture is the patient's discomfort in having sutures removed and the hassle of an additional visit to the clinic. Adhesives are being offered as a replacement for traditional suturing procedures as health care advances. Cyanoacrylates are powerful adhesives that are biocompatible, are biodegradable, and do not interfere with the healing process. It does, however, have minor stiffness and a variety of toxic effects that are still being investigated.[5]

Nonetheless, there were not enough articles comparing the different suture materials of interest together; however, the primary goal of this systematic review is to compare the physical strength and susceptibility to microbial accumulation of the most common types of sutures, including catgut, PGA, nylon, and silk. This evaluation will also offer some insight on the tissue response following an oral procedure.

Materials and methods

Study design and the focused question

This systematic review followed criteria stated in the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[6] The research question for this review was formulated according to the Population, Intervention, Comparison, Outcomes (PICO) criteria: "Which suture materials produce lesser tissue reaction and lower bacterial accumulation when used in oral surgical procedure. The primary outcome was the bacterial accumulation on suture materials whilst the secondary outcome was the oral tissue reaction after placement of these sutures."

Search strategy and eligibility criteria

Using selected Medical Subject Headings (MeSH), relevant papers were retrieved from four databases (PubMed, Dentistry & Oral Sciences, Ovid, and Scopus). The search terms used were as follows: (Sutures AND tissue reaction) AND (sutures AND bacterial accumulation) AND (sutures AND knot security) AND (Threaded OR Multifilament sutures) AND (silk OR catgut OR Nylon OR PGA sutures). All research published through July 30, 2021, was included in the search. The following were the eligibility criteria: published from January 1, 2000, to January 31, 2020, in the dental literature.

Publications were taken into consideration if all of the following criteria were met: (1) clinical trials, in vitro, or experimental studies, (2) sutures done in oral surgery, (3) articles published in the English language only, (4) full-text articles, (5) articles published after the year 2000, and (6) articles about silk, PGA, nylon, catgut, and n-butyl cyanoacrylate suturing materials.

Exclusion criteria

All case reports and case series studies, review papers, as well as animal studies were excluded.

Literature screening and data extraction

The retrieved articles went through a 3-phase screening procedure based on the eligibility criteria after a preliminary search in the specified databases. This included title and abstract screening as well as a thorough full-text reading.

Screening was done by 2 authors (A.F. and L.K.), and any disagreements were addressed by discussion with a third reviewer (M.H.). Cohen's Kappa was used to measure the level of inter-examiner agreement.[7] Published articles that met the qualifying criteria were included. Data including the author's name/year, study design, sample types and numbers, and follow-up periods were retrieved.

Data extraction and method of analysis

The process of study selection is documented in the PRISMA flowchart presented in the Figure, and the search was run in 4 phases:

Identification phase
The total numbers of recorded extracted articles from those 4 search engines were 269. After skimming the article's titles, 117 articles were eliminated as they were duplicates.

Screening phase
The titles and the abstracts of the remaining 152 records were examined based on predefined eligibility criteria. One hundred nineteen articles were excluded and only 33 articles remained.

Eligibility phase
After full text reading, 20 articles were found to be not eligible due to different reasons, as seen in the supplementary table.

Inclusion phase
The remaining 13 articles were checked, the full text of the relevant papers were separately examined by 3 reviewers, and any disagreements were resolved by consensus.

Quality assessment and risk of bias
Two authors performed the quality appraisal of the included papers (Z.H. and N.A.).

For randomised clinical trials (RCTs), the quality of the included studies was assessed using the Cochrane Risk of Bias tool (RoB2).[8] A total of 5 domains are examined for the RoB2 test, with judgments ranging from minimal risk of bias to some concerns and to high risk of bias. The overall risk of bias usually corresponds to the worst risk of bias in any of the domains.

