RESEARCH PAPER

SYNTHESIS AND CHARACTERISATION OF ALGINATE–COPPER OXIDE NANOPARTICLES FUNCTIONALIZED SILK SUTURES

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ABSTRACT

Introduction: Silk sutures are entwined threads from silkworm larvae. They are braided non-absorbable sutures. Copper oxide nanoparticles are incorporated in the study as they have potential anti-oxidant properties. Wound healing by alginate-based material has many advantages when compared to conventional gauze.

Aim: To evaluate the characteristics of alginate and copper oxide nanoparticles coated silk suture.

Materials and method: Antimicrobial and antioxidant properties were assessed for the alginate/copper oxide nanoparticles coated silk suture.

Results: The study shows positive antimicrobial activity for *S. mutans* and *E. coli* when compared to control samples.

Conclusion: Thus, it can be concluded that alginate/copper oxide nanoparticles coated silk suture possess antimicrobial and antioxidant properties.

Keyword: Alginate, copper oxide nanoparticles, silk suture.

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INTRODUCTION:

Surgical sutures can be single-braided or multi-braided, made of natural or synthetic materials, and either absorbable or non-absorbable. Silk is a naturally occurring, non-absorbable substance that has been used extensively for wound ligation.(1). Over the past 100 years, it has surpassed collagen as the most widely utilised natural suture in the biomedical field. The field of medicine has been dominated by a variety of biodegradable synthetic sutures for the past 25 years.(2–11)However, silk is still popular in ocular, neural, and cardiovascular surgery owing to its advantageous characteristics and properties(12). One of the major drawbacks associated with the use of silk sutures is its poor microbe resistance characteristics which can lead to adhesion of food substances and microorganisms.

One of the key factors contributing to postoperative infections is bacterial adhesion to a suture, particularly in any area of the oral cavity. An antibacterial coated suture material with improved wound healing function may offer higher protection against infections at the surgical site. It can take a long time for wounds to heal since bacteria and other microbes are frequently attracted to them.(13). External materials such as surgical suture and ex-vivo pathogens can cause complications such as infection in the surgical site.

Alginate on the other hand is a polysaccharide biopolymer, one of the most promising and widely used hydrocolloid materials for biotechnological applications. It's been successfully used as a thickening agent, a gelling agent, and a colloidal stabilizer in cell encapsulation, drug delivery system and tissue engineering applications(14). The high gel porosity of alginate particles allows considerable diffusion in a mixture. Assemblance of multilayer alginate films can improve the stability of the modification on substrates. It can agglomerate under normal physiological conditions , thereby improving the stability of polyelectrolyte layers.

Copper oxide (CuO) nanoparticles were characterized and investigated with respect to potential antimicrobial applications. It was found that nano scaled CuO, generated by thermal plasma technology, contains traces of pure Cu and Cu2O nanoparticles(15). Coating silk sutures with any kind of prepared nanoparticles can improve healing, surgical site infection prevention and mechanical properties. Recent studies show that silk sutures have been enriched with silver nanoparticles using a coating method(16). Copper nanoparticles is another type of Nano-structure in which its antibacterial properties have been demonstrated. The preferences of copper nanoparticles that makes them suture investigating aspects or low production cost, wide range of antimicrobial potency, catalytic activity. In addition to this, copper oxide has shown antioxidant properties. Sodium alginate is used for study as a carrier, it is a biocompatible material. It's a polysaccharide which has anti-inflammatory properties along with antioxidant properties.

Thus the aim of the study is to analyze the antibacterial antioxidant property of the coated suture. The wound healing property of silk suture is thus enhanced by the coating process by preventing entry of pathogens, providing a moist environment.

MATERIALS AND METHOD:

Sample preparation:

Silk suture of choice was preserved and was sterilized at 50°C in the hot air oven for 24 hours. The necessary size is 8 cm (one sample), 4 cm (three samples) was cut for the further analysis included in the study.

