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RESEARCH ARTICLE

COMPARISON OF WICKING EFFECT OF DIFFERENT SUTURES: AN IN VITRO STUDY

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ABSTRACT

Objective: The purpose of this study was to compare the wicking properties of different multifilament sutures.
Materials and Methods: Polyglycolic acid (PGA) 4-0 sutures and black silk sutures were placed in sheep blood agar media for 24 h and then suspended on a microscope slide. Fluorescein isoothiocyanate-dextran (FITC-D) was placed at the mid-point of the sutures and observed using fluorescence microscopy. The experiments were repeated, and the amount of *Staphylococcus aureus* and *Escherichia coli* was measured every 8 h.
Results: We observed no growth of *Escherichia coli* on the silk sutures after 24 h. In contrast, the concentration of *S. aureus* was approximately >100 CFU/µL, 60–80 CFU/µL, and 30 CFU/µL at 8, 16, and 24 h, respectively. For the PGA 4-0 suture, *S. aureus* concentration was >100 CFU/µL, 30–40 CFU/µL, and 30–40 CFU/µL at 8, 16, and 24 h, respectively and that of *E. coli* was >100 CFU/µL, 35 CFU/µL, and 27 CFU/µL at 8, 16, and 24 h respectively. The wicking effect of the black silk sutures thus resulted in 70% growth of *S. aureus* and no growth of *E. coli*, and the wicking effect of the PGA sutures resulted in 70% more growth of *S. aureus* compared to that on silk, whereas the growth of *E. coli* was 35%.

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INTRODUCTION

Sutures are used in surgical applications for varied reasons, including regathering of tissues separated as a result of surgical or trauma procedure, speeding of primary healing, and hemorrhage reduction (Miller, 1990). Sutures play an prominent role in tying the end of vessels and in the gathering of tissues. There are many types of sutures available, and they are segregated depending on composition, i.e., natural and synthetic; structure, i.e., monofilament and multifilament; and spontaneous degradation, i.e., absorbable and non-absorbable. These materials are graded based on different tissue responses as a result of their degradation by hydrolysis The rate of hydrolysis depends on variables such as pH and temperature of the tissue. Monofilament sutures are associated with a lower tissue abrasion, and reduced risk of infection compared with braided suture materials. There is a lower risk of colonization by microorganisms, and the sutures are easier to tie; however, their cut ends can irritate the tissue and mucosa and cause ulceration. Multifilaments are easy to handle and tie because they have less stiffness and are easier to form a knot; however, their braided structure often facilitates the accumulation of food debris or bacteria. Among monofilament suture materials, polytetrafluoroethylene has less surface tension, chemically inert, biocompatible, and moderate resistance. Multifilament sutures have higher tissue abrasiveness, capillarity, and bacterial resident capacity than monofilament sutures. Sutures are also segregated on the basis of fluid capillary action, a process in which fluid and bacteria become entangled in the texture of the multifilament sutures. A material with good capillary action acts as a wick that delivers serum fluid and bacteria; therefore, these sutures should be avoided in infected and inflammatory situations (Lily *et al.*, 1969). Coating of Multifilament sutures result in less fluid movements (Sethi *et al.*, 2016). Bacteria are less populated in the texture of certain multifilament absorbable sutures. Of the different suture materials, silk is associated with a lower incidence of infection. PGA is stronger than silk, but its strength gradually weakens significantly over period of time. Thus, the selection of the suture material is an important step during treatment planning for oral surgical procedures. According to Inflammatory reaction, based on several studies, synthetic materials perform better in oral tissues compared to non synthetic materials. Although silk is considered to be a preferred suture material, doubts are present regarding its efficacy. Studies have reported similar bacterial counts on braided silk sutures, and experiments have shown that polyglycolic acid (PGA) sutures

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are prone to bacterial colonization and higher tissue inflammatory reactions than other suture materials. Silk has added advantage in terms of cost, as it is less expensive than other non-absorbable materials. When 10-cm lengths of silk sutures were placed in agar broth containing *Streptococcus mutans* and *Escherichia coli,* there was no colony-forming unit (CFU) growth after 24 h, indicating that silk is safe for use in human oral tissues. However, when PGA sutures were tested in the same medium, there was a higher rate of CFU growth. These results demonstrate that inflammatory reactions are more common when PGA sutures are used in human tissues than when silk sutures are used. Studies have reported a variety of responses in extra-oral and intra-oral tissues as well as at different sites where the sutures are used (Yaltirik *et al*., 2003). An in-depth understanding of the mechanical and physical properties of suture materials is important in dental procedures. The choice of suture materials used in oral surgical interventions has a critical effect on optimal post-surgical wound healing. The aim of this studywas to evaluate the flow of microorganisms (*Staphylococcus aureus* and *E. coli*) in black silk and PGA suture materials.