For nonrandomised clinical trials (NRCTs), 2 authors (H.M. and Z.H.) used ROBINS-I instrument to assesses a total of 7 domains, with low risk, moderate risk, severe risk, and critical risk of bias being the judgments. The low risk of ROBINS-I corresponds to a high-quality nonrandomised study. Overall,

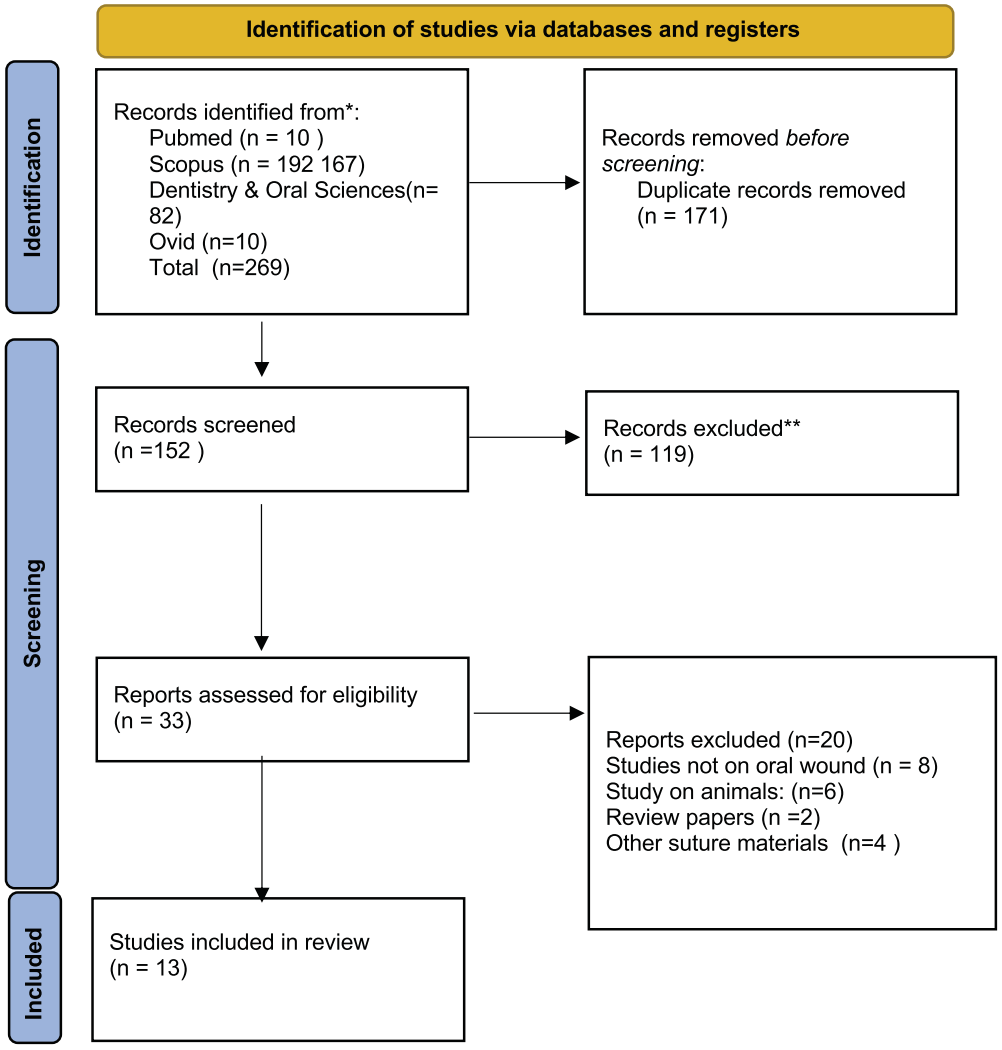

Fig. 1 – PRISMA flow chart of the included studies.

for low risk, the study is judged to be at low risk of bias for all domains; for moderate risk, the study is judged to be at low/moderate risk of bias for all domains; for serious or high risk, the study is judged to be at high risk of bias in at least one domain, but not at critical risk of bias in any domain; and for critical risk, the study is judged to be at critical risk of bias in at least one domain.

In vitro studies included in this review were assessed with the tool developed by the United States national toxicology programme.[9] The tool consists of 7 criteria: (1) experimental condition bias; (2) blinding during study; (3) incomplete data; (4) exposure characterisation; (5) outcome assessment; (6) reporting bias; and (7) other.

The interpretation for fulfilling a "high," "moderate," and "low" risk of bias score of the 3 study designs is depicted in Table 1.

Results

The kappa value was 0.85, so the agreement amongst the 3 investigators was almost perfect.

