International Journal of Research and Review
Vol.7; Issue: 11; November 2020
Website: www.ijrrjournal.com
Review Article *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Antimicrobial Sutures for Periodontal Surgeries

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ABSTRACT

Background: Flap surgeries could sometimes be followed by complications as they are more vulnerable to developing infection, due to surgical site contamination. Suture materials play an important role in this and it has led to the idea of developing suture materials coated with antimicrobial agents.

Highlights: Several metals and chemical agents that are known to have antimicrobial properties have been used to create and/or coat these suture materials to protect the surgical site from possible infections and enhance the healing process. Some of these even exhibit gradual drug release to keep the site relatively free of any active microbial action. These are especially useful in the oral cavity which is an easy access home to several micro-organisms. This review article carefully studies and elaborates on the effects of antimicrobial sutures and its advantages, as documented by various studies, obtained via electronic searches on various databases.

Conclusion: Many clinical trials have been done to assess the effectiveness of triclosan based sutures and their beneficial outcomes have been widely endorsed, while there is limited documentation on the effects of the other materials. Further research in this area would be useful to promote the future use of antimicrobial sutures, with a broad range of alternatives to choose from.

Key words: Antimicrobial sutures, bacterial colonization, bacterial adhesion, non- cytotoxic, surgical site infection

INTRODUCTION

Sutures, an integral part of surgeries, help in flap approximation, prevent dead space formation, enhance clot formation and minimize scar formation [1,2]. Initially, substances like animal gut strings, metal wires, bow strings, silk, linen, etc. were used. Biocompatibility, pliability and strength determined the type of material preferred. For years, silk has been the primary choice and recently synthetic resorbables are preferred, particularly in delicate procedures- soft and hard tissue grafting [3, 4].

The newly introduced materials are coated with biologically active molecules- antimicrobial materials, stem cells seeded, electronic and shape memory sutures [1, 5]. The idea is to reduce bacterial action due to biofilm formed on the suture surfaces and to enhance healing [6]. The benefits are site specific and maintain a relatively infection free environment [7].

This review article, obtaining information from several electronic databases, discusses the various antimicrobial sutures- their effects, advantages and future prospects.

Types of Sutures

Based on Structural Characteristics

- Filament structure:
  - Monofilament
  - Multifilament
  - Pseudomonofilament
- Surface texture:
  - Smooth sutures
  - Barbed sutures

Based on Physical Characteristics

- Tensile strength
  - Knot pulling strength

  - Straight pulling strength
- Flexibility
  - Ease of tying knot
  - Efficient handling properties
- Degradation property
  - Non-absorbable- Natural and Synthetic sutures
  - Absorbable- Metal and Synthetic polymeric sutures

Recent and Emerging Sutures

- Antimicrobial sutures- Antibiotics and Metal based- Ag & Zn
- Drug eluting sutures: Multidrug combination- Antibiotics/Analgesics/ Anti-inflammatory
- Stem cell seeded sutures
- Smart sutures: Electronic and Shape memory/Elastic

[*this list is based on information from the articles referenced as 1 and 5]

Antimicrobial Sutures and Their Effects:

The following passages will elaborate on the effects of various antimicrobial sutures as tested in vitro and in vivo. In several studies it has been stated that about 30-35% of reduction in infection was observed on use of antimicrobial sutures [8]. The common cause of wound infection is due to bacterial adherence to the sutures and this is more common in multifilament sutures. The liability for microbial colonization is based on the structure and composition of the suture material used and the specific microbiota present [9]. Monofilament suture materials are less prone to developing infection and are easier to handle but have the disadvantage of causing ulceration of the oral tissues. Although, multifilament sutures are more vulnerable to bacterial colonization due to the wicking effect that is seen because of the fluid capillary action, they are preferred because they have higher tensile strength [10, 11]. The qualities of a desirable suture material would include the following, resistance to traction, proper dimensional stability, reliable knot security, ample flexibility so as to prevent any possible injury to the oral mucosa, along with the ability to restrict bacterial adhesion and growth without interfering with the healing process [12-14].

In case of bacterial adherence to the sutures, there will be biofilm formation over it, which will serve as a niche for pathogenic microorganisms and will cause inflammation of adjacent tissues and there is a chance that this could be concealed from the immunological system of the host and may also be less affected by the effects of antibiotics [15]. Monofilament sutures harbor fewer bacteria, however, they lack some of the above mentioned desirable qualities, making multifilament sutures, the favorite of most clinicians [16]. There are in vitro studies that suggest that non-absorbable multifilament sutures are more susceptible to bacterial adherence and they concluded that Monocryl sutures and absorbable silk sutures are best suited for dental surgeries [12, 15]. In another study, following surgery, flaps were approximated and sutured with four different materials- silk, coated polyglactin, nylon, and polyester in a random sequence. The sutures were removed after 10 days and incubated for 7 days in aerobic and anaerobic conditions, to assess bacterial adherence and growth and it was observed that monfilamentous nylon material showed the least microbial accumulation [17]. For this reason, the researchers have attempted to develop the ideal suture that can include the strengths seen in multifilament sutures with additives to reduce the risk of bacterial growth and colonization, by inventing antimicrobial sutures, thus reducing the risk of surgical site infection (SSI).

