

# Study on Non-knotted Barbed Suture with Silk Fibroin Structure<sup>\*</sup>

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## Abstract

Surgical sutures allow for wound closure and tissue closure. Ordinary sutures require complicated knotting and manipulation. A kind of barbed silk thread was developed in this paper. The structure of barbed suture was tested and analyzed by infrared absorption spectroscopy and X-ray diffraction. The results showed that ethanol immersion and high pressure treatment changed the crystal structure of silk fibroin barb and increased the crystallinity of silk fibroin protein. The solubility and mechanical properties of silk fiber barbs showed that the solubility rate of silk fiber barbs was low, but the mechanical properties were strong. It was found that the barbs of silk fibroin were closely bound to the silk thread and formed a regular barb structure on the silk thread. In this paper, different barb Angle sutures of 30°, 45° and 60° were prepared. And the mechanical properties test results showed that the 45° barb sutures have a better stitching effect. This barbed sutures are expected to be used for tissue suturing.

*Keywords:* Silk Fibroin; Barbed Suture; Silk Suture; Medical Textiles

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## 1 Introduction

Surgical suture is a kind of widely used medical textile, which has the function of suture wound and tissue. The surface of common surgical sutures is mostly smooth, and the suture and fixation of biological tissue wounds can only be completed by tying after surgical sutures. Complex knotting requires a lot of time, and surgical sutures need ligation clips and other auxiliary fixation, so the operation is complicated and even wasting valuable surgical time [1].

With the development of medical technology and material science, surgical sutures with barbed structures have been developed rapidly. Warner, JP et al. [2] performed abdominal surgery using the barbed suture technique, and the results showed that the use of barbed suture is a safe

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and effective method, which can significantly shorten the operation time and retain the effect of ordinary suture. Barbed sutures make suturing faster, easier and knot-free. Barbed sutures in uniform stress distribution within the organization can effectively relieve the pain of the wound. Compared with traditional surgical sutures, barbed sutures have a good postoperative wound healing effect and reduce postoperative complications [3]. Barbed sutures are safe and effective, with wound strength and tissue response scores comparable to knotted sutures [4].

Silk suture is a natural protein material with good biocompatibility and no adverse effects on the human body [5]. A large number of clinical experiments have shown that silk sutures completely degummed and implanted into human tissues will not cause any inflammatory reaction or biological rejection [6]. Viju et al. [7] combined tetracycline with silk thread suture to prepare silk thread suture with antibacterial properties while retaining its original mechanical properties. Silk protein is a kind of excellent performance of natural protein, can promote wound healing and accelerate wound healing. Silk thread sutures have excellent mechanical properties and do not require chemical treatment to avoid the residue of harmful chemicals.

Silk fibroin is a kind of natural protein material with good biocompatibility. Silk fibroin is composed of heavy chain and light chain. It is a structural protein, which can give silk strong mechanical strength, good flexibility and elasticity. There are two kinds of silk fibroin crystal structure: Silk I crystal structure and crystalline structure of the Silk II [8, 9]. The conformation of  $\beta$ -folded molecules in silk fibroin is relatively stable [10]. Many research chose a variety of silk fibroin by random method will crimp structure into  $\beta$ -folding structure, in order to improve the crystallinity of silk fibroin material, as to improve the performance of materials. However, regenerated silk fibroin protein materials have problems of low mechanical properties and high water solubility in wet state [11].

Table 1: Experimental materials and reagents

Type	Specification	Manufacturer
Silk sutures	0.265 mm	Wuxi ideal silk thread Co. Ltd
Silicon substrate	120×120 mm	Meidi Family Co. Ltd
Bombyx cocoon	Fresh cocoon	Suzhou Xian Can Silk Biotechnology Co. Ltd
Lithium bromide	Analytically pure	Tiancheng Chemical Co. Ltd
Sodium bicarbonate	Analytically pure	Suzhou Keqing Biological Reagent Co., Ltd
Sodium carbonate	Analytically pure	Suzhou Keqing Biological Reagent Co., Ltd
Anhydrous ethanol	Analytically pure	Suzhou Keqing Biological Reagent Co., Ltd
Deionized water	Conductivity < 10 $\mu$ S	Self-made
Dialysis bag	Molecular cut-off 14 kDa	Jiangsu Bomeida Life Science Co., Ltd
New Zealand Rabbits	Conventional-CV animal	Laboratory Animal Center, Soochow University

Silk barbed sutures were prepared by pouring silk fibroin solution onto the surface of silk suture. It is hoped that they can maintain good biocompatibility of silk and have excellent mechanical properties. In order to achieve this goal, the following difficulties need to be solved: 1. reducing the water solubility of silk fibroin protein and preventing the silk suture from dissolving due to water absorption in wet environment; 2. Improve the mechanical properties of the wet silk barbs, solve the fibroin barbs after moisture absorption of the decline of the mechanical properties; 3.