Risk of bias

Using the RoB2 and ROBINS-1 checklists and in vitro studies checklist, 5 studies were assessed as having a low risk of bias, and 7 studies were rated as having a moderate risk of bias. Four studies were rated as having high or serious risk of bias (Table 1). The characteristics and the main findings of the included studies are depicted in Tables 2 and 3).

Bacterial accumulation

Six studies (4 RCTs,[10–13] 1 NRCT,[14] and 1 in vitro study[15]) investigated bacterial accumulation on different suture materials under different conditions.

Sortino et al[11] found that silk sutures exhibited a higher degree of aerobic bacteria. In particular, *Streptococcus viridans, Neisseria saprofita, Corynebacterium,* and *Staphylococci* than poly glycolic acid sutures. Pathogenic bacteria were also found such as *Pseudomonas aeruginosa, Klebsiella pneumoniae, Staphylococcus aureus, Streptococcus pyogens,* and *Enterobacterium.* It was also reported that fungi, in particular, *Candida albicans* was observed on silk sutures and not on PGA sutures. On the contrary, PGA sutures did not show significant differences in

Table 1 – Risk of bias of the included studies.

	Author/year	Bias arising from the randomisation process	Bias due to deviation from intended intervention	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported results			Overall bias
		D1	D2	D3	D4	D5			
Randomised clinical trials	Perez et al 2015	High	Some concern	Low	Some concern	Low			Moderate
	Sortino et al 2007	Some concern	Some concern	Low	Some concern	Low			Moderate
	Mahesh et al 2019	No information	Some concern	Low	Some concern	Low			High
	Balamurugan et al 2012	High	Low	High	High	Some concern			High
	Asher et al 2018	Low	Low	Low	Low	Low			Low
	Author/year	Same experimental condition	Blinding during study	Incomplete data	Exposure characterisation	Outcome assessment	Reporting	Other	Overall bias
		D1	D2	D3	D4	D5	D6	D7	
Non Randomised clinical trials	Kumar et al 2013	Low	Critical	Low	Low	Low	Serious	Serious	Serious
	Syafilda et al 2019	Low	Low	Low	Low	Low	Low	Low	Low
	Lekens et al 2019	Moderate	Moderate	Moderate	Low	Low	Low	Low	Moderate
	Author/ year	Bias in confounding	Bias in selection	Bias in classification of intervention	Bias due to deviation	Bias to missing data	Bias in measuring the outcomes	Bias in selection of reported results	Overall bias
		D1	D2	D3	D4	D5	D6	D7	
In vitro studies	Vasanthan et al 2009	Serious	Low	Low	Low	Low	Low	Low	Moderate
	Arce et al 2019	Low	Critical	Low	Low	Low	Moderate	Moderate	Moderate
	Abellan 2016	Low	Low	Low	Low	Low	Low	Low	Low
	Kumar et al 2013	Low	Critical	Low	Low	Low	Serious	Serious	Serious
	Sudhair et al 2018	Low	Serious	Low	Low	Low	Low	Low	Moderate
	Syafilda et al 2019	Low	Low	Low	Low	Low	Low	Low	Low
	Kim et al 2007	Low	Low	Low	Low	Low	Low	Low	Low
	Lekens et al 2019	Moderate	Moderate	Moderate	Low	Low	Low	Low	Moderate

Table 2 – Characteristics of the included studies.