In a study by Ford et al. in 2005, it was observed that polyglactin 910 sutures that were Triclosan coated produced better results, that the conventional polyglactin 910, in terms of healing, because of its ability to inhibit bacterial colonization and also stated that the postoperative pain was significantly lesser [18]. In another animal study, poliglecaperone 25 coated with

triclosan was tested by subcutaneous implantation and direct interaction with S. aureus and E. coli and found that the antimicrobial coated suture restricted colony formation, thereby suggesting that the surgical site can be kept free of bacterial contamination, upon its use [19]. Sala Perez S. et al. conducted a split mouth study in which the efficacy of Monocryl plus was tested- a monofilamentous poliglecaperone triclosan coated synthetic suture versus silk suture. It was found that the maximum efficacy of Monocryl plus was observed after 72 hours and that it provided an edge over non antibmicrobial coated sutures as it limited the bacterial growth in the surgical site, thereby reducing the risk of SSI. Although there are other studies reporting similar results, there are also records of some other studies done in the oral cavity, that have reported that there is no significant advantage of using this material as well [20]. Another study, in which following dental implant surgeries, Vicryl plus (polyglactin), a triclosan coated antibacterial suture and silk suture were placed and their roles were compared and it was found that there were no significant benefits on using the former [21]. There was another in vitro study where it was observed that triclosan and chlorhexidine coated sutures, showed lesser bacterial growth and adherence when compared with uncoated sutures. The same authors did a similar in vivo study and tested the same materials. They obtained similar results and concluded that antibacterial sutures were more effective in reducing SSI and according to their study, that chlorhexidine showed better results of the two antibacterial sutures that were studies [22, 23]. There is also an in vitro study by Venama et al. where they found no significant benefit in using antimicrobial sutures such the triclosan coated ones and the combined use of chlorhexidine antiplaque agent was suggested to be a counter-productive option [24]. Chlorhexidine coated polyglactin 910 sutures were found to exhibit the ability to reduce the bacterial colonization and therefore could be a potential tool to reduce SSI [25]. In all the above mentioned studies, the effects of triclosan and chlorhexidine were attributed to their safe, non-cytotoxic, antimicrobial and anti-inflammatory properties against Gram positive and negative organisms, viruses and fungi, and concluded that coated sutures would be an excellent choice in patients who are prone for surgical site infection [26].

Silicate glasses with ZnO at 14 and 17 mole% were used as a coating for non-absorbable Mersilk suture in an in vitro study to test the effects of the antibacterial properties of Zinc, to reduce SSI. It was found that Zinc inhibited both Gram positive and negative bacteria in an acidic medium (which in the oral cavity, is usually observed when there is a change in the microbiota from aerobic to anaerobic), when compared to the uncoated control [27]. Zinc oxide's antimicrobial action against gram positive and negative bacteria and fungi and its compatibility with mammalian cells have been well documented, hence would be a good choice to coat the sutures for future use to reduce SSI [28, 29].

In an in vitro study by S De Simone, silver nano particles were coated on non resorbable multifilament silk sutures and were tested with S. aureus and E. coli. It was found to exhibit excellent antibacterial property, inhibiting the growth of these two bacteria that are commonly found in infection sites, and also proved to be non-cytotoxic [30]. The antimicrobial (especially against multiresistant bacteria) and non-cytoxic properties of silver has been proved by previous studies and its already wide use in healthcare has been recognized [31- 33]. In another in vitro study, silk was coated with sericin from the cocoon of Bombyx mori and silver and found that there was bacterial inhibition and proper wound healing owing to the ability of proliferation of epithelial cells, fibroblasts, promotion of epithelialization and collagen formation [34, 35]. In an in vitro study by J Pratten et al., they stated that Mersilk suture coated with silver containing bioactive glass powder

was investigated against S. epidermis, was found to prevent bacterial adhesion and growth and colonization due to its enhanced antibacterial property [36]. In a study done in vitro, Mersilk sutures were coated with tertiary-component bioactive glass (45S5 glass) and multi-component bioactive glass modified by adding Mg, Zn and K into its composition and were tested against S.aureus, S. mutans, and Lactobacillus and the results suggested that, the multicomponent bioactive glass exerted antibacterial action whereas tertiary-component 45S5 glass coating didn't and that the former could serve as a reliable choice for use in the medical field [37].

