Characteristics of Silk Sutures Treated With Natural Coating Agents

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Abstract. In this study, chitosan, curcumin, and aloe vera gel powder were applied to braided silk sutures in both pure and combined forms, and their effects on braided silk suture features were investigated. The braided silk suture coated with a combination of chitosan, curcumin, and aloe vera gel powder outperformed conventional coated sutures in terms of tensile and knot performance. The braided silk sutures coated with a combination of chitosan, curcumin, and aloe vera gel powder (zone of inhibition 5 mm against E.coli and 8 mm against S.aureus) had greater antibacterial properties than those coated with pure forms (zone of inhibition 5 mm against E.coli and 8 mm against S.aureus). The aloe vera gel powder and chitosan-coated braided silk suture possesses a 7mm zone of inhibition against E.coli and S.aureus. The friction coefficient of the same is lower than that of different coated sutures. Sutures coated with aloe vera gel powder and combination had lower bending rigidity, but sutures coated with chitosan had higher bending rigidity.

Keywords: Silk suture, Coating, Tenacity, Knot strength, Braided structure.

1 Introduction

One of the most commonly used medical textiles is sutures. These are used to aid in the healing and closure of surgical or trauma-related wounds by binding tissues together during the healing process [1]. Suture materials for medical purposes come in a variety of kinds, including non-absorbable and absorbable. There has been an increase in the development of suture materials based on their qualities and abilities to promote tissue approximation and wound closure in recent years [2,3]. Commercially available silk sutures have a silicone or wax coating that does not have antimicrobial properties. Triclosan is used to cover antimicrobial silk sutures already on the market (Polyethylene glycol, poly glycolic acid). Triclosan is both hazardous to humans and harmful to the environment [1, 2]. Antimicrobial sutures with chitosan coating have been developed, but they have a higher bulk density. This study was carried out in order to solve the difficulties associated with the removal of commercially available sutures due to peel off property, antimicrobial property, weak strength, and bulk density [4,5].

Chitosan has an excellent peeling ability, as well as antimicrobial and tissue formation abilities [5, 6]. Other natural coating agents with antibacterial properties include neem, aloevera, curcumin, prickly chaff leaves, and others. As a result, chitosan, aloe vera, and curcumin were chosen for the study. In this study, chitosan, curcumin, and aloe vera gel

ICCAP 2021, December 07-08, Chennai, India

DOI 10.4108/eai.7-12-2021.2314634

powder were applied to braided silk sutures in both pure and combined forms, and their effects on braided silk suture features were investigated. Using the agar diffusion method, the antibacterial activity of natural coating agents against different types of bacteria including Staphylococcus aureus and Escherichia coli was assessed.

2 Materials And Methods

The work began with Bombyx mori silk filaments as the beginning material. Otto chemicals in India provides chitosan polymer. GCT Herbals, Coimbatore, provided aloe vera gel powder and curcumin extract. All other compounds were analytical grade and were used exactly as they were given to us.

2.1 Silk filaments degumming

To eliminate sericin, silk braided structures were dipped in an aqueous solution of 0.1 percent sodium carbonate for 30 minutes at 98–100°C. This is due to the fact that sericin, once implanted in the human body, might induce an unfavourable immunological response. To remove Na_2CO_3, degummed silk filaments were rinsed with enormous amounts of water

2.2 Braiding and coating of silk

Braided silk suture constructions were made by a circular braiding machine, which is commonly used to make braided structures. By exhaustion method with a liquor ratio of 1:20, curcumin ethanolic extract, aloe vera gel powder solution, and chitosan solution were applied onto silk braids. The chitosan-coated sutures and chitosan-combination sutures were rinsed in a 0.1M NaOH solution. The acetic acid was then removed by washing them with deionized water. The coated silk sutures were then cured in the curing room for 10 minutes at 100°C.

2.3 Measurement of mechanical properties

The tensile properties of silk braided sutures are measured using an Instron tensile tester. Knots can be created using the square knot method as explained in the knot strength measurement. The suture's bending rigidity is a critical feature that defines the suture's overall quality. Morton and Hearle created a loop test method that can be used to measure it. The frictional qualities of textile materials were typically assessed over a range of normal and sliding speeds. The friction tester was used to conduct the current study's frictional measurements.

2.4 Agar diffusion method for antimicrobial activity evaluation

The SN 195920- 1992 agar diffusion test is a qualitative and straightforward procedure. This test method is the best alternative when huge samples need to be analyzed for antimicrobial activity. The antibacterial properties of untreated and natural coating agents (chitosan, aloe vera gel powder, and curcumin treated silk sutures were assessed. The test specimen was evaluated based on the lack or existence of an influence on bacteria in contact region underneath it, as well as the potential construction of a zone of inhibition around it.