Author/year	Aim of the study	Study design	Surgical setting	Suture materials	Follow-up period	Main findings	Weakness
Perez et al 2015[10]	Compare the antibacterial effect of Monocryl® Plus suture with silk suture	RCT	Surgical extraction of upper right third molar	• SS • Monocryl	7 days	Silk suture showed significantly higher values for both aerobes and anaerobes. Monocryl® Plus yielded a lower count for almost all the isolated species. However, the differences were only statistically significant after 3 days (125 CFU/cm/mL; SD of 179 for silk suture and 28 CFU/cm/mL; SD of 42 for Monocryl® Plus suture) ($P = .013$). The presence of pathogenic microorganisms was also less evident in this suture after 72 hours and 7 days, though not statistically significant.	Small sample size (10 males and 10 females).
Sortino et al 2007[11]	Compare bacterial contamination of black silk and polyglycolic acid sutures that had been in the oral cavity for 8 days	RCT	Surgery at mandibular angle	• SS • PGA	8 days	Black silk sutures exhibited a high degree of aerobic bacteria. Both kinds of sutures had a similar degree of anaerobic bacteria. Polyglycolic acid sutures did not show significant differences for the presence of saprophyte bacteria if compared to black silk sutures. However, pathogenic bacteria as well as fungi were missing in polyglycolic acid sutures. The use of a 0.2% chlorhexidine solution did not significantly affect the pattern of bacterial contamination detected in both suture materials.	Confounding factors not mentioned in the study.
Mahesh et al 2019[12]	To study the microbial recovery from sutures explanted from noninfected or infected clinical specimens	RCT	Implant surgery with GBR	• SS • PG • Gut • PTFE • Polyamide	14 days	Two types of sutures, one monofilament (polyamide) and one braided (Vicryl), were found to harbour the maximum number of anaerobic bacteria. Aerobic bacteria grown around gut sutures showed minimum CFUs ($\approx 30 \times 10^4$/suture). However, Vicryl and polyamide sutures harbour the maximum number of anaerobic bacteria.	
Balamurugan et al 2012[13]	To assess histologically the tissue reaction of 2 suture materials	RCT	Minor oral surgical procedure	• SS • PG	7 days	Inflammatory cells detected in all samples. The intensity varied from mild (68% vs 64%) to moderate (16% vs 20%) to severe (16% vs 16%) in Vicryl group and BSS group, respectively.	Selection bias.
Asher et al 2018[14]	To compare bacterial accumulation on different suture materials following oral surgery	RCT	Implant and periodontal surgery	• SS • PGA • Nylon • Polyester	12 days	Nylon sutures showed significantly lower CFU levels compared to silk, coated polyglactin, and polyester sutures. The type of surgery (implant vs periodontal surgery) did not significantly influence bacterial accumulation. No significant differences were observed between antibiotic consumption and antibiotic-free groups for all the tested parameters.	
Kumar et al 2013[15]	To compare effectiveness of the black silk sutures with cyanoacrylate adhesives in closing the surgical incisions	NRCT	Bilateral apicoectomy	• SS • Cyanoacrylate adhesives	7 days	On the 3rd and 7th postoperative days epithelialisation was better on the sides treated with n-butyl-2 cyanoacrylate. However, the sites closed with black silk suture showed significant inflammation and scar formation.	Small sample size (10 patients only).
Syafilda et al 2019[16]	To compare post-odontectomy wound healing time using silk and catgut sutures	NRCT	Third molar impaction surgery	• SS • Catgut	7 days	On day 1 and day 7 of the surgery, the catgut sutures have a mean score of wound healing time that is better than silk sutures. However, the time needed to perform suture of cat gut is longer.	Posttest design with short follow -up (1st and 7th day postoperatively). Results were highly subjective.
Leknes et al 2005[17]	To evaluate clinically and histologically tissue reactions to silk and expanded polytetrafluoroethylene (ePTFE) suture materials placed in human oral tissues	NRCT	Periodontal surgery	• SS • ePTFE	7-10 days	Bacterial plaque was detected in 10 of 11 silk and four of 11 ePTFE suture channels at 7 days, and 8 of 10 and 4 of 11 suture channels at 10 days. Braided silk sutures apparently cause a more extensive inflammatory tissue reaction than ePTFE. Silk sutures present a higher risk of slack of the suture loop than does ePTFE.	The examiner could not be masked with regards to suture material under study.

(*continued on next page*)

Table 2 (*Continued*)