MATERIALS AND METHODS

This in vitro study was designed to measure the amount and frequency of growth of *Staphylococcus aureus* and *E. coli* on black silk and PGA 4-0 sutures after incubation in agar media for 24 h. The suture samples were 10 cm in length, and they were divided into three parts, A, B, and C. Growth measurements were performed every 8 h. The sutures were divided into equal lengths of 10 mm for ease of insertion into the test tubes so they could be immersed in the blood agar medium. The sutures were suspended in the agar medium for 8, 16 and 24 h for parts A, B, and C, respectively. The temperature was kept at 37°C. The black braided silk and PGA 4-0 sutures were sectioned into three equal parts and evaluated at 8-h intervals for a total period of 24 hrs. Both *E. coli* and *S. aureus* were selected for the study because of the ease of cultivation of both microorganisms in blood agar medium and their ability to be retained in suture samples. Sheep blood agar was selected as it is a differential and enriched medium used for investigating different types of hemolysis. *E. coli* is lactose-fermenting and beta-hemolytic on blood agar, and *S. aureus* is beta-hemolytic. Results in these assays were based on the clearance zones seen in the Petri dish. For beta hemolysis, a wide clearance one was usually observed. The population of bacteria resulting from the wicking property of the suture materials immersed in the medium was determined after the samples were transferred to a test tube for ease of determining microorganism counts under fluorescence microscopy.

RESULTS

The results from the experiment clearly indicate a decreasing bacterial count for both silk and PGA for both *E. coli* and *S. aureus*. The intriguing factor lies in the complete absence of *E. coli* on silk, with the CFU at 70 for 8 h and later reaching the baseline value of 0 at 16 h and 24 h. The reason for this finding is unclear. However, some possible reasons could be differences in temperature or inadequate presence of suture material in the medium resulting from insufficient placement of the suture material during the evaluation period or from tilting or improper positioning of the test tube with relation to the suture materials.

Table 1-4. The tables reflect 24 hrs of incubation with measurement done every 8 hrs

***S. aureus* on silk**

Silk	Time	Average
A	8 h	100 CFU
B	16 h	70 CFU
C	24 h	30 CFU

***E. coli* on silk**

Silk	Time	Result
A	8 h	70 CFU
B	16 h	0 CFU
C	24 h	0 CFU

***S. aureus* on PGA 4-0**

PGA	Time	Result
A	8 h	100 CFU
B	16 h	50 CFU
C	24 h	50 CFU

***E. coli* on PGA 4-0**

PGA	Time	Result
A	8 h	100 CFU
B	16 h	35 CFU
C	24 h	27 CFU

These factors can be excluded by applying a longer experimental period to rule out the possibility of any errors.

DISCUSSION

The results of our study indicate that silk does not produce more fluid movement via capillary action and that it actually produces less movement than PGA. Additionally, there seems to be less mechanical transmission of bacteria with silk than with PGA. These results correlate with those of Chatterjee (Chatterjee, 1975), who found no changes in tissue reactions to Dexon, collagen, and silk in when used in ophthalmic procedures, and with those of Blomstedt (Blomstedt, 1985), who found no difference in acute infections when silk or PGA was used. Further studies are needed to investigate the mechanisms involved in reducing active bacterial migration through effects on colony growth. These results support the hypothesis of Katz (Katz, 1981) that the physical characteristics of a suture material may be a major determinant of the tissue response. Previous studies have reported that absorbable suture materials have a greater resistance to tension than non-absorbable materials, as shown by Moser *et al.* (1974) who obtained better results with polyglycolic acid than with silk under natural conditions as well as after immersion in Ringer's solution for 5-7 d. In the present study, the CFU results for *S. aureus* and *E. coli* on silk were mixed when compared over time. After 8 h, 100 and 70 CFU were seen for *S. aureus* on silk. After 16 and 24 h, 70 and 30 CFUs formed for *S. aureus*, whereas the amount for *E. coli* was 0, on silk. In contrast, results such as those of Lilly, (1968) suggest that the physical characteristics of the suture material might play a role and that bacteria can be resident in deeper areas of tissue by wicking. For PGA 4-0, no difference in CFU growth was seen between *S. mutans* and *E. coli* after 8 h, but the CFU values changed considerably after 16 and 24 h. This result agrees with that of Scher *et al*. (1985) lesser bacteria adhered to polypropylene monofilament sutures than to polyester multifilament sutures.