3 Results And Discussion

3.1 Tenacity and knot pull strength measurement

Tensile characteristics of sutures are important such that these properties determine the quality of the sutures. If the sutures have poor tensile properties then, these materials cannot withstand the force applied to knot which will then result in breakages while knotting or suturing. Figure 1 and Figure 2 shows the tensile and knot pull properties of braided suture materials respectively.

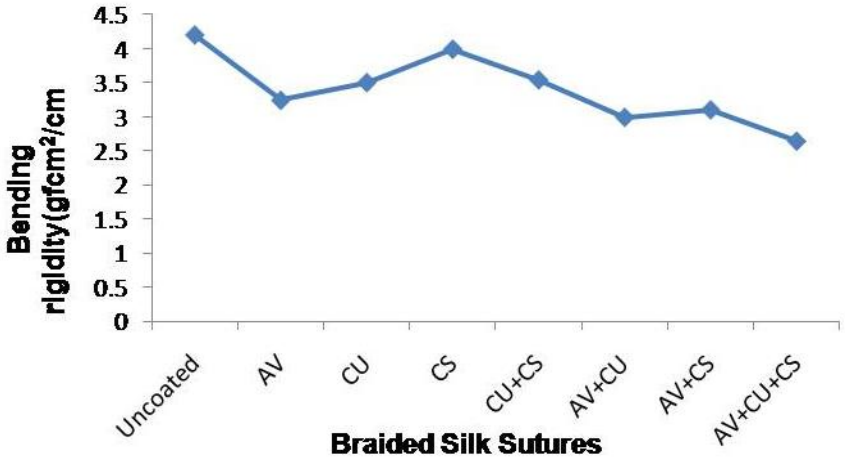

Fig. 1 Tenacity of braided silk sutures

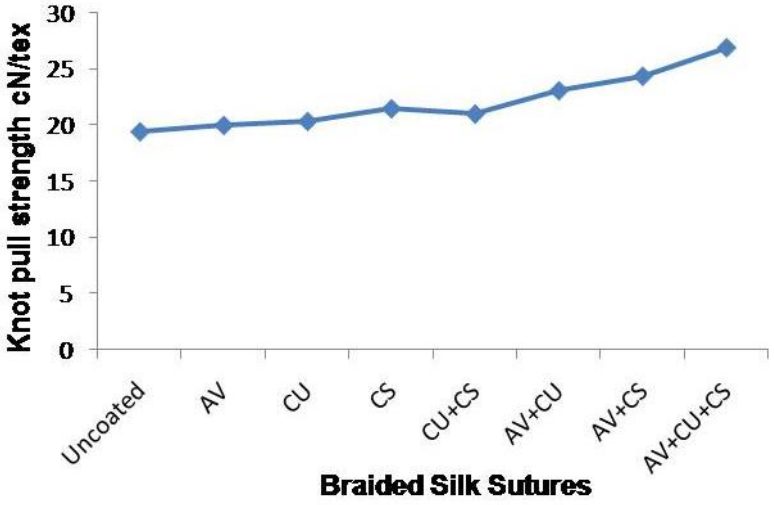

Fig.2 Knot pull strength of braided silk sutures

3.2 Bending rigidity

The flexibility of the suture is determined by the bending rigidity of the suture. If the bending rigidity is lower, the flexibility of the sutures can be more. Figure 3 shows the bending rigidity of the various developed sutures.

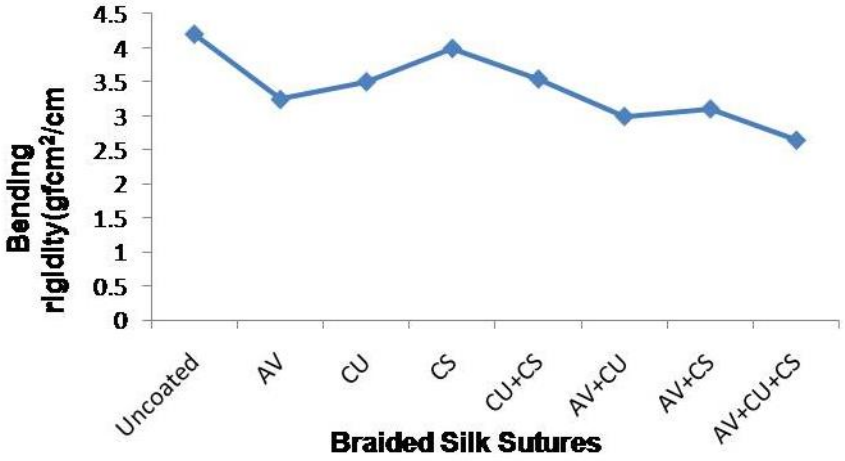

Fig.3 Bending rigidity of braided silk sutures

3.3 Co-efficient of friction

The tissue drag and the suture slide between surgeon's hands are determined by the co-efficient of friction values. The co-efficient of friction is lower for the silk sutures coated with blends of natural coating agents than their pure forms. The result is shown in figure 4