Author/year	Aim of the study	Study design	Surgical setting	Suture materials	Follow-up period	Main findings	Weakness
Vasanthan et al 2009[18]	To compare the tensile strengths of commonly used sutures over a 2-week period under simulated oral conditions	In vitro	A biologic simulation was created in vitro . All samples were tested pre-immersion and 1 hour and 1-, 3-, 7-, 10-, and 14-days post immersion. The tensile strength was assessed using a micro tensile tester, and the maximum load required to cause suture breakage was determined. The point of breakage in the samples and the samples themselves were also assessed.	• Chromic gut • PG • PG-FA	14 days	4-0 sutures are stronger and have greater tensile strength than 5-0 sutures. CG seems to sustain its strength better than PG and PG-FA after 2 weeks. PG-FA may not be a desirable suture if tensile strength is required after 10 days.	The controlled aseptic in vitro environment in this study, without the influence of bacterial proteolytic enzymes, might affect the results.
Arce et al 2019[19]	To compare the in vitro tensile strength of sutures used in implant surgery according to the type of thread and the immersion time in artificial saliva	In vitro	A universal test machine was used to measure the tensile strength. The failure point of the samples was evaluated at 10 × increase using a stereomicroscope.	• SS • PG • PTFE	21 days	When comparing the in vitro tensile strength of PG, BS, and PTFE sutures at baseline and 3, 7, 14, and 21 days, there was no statistically significant difference.	Suture technique, type of saliva, diet, and hygiene habits could be confounding factors and were not measured.
Abellan et al 2016[20]	To compare the mechanical properties of 5 suture materials on 3 knot configurations when subjected to different physical conditions	In vitro	Three knot configurations were compared A.2=1=1 (forward−forward −reverse), B.2=1=1 (forward−reverse−forward), C.1=2=1 (forward−forward −reverse). Mechanical properties (failure load, elongation, knot slippage/breakage) were measured using a universal testing machine.	• SS • PV • PGA • GC • PTFE	14 days	Polyglycolic acid followed by glycoside-e-caprolactone copolymer showed the most knot failure load, whilst polytetrafluoroethylene showed the lowest. Physical conditions, such as pH concentration and thermal cycle process, have no influence on suture mechanical properties.	
Sudhair et al 2018[21]	To evaluate the presence of *Staphylococcus aureus* and *Escherichia coli*, in polyglycolic acid (PGA) 4-0 and silk sutures, with or without hyaluronic acid (HA) treatment	In vitro	This in vitro study measured *S aureus* and *E coli* growth on PGA and silk sutures, through incubation in agar media for 24 h.	• SS W/WO HA • PGA W/WO HA		The mean *S aureus* colony-forming units (CFUs) differed at each time point between non-HA and HA-PGA sutures, with a greater number of CFUs on non-HA-PGA. The mean *S aureus* CFUs were significantly higher on non-HA silk than on HA-silk sutures. There was a significant increase in *E coli* CFUs on non-HA silk than on HA-silk sutures. *E coli* CFUs were higher on non-HA-PGA than on HA-PGA sutures.	Compared 2 types of suture material with different filament synthesis.
Kim et al 2007[22]	Tensile properties such as maximum tensile load, elongation rate, stiffness, and energy absorbed before breakage of 7 kinds of surgical sutures were measured	In vitro	Tensile properties were measured for 6 sutures (3 absorbable and 3 non-absorbable) using a universal testing machine.	• SS • Nylon polypropylene • Catgut chromic catgut PGA		In non-absorbable sutures, the type of suture material influenced the tensile properties ($P < .05$). In absorbable sutures, the maximum tensile load after tensile loading decreased, which was significant in chromic catgut. Type of non-absorbable suture influenced knot security and the synthetic monofilament materials showed a tendency to be untied easily.	One knotting method used.

CFU, colony-forming unit; ePTFE, expanded polytetrafluoroethylene; GC7, glycolide-e-caprolactone copolymer; HA, hyaluronic acid; PGA, polyglycolic acid; PG, polyglactin; PTFE, fluoropolymer of tetrafluoroethylene; PG-FA, polyglactin-fast absorbing; PV, polyamide; RCT, randomised clinical trial; SS, silk suture.

Table 3 – Summary of findings.