Sutures tied after surgical procedures are partly present in tissue and in saliva, with a mean concentration of bacteria of approximately 750×10^6 units/mL. The bacteria that populate sutures have a presence of 200×10^9 cells per gram, similar to cultured cells present using a centrifuge (Katz *et al*., 1981). The inflammation caused by these bacteria produces erythema around the puncture wounds, leading to the suspicion that the suture could wick the bacteria into the surgical site itself (Silverstein *et al*., 2005). There are many available suture materials for dental and medical surgical procedures, and it is important for a surgeon to understand the properties of these materials, the healing factor, and how these suture materials will react with surrounding tissue (Scher *et al*., 1985). Silk is the most commonly used suture material for dental and several other surgical procedures. Although silk is easy to handle and inexpensive, some surgeons believe that it should not be considered as a material of choice for surgical interventions. Because of their ability to adhere to sutures, bacteria may act as a foci of infection, as reported by Scher *et al*. (1985). Some studies have shown that oral tissue reacts less to silk sutures with fewer inflammatory reactions compared to polyglycolic acid sutures.

Other studies have shown that fibroblasts and capillaries form at a slower pace in oral tissue near where silk sutures were used, possibly explaining the delayed healing and tissue reactions associated with silk sutures. Katz *et al*. (1974) showed in vitro that tissue reactions shows the ability of bacteria to populate to different suture materials. They also investigated the capability of bacteria to adhere to different types of sutures and to induce tissue reactions. The colonization of different microbes on different suture materials in different patients was investigated, more bacteria were observed on silk than on polyglycolic acid (Yaltirik *et al*., 2003). These different rates of bacterial adhesion to various suture materials support the hypothesis that microbial adhesion to sutures plays an important role in inducing tissue reactions.
A few studies have shown that sutures that are away from connective tissue induce less intense inflammatory reactions but maintain the same histological pattern. The responses to silk sutures reported by some studies indicate that the material induces unsatisfactory tissue reactions (Lilly *et al*., 1968).

Grigg *et al*. (2004) evaluated the microbial wicking characteristics of different multifilament suture threads (silk, PGA, and polygalactic acid) using *Streptococcus salivarius*. It was found that all of the multifilament sutures evaluated for, became saturated with and absorbed the fluids after 48 h, but that PGA did so at a faster pace. Selvig *et al*. (2005) compared silk, catgut, and poliglecaprone among diabetic and control groups. All of the materials were well-tolerated; however, poliglecaprone 25had comparable positive effects on wound healing compared to the others (Yilmaz *et al*., 2010). Moser *et al*. (1974) compared silk and chromic gut in animal models after periodontal surgery. Bacterial invasion of the suture length was a common outcome irrespective of the material used, but it predominated with silk sutures. Sutures used in the oral cavity are continuously bathed in saliva containing 7.5×10^8 microorganisms/mL. This results in the continuous wicking of microorganisms along the suture at the surgical site, which results in a prolonged inflammatory response and surgical site infections (Okamoto *et al*., 1994). Studies on the use of antibiotic-coated sutures have reported mixed results for the prevention of surgical site infections (Sethi *et al*., 2016). In previous studies, agar plates were incubated aerobically at 37°C for 48 h. Colonies of bacteria were counted using classical bacterial counting techniques, and the results were expressed as CFU/mL. The results indicated that a non-absorbable material was less inflammatory than natural products but that it still produced a measurable response. Mirelman observed that multifilament suture materials consistently produced stronger inflammatory reactions than monofilament materials (Katz, 1981). The stronger inflammatory reaction observed with multifilament suture materials was due to the presence of bacteria within the core of the suture. Supportingly, colonies were observed along the suture track, which could be interpreted as bacteria between the filaments of the silk sutures (Miller, 1990).

Conclusion

The various suture materials used in oral surgical interventions present varying degrees of wicking effects depending on several factors, including their surface properties and bacterial adhesion properties. The results of the present study emphasize the need for careful selection of suturing materials for oral surgical interventions. In the present study, there was no growth on silk after 24-48 h when the suture was placed in a test tube, possibly because of surface tension as the bacteria moved up the suture, which is called the wicking effect. The wicking effect of *E. coli* decreases as the distance increases. Because this study only included two suture materials, the wicking effect could not be fully evaluated. Further studies with other suture materials over longer time periods are needed to fully understand the physical and biological properties of the wicking effect. But, taking the present study as a guideline,it holds promising results.

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