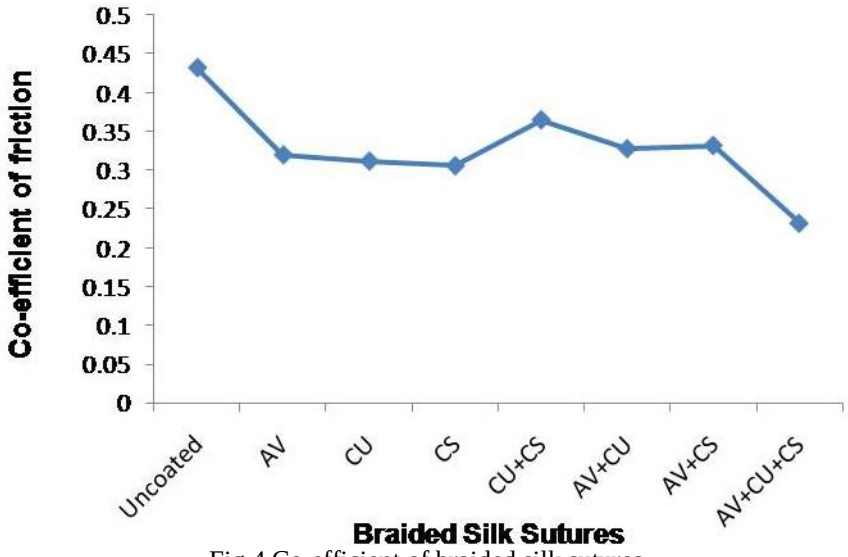

Fig.4 Co-efficient of braided silk sutures

3.4 Antibacterial activity

Antibacterial screening was carried out with *Escherichia coli* and *Staphylococcus aureus*. 6.08 g Muller hinton agar (160ml) was dissolved in distilled water and heated to a boil. After autoclaving at 121°C, the agar was permitted to chill to ambient temperature. The medium was placed into petri dishes when it had cooled to roughly 450°C. Each petri dish was placed on a flat surface for 30–40 minutes to fully set. Spread plate method was used to seed the test microorganisms (E.coli and S. aureus) into their respective media. A sterile cotton swab was used to spread 60 l onto 20 ml of sterile agar plates. For around 3 minutes, the medium's surface was allowed to dry. The sutures were then placed on the agar plate, both bare and coated. The diameter of zone of inhibition generated around each disc was measured in mm and documented after incubation (Table 1).

Table 1 Antibacterial action of braided silk

[1]	**Sample**	**[2] Zone of inhibition (mm)**	
		[3] E. coli	***[4] S .aureus***
[5]	Control	[6] NIL	[7] NIL
[8]	Aloe vera gel powder 5 g/l	[9] 6	[10] 4
[11]	Curcumin 5 g/l	[12] 2	[13] 3
[14]	Chitosan 3 g/l	[15] 5	[16] 4
[17]	Curcumin 5 g/l + Chitosan 3 g/l	[18] 3	[19] 5
[20]	Aloe vera gel powder 5 g/l + Curcumin 5 g/l	[21] 4	[22] 7
[23]	Aloe vera gel powder 5 g/l + Chitosan 3 g/l	[24] 7	[25] 7
[26]	Aloe vera gel powder 5 g/l + Curcumin 5 g/l + Chitosan 3 g/l	[27] 5	[28] 8

3.5 SEM Analysis

The below images Fig. 5 and 6 indicate the SEM images of uncoated and coated silk braids respectively. The Figure 5 clearly shows the braid of the silk suture with rough surface of the filament that has been used to braid the silk suture. The Figure 6 clearly shows the change in braid of the silk suture. Also, the adherence of natural bioactive agents on the surface the silk filament can be clearly seen.

