Original Article

Comparative Evaluation of Tensile Strength and Knot Strength of *Nigella sativa* Coated and Non-Coated Sutures: An *In vitro* Study

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Abstract

Background: Surgical sutures, essential for wound closure, must possess optimal mechanical properties to ensure patient safety and healing efficacy. The antimicrobial and anti-inflammatory properties of *Nigella sativa* have prompted its use as a suture coating to enhance wound healing. The aim of the study is to coat the sutures with *N. sativa* extract, and their mechanical properties like tensile strength and knot strength were evaluated and compared to non-coated sutures. **Materials and Methods**: *N. sativa* extract was prepared by distillation method and knot strength and tensile strength were evaluated by standardized testing methods using Instron tester. **Results**: The results show that there are some statistically significant differences between *N. sativa*-coated suture and non-coated suture in tensile strength and no significant differences were found while measuring knot strength between the groups. **Conclusion**: *N. sativa*-coated sutures have good tensile strength and equal knot strength compared to non-coated sutures.

Keywords: Coated sutures, knot strength, *Nigella sativa*, tensile strength

Introduction

Surgical sutures are medical devices, which are used for binding body tissues in the case of any medical apathy.[1] The word "suture" describes any strand of material used to approximate tissues.[2] The primary objective of dental suturing is to position and secure surgical flaps to promote primary healing. Healing may be hampered or delayed if the flaps are not positioned correctly. Suturing is a crucial step for a successful result of a surgery because, in certain situations, this could jeopardize the procedure's outcome.[3]

Surgical site infections (SSIs) are challenging surgical complications occurring after surgical procedures.[4] Based on the surveillance system of Center for Disease Control and Prevention, SSIs were the third most common nosocomial infection (17%) among hospitalized patients.[5] To mitigate the risk of suture material becoming a potential source of infection, it was coated with an antibacterial agent.

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The use of "Antibacterial coated suture" is a promising method for achieving sustained release of an antibacterial agent at the surgical site. These coated sutures can help to minimize or prevent plaque formation and play an important role in inhibiting the colonization of pathogens around the suture, thus impeding biofilm formation. Therefore, sutures coated with antimicrobial agents have the capability to impede the growth of microbes at the surgical site, thereby reducing the risk of SSI.[6]

Medicinal plants are "Gift of Nature." "*Nigella sativa*" is also known as "black seed" or "black cumin" and belongs to Family-*Ranunculaceae*. The main active ingredient of *N. sativa* is "Thymoquinone." It provides antimicrobial, anti-cancer, gastro-protective, anti-oxidant activity, immune-modulatory, anti-inflammatory, anti-tumor, anti-anxiety, anti-asthmatic effects.[7]

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The tenacity of suture material is significant for the practitioner making a knot. If the material is too weak and the knotting force is stronger than the tensile strength of the suture material, the suture can easily break while tightening the knot. Suture material weakness may lead to premature suture breakage, resulting in poor surgical flap adaptation and secondary intention tissue healing.[8] Therefore, it is essential to know the tensile strength of sutures.[9] Hence, to our knowledge this is the first study to coat the suture with *N. sativa* and compare its knot strength and tensile strength with non-coated suture.

Materials and Methods

This is an *in vitro* study consisting of two Group A (Test) – *N. sativa*-coated 3.0 Multifilament Braided Silk sutures ($n = 10$) and Group B (Test) – Non-coated 3.0 Multifilament Braided Silk sutures ($n = 10$), all of which are 15 cm long.

Laboratory procedures

Pretreatment of sutures

The silk suture was dipped in 1% sodium hydroxide for half an hour, followed by washing with distilled water. This process is called scouring of the suture which was done to remove natural and added impurities present in the suture and improve the absorbency.[10]

Chitosan solution preparation

Chitosan solution was prepared by stirring 8 g chitosan in 2% (v/v) aqueous acetic acid solution at 60°C for 1 h, followed by 2 g of sodium alginate polymer was added and stirred for 10 min. The scoured suture material was immersed in this solution for about 2 h and dried at 80°C for 5 min and was cut, each of length of 15 cm.