Preparation of alginate and copper oxide nanoparticles:

1% of alginate and 0.1% of required nanoparticles were taken. 1% alginate was dispersed in 100 mL of distilled water overnight in the shaker. The next day, to the alginate, copper oxide nanoparticles are added along with the wearing lens of the suture material and they are allowed to get coated for 24 hours and further analysis were done.

Antimicrobial test:

Broth inoculated with E.coli and S.mutans were prepared and kept aside. Agar was sterilised at 37°C for 24 hours and solidified. The agar used for the study is Muller Hinton agar. A sterile swab was taken and strikes of the above mentioned bacteria were made on the agar plate. Now the control i.e., uncoated suture and coated sutures are placed on the plate to observe the zone of inhibition against both the microorganisms.

Antioxidant activity:

DPPH assay was used to test the antioxidant activity of the prepared copper oxide nanoparticle. Diverse concentrations are 10 µL 20 and 30 µL 40 µL and 50 µL of alginate/copper oxide nanoparticles mixed with 1 mL of 0.1 DPPH in methanol. Later, the reduction in the quantity of DPPH free radicals was assessed dependent on the absorbance at 517 nm. Ascorbic acid was used as the standard.

Characterization:

SEM analysis for both coated and uncoated sutures were done to ensure the proper coating of the alginate dispersed particles and copper oxide nanoparticles.

RESULTS:

Figure 1 , 2 depicts the scanning electron microscope analysis of uncoated silk suture is compared to the SEM of nanoparticle coated suture.

Figure 3 shows the zone of inhibition of nanoparticle coated silk suture. The zone of inhibition was 2-3 mm for the control silk suture i.e., uncoated with nanoparticles and the T1 and T2 i.e., the suture which is coated with the nanoparticle shows a zone of inhibition of 3mm. The above are the results achieved against Streptococcus mutans.

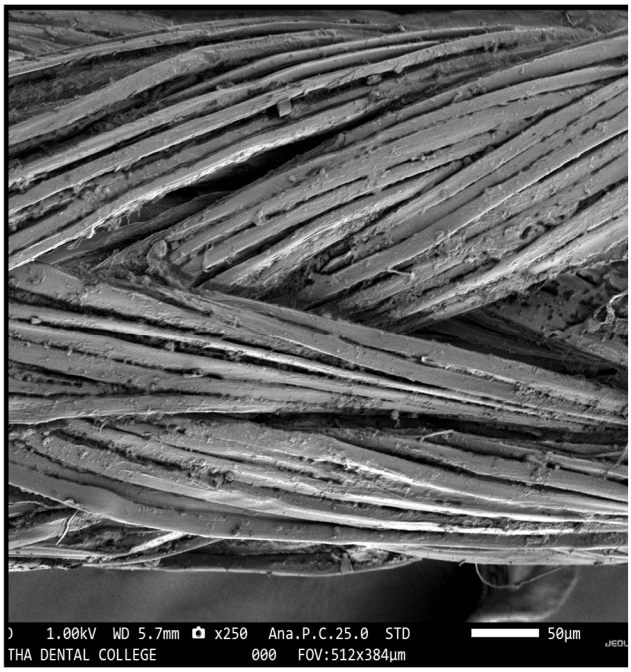

Figure 4 depicts the zone of inhibition of nanoparticle coated silk suture. The zone of inhibition was 2-3mm for the control silk suture i.e., uncoated with nanoparticles and the T1 and T2 i.eThe suture which is coated with the nanoparticle shows a zone of inhibition of 3mm. The above are the results achieved against E. coli.

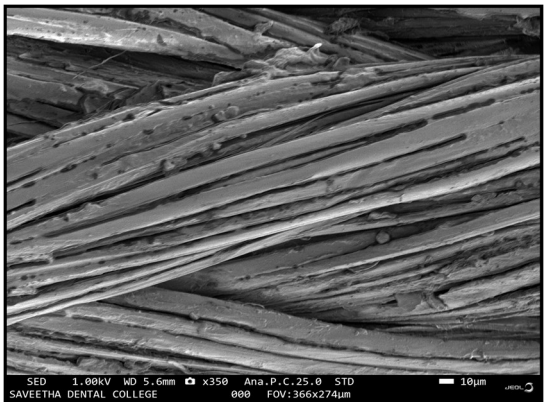

Figure 1: Shows the SEM analysis of the uncoated silk suture.