Type of suturing material	Number of studies	Level of evidence	Strength of evidence	Main findings
Silk	Sortino et al[11]	RCT	Medium	◦ Biocompatible and good handling characteristics ◦ High amounts of bacterial and fungal accumulation (both aerobes and anaerobes) ◦ Extensive inflammatory tissue reaction ◦ More scar formation and longer wound healing
	Perez et al[10]	RCT	High	
	Mahesh et al[12]	RCT	Medium	
	Sudhair et al[21]	In vitro study	High	
	Asher et al[14]	RCT	High	
	Leknes et al[17]	NRCT	Medium	
	Syafilda et al[16]	NRCT	High	
	Balamurugan et al[13]	RCT	Low	
	Kumar et al[15]	NRCT	Low	
PGA	Sortino et al[11]	RCT	Medium	◦ Most susceptible to knot unwinding ◦ No significant difference in saprophyte bacterial accumulation when compared with silk
	Asher et al[14]	RCT	High	
	Abellan et al[20]	In vitro study	High	
	Sudhair et al[21]	In vitro study	High	
Nylon	Asher et al[14]	RCT	High	◦ Significantly lower CFU and bacterial accumulation levels when compared to other suture materials (silk, coated PG, and polyester)
	Kim et al[22]	In vitro study	High	
PTFE	Mahesh et al[12]	RCT	Medium	◦ No significant difference in terms of tensile strength to PG and SS ◦ Lowest knot failure
	Leknes et al[17]	NRCT	Medium	
	Arce et al[19]	In vitro study	Medium	
	Abellan et al[20]	In vitro study	High	
Catgut	Mahesh et al[19]	RCT	Medium	◦ Better wound healing time than silk sutures ◦ Longer time required to perform the sutures ◦ Better strength than PG and PG-FA sutures after 2 weeks (chromic gut)
	Syafilda et al[16]	NRCT	High	
	Vasanthan et al[18]	In vitro study	Medium	

CFU, colony forming unit; NRCT, non randomized clinical trial; PG, polyglactin; PGA, polyglycolic acid; PGFA, polyglactin-fast absorbing; PTFE, polymer of tetrafluoroethylene; RCT, randomised clinical trial; SS, silk suture.

the presence of saprophyte bacterial accumulation when compared with silk sutures; however, both sutures had a similar degree of anaerobic bacterial accumulation like *Fusobacterium nucleatus*, *Peptococcus anaerobes*, and *Bacteroides melaninogenicus*. Bacterial accumulation was not affected when sutures were treated with 0.2% chlorhexidine solution. Perez et al[10] found that silk sutures showed significantly higher values for both aerobes and anaerobes. However, Monocryl® Plus yielded a lower count for almost all the isolated species. However, the differences were statistically significant after 3 days (125 ± 179 colony-forming units [CFUs]/cm/mL for silk suture and 28 ± 42 CFU/cm/mL for Monocryl® Plus suture). The presence of pathogenic microorganisms was also less evident in this suture after 72 hours and 7 days —though not statistically significant. Mahesh et al[12] conducted a study on suture segments (silk, gut, polyglactin [PG], polytetrafluoroethylene [PTFE], and ployamide sutures) that were extracted 14 days postoperatively; they were inoculated on culture media of blood agar plates. They found that aerobic bacteria were minimal around gut suture, showing CFU (≈30 × 104/suture) in comparison to silk 102 × 104/suture. Nylon (polyamide) sutures had equal amounts of aerobes and anaerobes showing CFUs (≈300 sutures × 104/suture). Correspondingly, the effectiveness of hyaluronic acid (HA) at reducing bacterial accumulation in silk and PGA sutures (PGA) was examined in vitro by Sudhair et al,[16] and results showed that the mean *S aureus* and *E coli* CFUs were significantly higher on non-HA-treated silk than on HA-treated silk sutures. *E coli* CFUs were significantly higher on non-HA-treated PGA sutures than on HA-treated PGA sutures. Thus, HA reduced bacterial accumulation in both PGA and silk sutures.[16] Asher et al concluded that neither the type of surgery (implant vs periodontal surgery) nor antibiotic taking significantly influence bacterial accumulation. However, nylon sutures showed significantly lower CFU levels compared to silk, coated polyglactin, and polyester sutures.[13] Lekens et al found that bacterial plaque was detected in 10 of 11 silk and 4 of 11 expanded polytetrafluoroethylene (ePTFE) suture channels at 7 days and 8 of 10 and 4 of 11 suture channels at 10 days.[14]