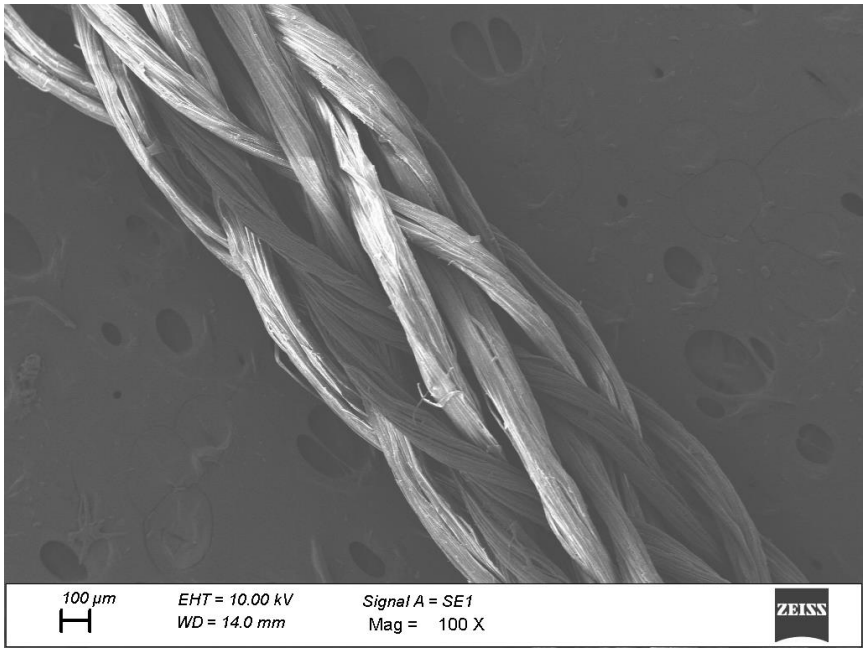

Fig. 5. SEM image of uncoated silk suture

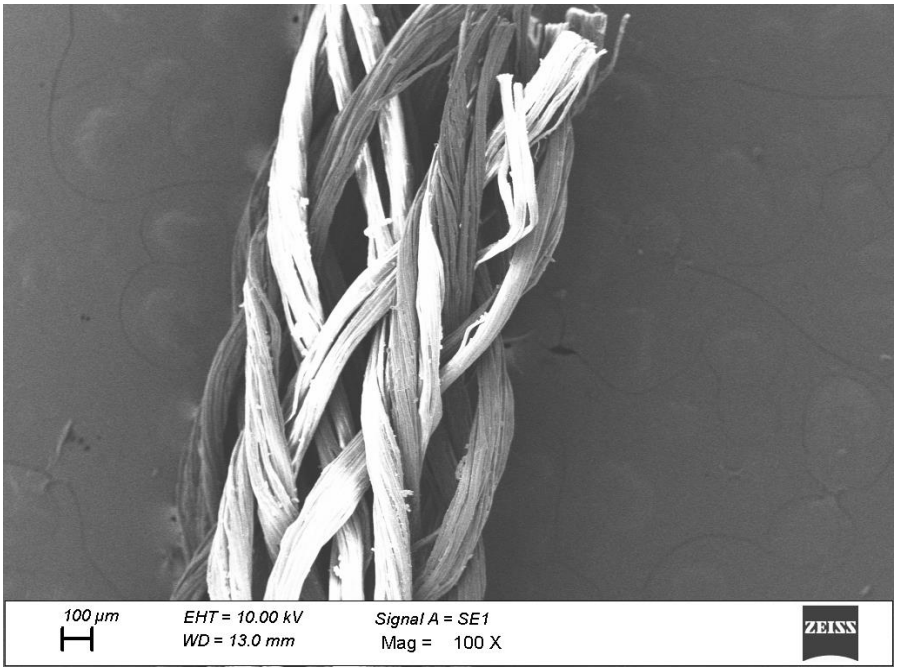

Fig. 6. SEM image of coated silk suture

4 Conclusion

The sutures coated with a combination of chitosan, curcumin, and aloe vera gel powder showed superior tensile and knot strength than other coated sutures, according to the findings. Silk sutures coated with a combination of chitosan, curcumin, and aloe vera gel powder (zone of inhibition 5 mm with E.coli and 8 mm with S.aureus) had greater antibacterial properties than braided silk sutures coated with pure forms (zone of inhibition 5 mm against E.coli and 8 mm against S.aureus). The aloe vera gel powder and chitosan-coated braided silk suture possesses a 7mm zone of inhibition against E.coli and S.aureus. Sutures coated with aloe vera and its combination exhibited lower bending rigidity than sutures coated with chitosan and curcumin, according to the findings. The presence of aloe vera, curcumin, and chitosan is confirmed by a superficial examination using Scanning Electron Microscopy.

References

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