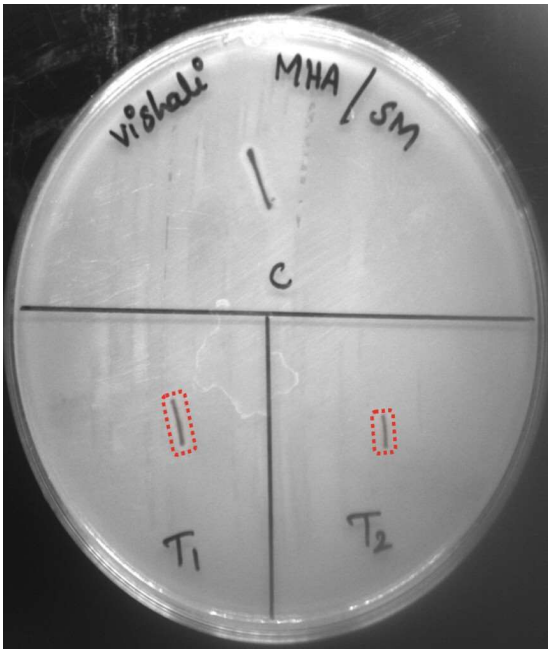

Figure 2: Shows the SEM analysis of the nanoparticles coated silk suture.

Figure 3: Shows zone of inhibition of control, nanoparticles coated silk suture against S.mutans.

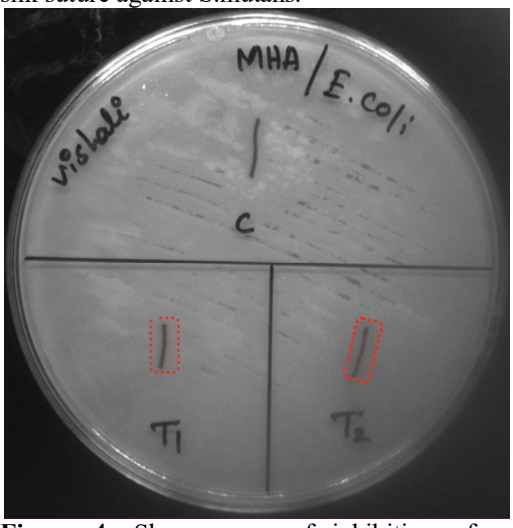

Figure 4: Shows zone of inhibition of control, nanoparticles coated silk suture against E.coli.

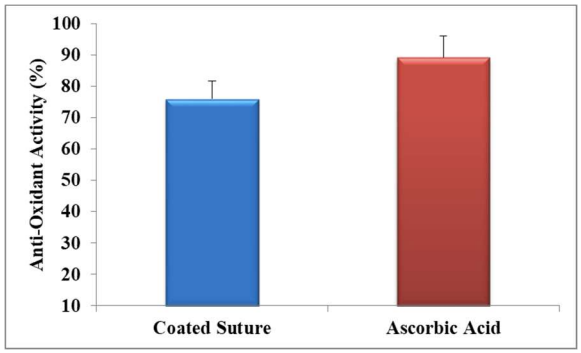

Figure 5: The graph depicts the antioxidant activity of alginate/copper oxide nanoparticles coated suture and the control was chosen to be ascorbic acid. Copper oxide had 75% of antioxidant properties which was almost similar to the standard

DISCUSSION

Suture materials are thought to be the substances most frequently implanted in human bodies since they are regularly employed in oral surgery. Three distinct absorbable synthetic suture materials (catgut, Dexon, and Vicryl rapide) were used in oral surgery in a clinical research to
compare the incidence of problems and the speed at which wounds healed. Vicryl rapide provided faster wound healing than the other two suturing materials evaluated, according to the study's findings. On the 21st postoperative day, there was no discernible difference between any of the three patient groups with regard to the occurrence of local reaction in 3rd molars.