Tissue reaction

Four clinical trials assessed the tissue reaction. A clinical study was conducted by Lekens et al[14] to assess the inflammatory response against 2 sutures (braided silk suture and ePTFE sutures) in histological sections. They concluded that braided silk sutures cause more extensive inflammatory

tissue reaction than ePTFE sutures. Syafilda et al,[17] in their clinical trials, tested wound healing with 2 suture materials (silk and catgut). They found that on day 1 and day 7 of the surgery, the catgut sutures had a better score of wound healing time than silk. However, the healing time needed to perform suturing with catgut is longer. Balamurugan et al[12] found that inflammatory cells are detected in both silk and PGA suture samples. However, the intensity varied from mild (68% vs 64%) to moderate (16% vs 20%) to severe (16% vs 16%) in the PGA group and the silk suture group, respectively. Kumar et al[18] concluded that surgical sites closed with silk sutures showed significantly more inflammation and scar formation than those closed with n-butyl cyanoacrylate adhesives. Moreover, n-butyl-2cyanoacrylate also showed dense inflammatory infiltrate and more uniform distribution of neutrophils, lymphocytes, and histocytes, unlike silk which had infiltrates on the margins of the gap.

Knot security and tensile strength

Four in vitro studies evaluated tensile strength and knot security.[15,19–21] Vasanthan et al[19] measured the tensile strength of 3 suture materials (chromic gut, PG, and glycolide-e-caprolactone copolymer [PG-FA]) after immersing the sutures with serum saliva mixture using a microtensile tester, the maximum load required to cause suture breakage and the point of breakage were assessed. They found that 4-0 sutures have greater tensile strength than 5-0 sutures. Chromic Gut seems to sustain its strength better than PolyGlactin and PG-FA after 2 weeks. Arce et al[20] used a stereomicroscope to compare the tensile strengths of sutures used in implant surgery according to the type of thread and immersion time in serum saliva mixture. They used 3 suture materials (silk, PG, and PTFE). They found no statistically significant differences in tensile strengths of PG, silk, and PTFE sutures at baseline and after 3, 7, 14, and 21 days. Abellan et al[15] compared the mechanical properties of 5 suture materials on 3 knot configurations. They assessed the mechanical properties (failure load, elongation, knot slippage/breakage) of the following sutures: (silk, polyamide, PGA, glycolide-e-caprolactone copolymer, PTFE). Three knot configurations were compared. They observed that polyglycolic acid followed by glycolide-e-caprolactone copolymer showed the most knot failure load, whilst PTFE showed the lowest. Kim et al[21] evaluated the tensile properties of 6 different surgical sutures, including maximum tensile load, elongation rate, stiffness, and energy absorbed before breakage. They found that in non-absorbable sutures, the type of suture material significantly influenced the tensile properties. However, in absorbable sutures, the maximum tensile load after tensile loading decreased, which was significant in chromic catgut. Moreover, the type of non-absorbable suture influenced knot security, and the synthetic monofilament materials showed a tendency to be untied easily.

Discussion

Bacterial accumulation

Bacterial aggregation on catgut sutures were observed to be less than other materials, but since all sutures harbour bacteria contributing to delay in healing, it is recommended to limit suture usage in surgery.[22] There was a higher number of bacteria found in non-absorbable sutures compared to absorbable sutures. Sutures should be removed as soon as possible (6-10 days), according to recent research, because systemic illnesses can have oral origins, such as how bacteremia can occur after suture removal.[3] Nylon's bacterial adhesion was comparatively lower than silk, indicating that nylon should be the first target of sutures for microbial adhesion whenever possible.[13] In one study, the bacterial colonisation was 83% and 65% lower than silk after 3 and 7 days, respectively. Streptococci were the most abundant organisms in both sutures, followed by *Neisseria* spp and coagulase-negative *Staphylococcus*.[10] Silk and PGA sutures were also evaluated. Silk exhibited a high level of aerobic bacteria, pathogenic bacteria, and fungi. PGA did not display a substantial difference in the presence of aerobes, with no pathogenic bacteria or fungi.[11] Although multifilaments are simple to handle, they harbour more bacteria than monofilaments; multifilament sutures may be treated with HA due to the anti-inflammatory, anti-edematous, and anti-bacterial properties.[16] Every suture serves as a point of entry for an infection that might impede the wound's healing. Due to the greater surface area on which microorganisms can adhere, multifilament sutures have a higher bacterial adhesion index than monofilament sutures. That is why sutures should not be left for long durations.[13]