Preparation of Nigella sativa extract

The *N. sativa* extract was prepared by Soxhlet Extraction Process. *N. sativa* seeds were purchased and grinded into a course powder. A quantity (1000 mL) of the organic solvent 70% ethanol was poured into a round bottom flask equipped with a Soxhlet apparatus and condenser. 500 g of *N. sativa* powder was placed inside the extractor and extraction was carried out at 60°C for 4 h.[11] The resulting suspensions was filtered through a sterile filter paper and underwent distillation process and cooled in the desiccator. Finally, Chitosan-coated pieces of suture were dipped into *N. sativa* extract for 24 h followed by drying for 48 h at room temperature.

Knot strength and tensile strength

Instron universal testing machine was used to measure the tenacity and knot strength of silk sutures. Knot was formed with surgeons knot method with Gage length (150 mm) and Extension rate (200 mm/min).[12] For each test method, at least 10 readings were taken. Tensile strength was measured to know the breaking strength. The Straight-Pull test is the tensile test method where the suture specimen is clamped between two tensile grips and pulled apart and in the Knot-Pull test, the suture specimen is tied into a knot in the center of the grips then pulled apart.

Results

The results were statistically analyzed by the independent *t* test. It shows that tensile strength was statistically significant (0.0002) between Group A and Group B with mean for Group A of 34.67 ± 1.21 and Group B for 32.17 ± 1.18 [Table 1] which reveals that the tensile strength is higher for Group A.

On comparing the Knot strength between two groups, it was not statistically significant (0.1492) with mean for Group A of 24.21 ± 0.47 and Group B of 23.82 ± 10.67 [Table 2] which revealed that although no major difference was observed between the groups, group A had mild higher Knot strength than Group B.

Discussion

Suturing is done mainly to approximate the tissues which helps in controlling bleeding and healing by primary intention.[13] In both Group A and Group B, tensile strength is found to be more than the knot strength which was consistent with the results of Sudha *et al.* in 2017 where tensile strength is more in drug-loaded antimicrobial silk suture due to better binding of fibers by chitosan, thereby resisting the axial load.[4] The knot is the weakest part when subjected to tension, this observation correlates with findings done by Ben Abdessalem *et al.* in 2009[12] where they found that tightening of the knot and the friction between yarns in the knot may contribute to the failure.

Shanmugasundaram *et al.* in 2011[14] conducted a study on Drug release and antimicrobial properties of polylactic acid sutures where they analyzed for tensile strength, and knot strength of coated sutures and

Table 1: Comparison of tensile strength, cN/tex

Groups	Mean	Standard Deviation	*P* value
Group A	34.67	1.21	0.0002
Group B	32.17	1.18	

Table 2: Comparison of knot strength, cN/tex

Groups	Mean	Standard Deviation	*P* value
Group A	24.21	0.47	0.1492
Group B	23.82	0.67	

found that coated sutures have high tensile strength and decreased knot strength due to the internal fiber fracture and the force oriented at the knot was at an acute angle to the suture axis and loading forces area of high-stress concentration.[15]

Benlafya *et al*., in 2014,[16] conducted an *in vitro* study to determine the antimicrobial and antifungal activity of different extracts and essential oils of *N. sativa* and the results showed that all the extracts and essential oils showed varying degrees of inhibition against microbes due to the presence of the natural phytochemical constituent "Thymoquinone."

When suture material comes in contact with saliva or other body fluids, its mechanical properties changes. Hence, a suture with good tensile strength and added effect of drug-releasing properties of *N. sativa*, helps in better wound healing by primary intention at the surgical site[17] which was similar to the results of an *in vitro* study conducted by Sibanda Pethile., in 2014,[18] on the preparation of antimicrobial-coated silk sutures; results show that sulfamethoxazole trimethoprim combined with high concentrations of poly (ε-caprolactone) was an effective antibacterial coating agent for braided silk suture with an increase in both tenacity and knot strength. The limitations of this study were the low sample size and the need to check the antimicrobial effect of *N. sativa*-coated silk suture. The pH of the saliva will change between 7.4 and 8.1.[19] Hence, a change in tensile strength due to varying pH must also be observed.

Conclusion

Hence, *N. sativa*-coated sutures have good mechanical properties compared to non-coated sutures, which help in appropriate tissue suturing, prevent the SSI, and promote wound healing.

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Conflicts of interest

There are no conflicts of interest.

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