The impact of saliva, the presence of oral microorganisms and their metabolic byproducts, the high tissue vascularization, and the movement of the wound edges during mastication and speaking, influence the selection of suture material in dentistry from general medicine. In the current study, sutures coated with Alginate and copper oxide nanoparticles were characterized and their antimicrobial and antioxidant properties were evaluated. There were no previous study showing the same activities of coating of nanoparticles. SEM analysis of uncoated silk suture material which are fine and uniformly braided fibers with a smooth surface as seen in figure 1. The accuracy of coating of the silk suture with nanoparticles and alginate was confirmed with SEM analysis as shown in figure 2. The coating is present throughout the entire length of the silk suture. Also, the nanoparticles are interlocked between the filaments of the silk which aids in better antimicrobial properties.

The antimicrobial activity of coated silk suture was enhanced by the harmonious effect of alginate acid and CuO nanoparticles in comparison with uncoated silk suture. The standard measurement of a zone of inhibition of more than 1mm, the material is said to have good antimicrobial properties. The zone of inhibition of coated suture against S.mutans is 2-3mm and E.coli is 2-3mm as seen in figure 3 and 4. which reveals the coating of suture has a good antibacterial effect against S.mutans and E.coli which are the major cause for dental infection. On the contrary, a study by Varma et al., shows the antibacterial activity of suture coated with Hyaluronic acid was comparatively less than uncoated suture materials. But hyaluronic acid promoted the process of wound healing and reduced the inflammation at the site. There are no such studies showing a combination of alginate and copper oxide nanoparticles. In the current study, the coated silk suture with alginate and copper oxide nanoparticles exhibits extremely good antioxidant activity of 76% when compared with standard Ascorbic acid which exhibits 88% activity. This proves that alginate and copper oxide coated nanoparticles show very good antioxidant properties when compared to standard i.e., ascorbic acid. A study by Akshayaa et al showed that Carrageenan and fucoidan based silica nanoparticles developed membrane has shown to have good tensile strength and proven to have better antimicrobial, antioxidant activity
with water absorption capacity which can be used for

guided bone regeneration around the implant sites.(17)

The suture which is used in the surgical procedure is usually removed after 7-10 days depending on the site of the wound. During this period the suture is subjected to a high bacterial load, so sutures can be coated with some materials which have antimicrobial activity. In the current study, silk is coated with alginate and copper oxide nanoparticles which have sufficient antimicrobial activity against E.faecalis and S.mutans a major cause of dental infection.The limitations of the current study includes the mechanical properties like tensile strength was not assessed, future studies will be done for the same. Future studies will aim to assess the wound healing in animal models.

The process of healing after damaged, harmed, or inflamed skin and other tissues is known as wound healing. Consequently, suture is crucial for faster wound healing and improved angiogenesis. (18). Thus, by promoting angiogenesis better wound healing can be achieved. In recent advancements wound healing with tissue adhesives is also said to be better to that of sutures in periodontal flap surgery.(19) Faropenem-coated sutures have proven to be superior in wound healing with effective antimicrobial activity(20), The role of Faropenem-coated sutures demonstrated robust tensile strength, sustained drug release, and significant antimicrobial efficacy against *S. mutans*. (21)

CONCLUSION

Thus , the above study provides evidence that coating the suture with alginate and copper oxide nanoparticles can be a new innovative suture material of choice in oral and periodontal aesthetics surgeries where alginate aids in wound healing and reduces inflammation as it is a biocompatible and copper oxide nanoparticles reduce microbial colonization. This can be suggested as novel material of choice in clinical usage in dentistry. These coated sutures can be efficiently used since they possess antimicrobial and antioxidant properties.

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