A quaternary ammonium compound K21 coated sutures (Nylon, Silk, Polyester and chromic gut) were tested against P. gingivalis and E. faecalis, both of which are very common in dental infections. It was found to exhibit a zone of inhibition and the authors of this in vitro study concluded that the coated sutures showed resistance to bacterial colonization and could therefore exhibit antibacterial properties, useful to prevent any infection during healing [38]. The bactericidal action is by the interruption of the electrostatic interactions of the cytoplasm and bacterial cell wall [39]. An in vitro study by Carneiro et al., studied the effects of eugenol coated cotton sutures when investigated against the streptococcus strains and concluded that it exhibited anti-adhesive (against the bacteria) and anti-biofilm properties and therefore could be an inexpensive method to prevent SSI [40]. In another study, cotton yarns were coated with chitosan and then with tetracycline over it and it were found that tetracycline provided the first line of inhibition of bacteria and once that substrate was over, chitosan continued the inhibition. Chitosan is known to have good antibacterial and wound healing characteristics [41].

A study was done where silk and polyglycolic acid was treated with hyaluronic acid and it was found that those sutures showed reduced wicking and thereby reduced bacterial colonization when tested with S. aureus and E. coli. Hyaluronic acid as we know reduces inflammation and promotes healing [42, 43]. In yet another study, silk sutures were coated with aloe vera and gum acacia and the results revealed the ability to reduce bacterial accumulation due to sustained drug release, promote healing (in the skin) and biocompatibility to mammalian cells. The prepared suture showed antimicrobial efficacy against S. aureus, E. coli, and C. albicans and could effectively prevent bacterial adherence on it [42]. Aloe vera has effective antibacterial, antiviral and antifungal properties and also has the capacity to increase the collagen cross-linking, thereby facilitating wound healing and gum acacia has antimicrobial properties that can contribute to faster tissue regeneration and the overall healing [44-46]. In another study, aloe vera and ciprofloxacin were coated on silk sutures separately and tested against E. coli and it was found to inhibit bacterial growth owing to their antibacterial characteristics with ciprofloxacin demonstrating a greater degree of inhibition [47]. In a human clinical trial, a mixture with iodoform and calendula oil was coated on silk sutures before suturing and it was found that the control groups showed a healthier healing site with reduced bacterial accumulation. Several studies have reported their individual antimicrobial properties and this study has used a combination that has proved to be effective even upto 5 years in a prospective study by the same authors. It was also proved to cause no harm to the adjacent tissues [48, 49]. In a similar study, the silk sutures were coated with either tetracycline or chlorhexidine before suturing and stated that there was definitely a benefit in using sutures coated with antimicrobial substances when compared to plain sutures. In this, tetracycline proved to be more beneficial than chlorhexidine [50].

Advantages and Limitation

Many of the above mentioned studies have suggested that the antimicrobial sutures are beneficial in preventing SSI when compared to plain

sutures. Bacterial colonization on sutures due to their wicking effect results in formation of biofilm and this serves as a niche for bacterial growth, proliferation and metabolism and in this environment, it may even remain protected from the immune system, going unnoticed, causing local inflammation with no remedy [51, 52]. Pathogenic microorganisms compete with fibroblast cells and affect wound healing and tissue regeneration [53].

Antimicrobial - impregnated substances can prevent bacterial adhesion, colonization and biofilm formation. By this means we will be able to avoid the use of long-term and fruitless systemic antibiotics and we can reduce the risk of microbial resistance generation [54]. Hence, as a solution for these problems, the wide spectrum antimicrobial activities of the various substances available to us should be used to locally contain infections. To achieve this, antimicrobial sutures may be very useful. Currently there is lack of an adequately regulated protocol and economical manufacturing of the same, which needs to be rectified. More options at a reasonable price must be presented to choose from, in the market and more clinical studies are needed to increase the awareness of the benefits of these antimicrobial sutures.

Commercially available sutures

So far, the only group that manufactures antimicrobial sutures is ETHICON. They have released two sutures, Monocryl Plus and Vicryl Plus. Monocryl is a monofilamantous synthetic suture and Vicryl is a multifilamentous suture material.

Several studies have tested these triclosan coated materials, against the microbes usually found in SSI and it was found to be extremely useful in containing the bacterial colonization, thereby reducing the risk for SSI [26].

CONCLUSION

Antimicrobial sutures may be expensive, but their usefulness cannot be invalidated. Several clinical trials have extensively studied the effectiveness of triclosan based sutures, and their benefits have been widely accepted. The sutures coated with various other materials that have been sparsely studied, especially chlorhexidine and tetracycline whose benefits in the oral cavity has already been proven, also need the same attention to firmly ground their advantages. Further clinical trials in this area would be welcomed to enhance the future use of the various antimicrobial sutures, with a wider range of options to choose from.

Local substitutes would serve this purpose of reducing SSI better than systemic solutions, particularly for local infections, without increasing the risk of multiple drug resistance. Based on the knowledge obtained from the above mentioned studies, and with the clearer understanding of its benefits, we must be motivated to better our thinking and put into regular practice the use of the antimicrobial sutures especially in vulnerable immune-compromised individuals, thereby reducing the extensive use of systemic antibiotics to control the infection.

Conflict of Interest Statement: There are NO conflicts of interest among the authors.

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How to cite this article: Devadason ND, Rajasekar S., Jacob S et.al. Antimicrobial sutures for periodontal surgeries. International Journal of Research and Review. 2020; 7(11): 167-174.

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