Tissue reaction

A study of Sudhair et al found that silk is known to cause inflammation due to its structure that acts as a great bacterial receptor; however, PGA had a more restricted inflammatory reaction.[16] The clinical parameters included in the study by Lekens et al[14] were the variation in the slack of the suture loop and "bite" of the suture in the tissue, which were significant variables in the assessment of immobilisation and healing of the wound margins. Slack of suture is assessed by manual probing from the top of the interdental papilla to the suture level. Tissue bite is the amount of suture embedded inside the oral tissue determined by measuring its length by a caliper. The less tightness the suture receives, the less compact contact is between the suture thread and the underlying tissue, creating gaps. Those potential spaces can prevent the optimal epithelial healing through direct contact inhibition mechanism. Findings showed that the durability and integrity of the wound cannot be properly preserved by silk sutures.[14] A separate study by Syafilda et al revealed that although catgut sutures have a faster average wound healing time than silk, their stiff nature makes them more susceptible to injury to the oral tissues during treatment and makes them more difficult to tie than silk. Meanwhile, silk sutures outperform catgut in terms of biocompatibility and handling characteristics, making them more appealing to practitioners.[17] Tissue reactions linked to the physical properties of the sutures can be correlated to the capillary and fluid absorption profile of the suture, and PGA was assessed in the Balamrugan et al study as demonstrating superior results to silk, which were also attributed to the fact that monofilaments had a lower friction coefficient resulting in less tissue

injury.[12] Another study found that areas sealed with silk sutures took longer to heal and had more inflammation than those sealed with cyanoacrylate. The attachment of the 2 ends of the wound with cyanoacrylate leaves no room for moisture to enter during the healing process. Accordingly, this study advocated the usage of cyanoacrylate as an effective tool for sealing the incision margins and decreasing the inflammatory reactions along with the antimicrobial activity.[18]

Knot security and tensile strength

Sutures break quickly when twisted into a knot because they are weak, and their tensile strength is less than the knotting strength. Suture gauge length is inversely related to tensile strength, since smaller volumes have less dispersed defects, resulting in less possibility of breakage. In one study, nylon had the highest tensile load due to its high elongation rate; however, due to the smaller diameter when elongated at the suture site, this resulted in displacement, gap formation, and tissue rupture, which is considered a clinical failure. Another property that inversely affected the tensile load of all studied suture materials was the caliber of the suture; when it increased, the maximum tensile loads of sutures decreased. In addition, knotting sutures decreases the mechanical properties, and when faced with a higher load, failure happens in 2 ways: slippage or breakage, which disrupts the healing process. Kim et al showed that the tensile load decreased for all sutures except silk, concluding that monofilament absorbable sutures have a higher knot slippage incidence in a salt solution.[21] In another study, the tensile strength of silk declined unstably over the time when soaked in serum-saliva mixture. The study found that the force needed to affect slippage was highest at baseline and lowest after 7 days, confirming that monofilaments had a higher resistance to forces than multifilament.[20] In yet another study, the monofilament catgut had a uniform strength that was distributed throughout the suture and the presence of chromic coating, which prevents slippage and delays the loss of tensile strength, increased the knot stability of the suture.[19] An in vitro study was conducted to check the physical and mechanical properties of silk and PGA, using 3 different knot configurations. They concluded that suture resistance hinges mainly on 2 things: the type of material and the configuration of the knot used, where silk was more resistant with knot B, and a satisfactory result with the use of knot A for PGA. It is also noted that the physical contact to biodegradable agents did not affect the quality or knot resistance of sutures.[15]

The current study includes a few limitations, including a wide range of inclusion criteria, such as RCTs and NRCTs, as well as in vitro investigations, which were all examined together in this review, which could be a source of bias due to the diversity of study designs. Furthermore, clinical studies with fewer patients (both randomised and non-randomised) may not have enough power to detect the primary and secondary outcomes. For these reasons, before advocating the use of resorbable/non-resorbable sutures for oral wound closure, a large, multicentre, and high-quality randomised clinical research is required to validate these findings.

Conclusions

In comparison to polyfilament sutures, nonresorbable monofilament synthetic sutures showed less tissue reaction and microbial accumulation. Of all the suture materials evaluated, nylon and chromic gut sutures had the least degree of bacterial aggregation.

Conflict of interest

None disclosed.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.identj.2022.02.005.

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