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Some Significant Trends in Biodegradable Surgical Sutures

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Abstract:

The article highlights some significant trends in biodegradable surgical sutures. Surgical site infections (SSIs) are one of the most common nosocomial infections, which can result in serious complications after surgical interventions. Foreign materials such as implants or surgical sutures are optimal surfaces for the adherence of bacteria and subsequent colonization and biofilm formation. Two types of sutures made by two different biopolymers were tested in terms of hydrolytic biodegradation in phosphate buffered saline solution, which simulates the physiological conditions, varying the pH of the medium and the immersion time.

1. Keywords: Antibacterial coating; Biodegradable; Suture; SEM; Totarol; Weight loss

2. Introduction

Surgical Site Infections (SSIs) are one of the most critical parameters after surgical intervention, especially in contexts in which foreign materials such as implants or sutures are brought into the wound. Different bacteria are able to adhere and colonize on the surface of surgical sutures, causing infection. Surgical sutures are sterile stiches used to seal wounds after surgical procedures. They are an important tool to support wound healing, and the increased risk of SSIs compromises their usefulness **[1,2]**. Due to their great advantages over natural materials, the synthetic bio absorbable sutures became widely used in the surgical field **[3-5]**. An ideal suture must be sterile, easy to handle, causing minimal tissue damage or minimal tissue reactions, to provide high tensile strength, to present a favourable absorption profile and to be resistant to infection. Polymers used as biomaterials in sutures' fabrication must meet certain characteristic, namely appropriate tensile strength and Young modules value, capillarity, handling,

biocompatibility and biodegradability. The most widely used homopolymers and copolymers in obtaining absorbable sutures are polydioxanone, polyglycolic acid, and the copolymer of glycolic acid and trim ethylene carbonate, the copolymer of caprolactone and glycolide and the copolymer of glycolic acid and lactic acid **[6]**.

3. Biodegradable Antibacterial Coating

The most common pathogen causing these infections is Staphylococcus aureus, a gram-positive bacterium, which is responsible in 23% of the cases **[7,8]**. To reduce the incidence of SSIs, this source has to be eliminated **[9]**. One approach is to coat the surface of surgical sutures with antibacterial agents like antibiotics or other antibacterial substances in order to prevent bacterial adhesion on the surface without impairing other properties of the surgical suture. Such a coating can be implemented with the aid of poly (lactide-co-glycolide acid) (PLGA) in combination with an antibacterial active ingredient. Biodegradable polymers, especially PLGA, have been used, mainly due to their good biodegradability, biocompatibility, and toxicological properties, as drug delivery systems in medicine and pharmacy. PLGA can be combined with a wide range of active ingredients, which are enclosed in PLGA and released over time during its degradation process **[10-12]**. Moreover, it is one of the few polymers that have been approved by the Food and Drug Administration (FDA) for clinical use in humans. Nowadays, PLGA is very widely used in systems with controlled drug release over a few days to months, including microspheres, nanoparticles, and implant coatings for local delivery **[13,14]**. In addition to antibiotics, natural antibacterial agents exist, which have great potential to be used as prophylactic agents against wound infections, mainly because antibiotic resistance may be circumvented. The active ingredient, totarol, a natural substance extracted from Podocarpustotara, demonstrates antibacterial activity against different bacteria, including Staphylococcus aureus (S. aureus) **[15,16]** and Methicillin-resistant Staphylococcus aureus (MRSA) **[17]**. So far, the exact mechanism of the antibacterial activity of totarol is not entirely clear. It is speculated that totarol inhibits bacterial respiratory transport **[18]**, influences the multi drug efflux-pump **[19]** or disrupts the phospholipid membranes **[20]**. Another antibacterial impact is the targeting of the protein Fts Z to inhibit bacterial cytokinesis **[21]**. These properties are very interesting for future antibacterial therapies since totarol has low cytotoxicity **[22,23]**. Therefore, we hypothesize that, by combining PLGA and totarol in to a biodegradable, antibacterial coating on sutures, a controlled release of the natural active substance and hence an inhibition of bacterial adhesion and biofilm formation on the material may be achieved. Our data indicate that totarol-coatedsuturesexhibitantibacterialactivityagainstS.aureusin vitrooveratleast15days, while they do not induce adverse effects on the viability of fibroblasts.

This study analyzed the use and effectiveness of totarol as an antibacterial coating for suture material. Totarol-solutions and solutions containing both totarol and the polymer PLGA were used to successfully coat non-absorbable monofilament as well as multifilament sutures. It was shown that totarol has antibacterial properties as a purified substance in solution and that it retained those properties in vitro as a coating on its own and in combination with PLGA **[24]**.The safest and most efficient combination of totarol and PLGA tested appeared to be the coating solution containing 100 mg/mL totarol and 75 mg/mL PLGA. The growth of Staphylococcus aureus around the totarol-coated material was inhibited in the long-term largely independently of its concentration and, therefore, can prevent biofilm formation in vitro. It was also demonstrated that totarol has no negative effect on the viability or morphology of murrain fibroblasts in vitro. In conclusion, our biodegradable to tarol coating shows promise as a coating for sutures to prevent biofilm formation during the critical phase of wound healing and hence may decrease the occurrence of surgical site infections.

4. In Vitro Assessment of Biodegradability

After implanting the absorbable suture, the polymers used in the synthesis process, are broken down by enzymal and hydrolytic process. Strength, mass loss profiles and biocompatibility of the absorbable sutures are the most important characteristics in the degradation and absorption processes **[4,5]**. The literature shows that the strength and mass loss profiles of the absorbable sutures depend not only on the chemical differences between the used biopolymers, but also on some intrinsic and extrinsic factors, such as electrolytes, pH, applied stress, temperature, microorganisms and tissue type **[6]**. The objective of this work was to make a comparative analysis of the way and degradation degree of surgical sutures commonly used in orthopaedic surgery. Two types of sutures made by two different biopolymers were tested in terms of hydrolytic biodegradation in phosphate buffered saline solution, which simulates the physiological conditions, varying the p H of the medium and the immersion time. Phosphate Buffered

Solution (PBS) was selected as testing medium because it is accepted as usual medium for testing the hydrolytic biodegradation of polymers for medical devices **[25-29]**.

The degradation of the investigated surgical sutures immersed in PBS solution is the result of a process of hydrolysis. Some important issues, which affect the degradation rate, are the polymer hydrophilicity and molecular weight. Water can easy penetrate hydrophilic polymers and react easily with functional groups on these polymers. Regarding the polymer molecular weight, the lower molecular weight is, the higher degradation rate is **[30]**. This study demonstrates the influence of some extrinsic factors concerning the degradation rate of the bio polymeric surgical sutures. The experimental results obtained revealed that both investigated surgical sutures exhibit quite different hydrolytic degradation at various immersion times and pH values. They degrade faster in a high-alkaline medium, and the sutures made by polyglicolic acid shown a total degradation at pH of 10. In conclusion, we consider that the degradation rate of the biodegradable suture can be tailored to different applications depending on the type and area of surgery.

5. Conclusions

Due to a significant increase in antibiotic-resistant bacterial strains, naturally occurring agents exhibiting antibacterial properties have great potential in prophylactic therapies. The objective has been to develop a coating for surgical sutures consisting of the antibacterial substance totarol, a naturally occurring diterpenoid isolated from Podocarpustotara in combination with poly (lactide-co-glycolide acid) (PLGA) as a biodegradable drug delivery system. Hence, non-absorbable monofilament and multifilament sutures were coated with solutions containing different amounts and ratios of totarol and PLGA, resulting in a smooth, crystalline coating. Using an Agar Diffusion Test (ADT), it became evident that the PLGA/totarol-coated sutures inhibited the growth of Staphylococcus aureus over a period of 15 days. A 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay showed that the coated sutures were not cytotoxic to murine fibroblasts. Overall, the data indicates that our innovative, biodegradable suture coating has the potential to reduce the risk of SSIs and postoperative biofilm-formation on suture material without adverse effects on tissue. In the case of sutures made by two different biopolymers the determination of the degradation rate was conducted by measuring the weight loss of the sutures. The study revealed that both investigated surgical suture exhibit quite different hydrolytic degradation at various immersion times and pH level, a more intense degradation being recorded in the alkaline environment.

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