Biomedical Data Science
2025, VOL. 5, NO. 2, 150-153
DOI: 10.47297/wspbdsWSP2752-630527.20250502

Research on innovative development and application of absorbable medical sutures of mulberry bark

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ABSTRACT
This paper aims to comprehensively review the innovative research and development process, technical breakthrough and application research results of mulberry bark absorbable medical sutures. Through in-depth analysis of its material properties, preparation technology, biocompatibility, mechanical properties and clinical application effects, the advantages and challenges of the new suture were discussed, and its future development prospects were prospected to provide reference for relevant researchers and medical practitioners.

KEYWORDS
Mulberry bark; Absorbable; Medical sutures; Innovative research and development; Applied research

In the field of modern medicine, medical sutures are indispensable key instruments in surgery, and their performance has a direct and vital impact on the quality of wound healing and the process of patient rehabilitation. Traditional sutures have exposed many drawbacks in medical practice, the most significant problem is the need for secondary suture removal after surgery, which not only brings additional pain to patients, but also increases the risk of infection, prolonging the recovery cycle of patients, and causing a certain burden on patients physically and mentally as well as economically. With the rapid development of biomedical technology and material science, absorbable medical sutures have come into being, bringing great innovation to surgery. This new type of suture can automatically degrade after surgery, without the need for removal operation, significantly reducing the chance of infection caused by removal, accelerating the recovery process of patients, greatly improving the quality of life of patients, and becoming a hot field of contemporary medical materials research. In recent years, the research and development of absorbable sutures based on natural materials has been fruitful, and a variety of new materials have been introduced into the production of sutures, among which the absorbable medical sutures of mulberry bark have emerged with its unique advantages and attracted much attention. Mulberry bark, as a common material in traditional Chinese medicine, has good biocompatibility and natural antibacterial, anti-inflammatory and other properties. The absorbable sutures developed from it not only inherit the advantages of traditional absorbable sutures, but also show unique advantages in promoting wound healing and reducing tissue reaction, opening up a new development direction for the field of medical sutures. It is expected to play an important role in future clinical applications.

1 Characteristics and medical potential of mulberry bark

1.1 Plant source and composition analysis

Mulberry white bark, or mulberry root bark, is the dried root bark of mulberry family, which is widely used in traditional Chinese medicine. Mulberry bark mainly contains flavonoids (such as rutin, quercetin), polysaccharides, triterpenoids and other active components, which together give mulberry bark unique pharmacological properties. Studies have shown that flavonoids in mulberry bark have significant antioxidant, anti-inflammatory and capillary protective effects, which can enhance vascular toughness and reduce vascular permeability, and have potential value for preventing and improving cardiovascular diseases. Polysaccharide has the function of immune regulation and enhancing body resistance, can activate immune cells and promote the release of immune factors. Triterpenoids have anti-inflammatory, antiviral and hepatoprotective pharmacological effects, which can inhibit the production of inflammatory mediators and reduce inflammatory response. At the same time, triterpenoids can inhibit some viruses and help protect the liver and other important organs from damage. These rich chemical components and diverse pharmacological effects make mulberry bark have great development potential in the field of medicine, which is worthy of further research and exploration [1].

1.2 Pharmacological Effects

In terms of anti-inflammatory, mulberry bark can effectively inhibit the release of inflammatory mediators such as interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α). These inflammatory mediators play a key role in the postoperative

inflammatory response, and their excessive release can lead to redness, swelling, heat and pain at the inflammatory site and tissue damage. The active ingredients in mulberry bark inhibit the activation and aggregation of inflammatory cells by regulating inflammatory signaling pathways, such as NF- κB signaling pathway, thereby reducing postoperative inflammatory response and promoting tissue repair at the site of inflammation.

In terms of analgesia, some components of the bark can act on ion channels and receptors of the nervous system, such as voltage-gated sodium channels and opioid receptors. These ingredients can reduce the transmission of pain signals, thereby relieving postoperative pain and improving patient comfort. This is especially important for patients who need long bed rest or rehabilitation training after surgery, and good analgesia can help patients better cooperate with the treatment and rehabilitation process.

In terms of antioxidants, mulberry bark is rich in antioxidant substances that can effectively remove excessive free radicals in the body. After surgical trauma, the body produces large amounts of free radicals, which attack biomolecules such as cell membranes, proteins and DNA, leading to cell damage and tissue oxidative stress. The antioxidant properties of mulberry bark help to maintain the REDOX balance of the body, reduce the damage of free radicals to tissues, and promote the repair and regeneration of damaged tissues[2-3].

2 Innovative research and development of mulberry bark absorbent medical sutures

2.1 Material selection and composite process

The suture line consists of mulberry white bark fiber as the main material, and the outer layer is composed of sodium alginate and other materials. Mulberry bark fiber provides good biocompatibility and mechanical strength, while sodium alginate enhances its absorbability and lubricity. Through the original fiber weaving technology, the inner and outer layer materials are closely combined to solve the problem of easy release of coating materials [4]. In the process of developing medical sutures, the choice of materials is very important. As a kind of natural plant fiber, mulberry white bark fiber has many unique advantages. It is widely available, relatively low cost, and has good biocompatibility, and can be compatible with human tissues without causing significant immune responses or allergic reactions. In addition, the mulberry bark fiber also has a certain mechanical strength, which can meet the basic requirements of the wire in the stitching process, such as withstand a certain tension and not easily break.

Sodium alginate is a natural polysaccharide extracted from Marine algae, which has good biodegradability and biocompatibility[5]. When it is applied to sutures as an outer composite material, it can significantly enhance the absorbability of sutures, so that it can be gradually absorbed and metabolized by the human body after the completion of the wound suture task, without the need for secondary suture removal, reducing the pain and infection risk of patients. At the same time, sodium alginate also has a certain lubricity, which makes the suture more smooth when passing through the tissue, reducing the damage to the tissue. In order to fully combine the advantages of the two materials, mulberry white bark fiber and sodium alginate, the research and development team used an original fiber weaving technology. This technique enables the inner and outer layers of materials to be tightly combined to form a whole. During the weaving process, the density and strength of the weaving are precisely controlled to ensure the uniformity and stability of the suture[6]. At the same time, this weaving technology can also effectively solve the problem that the coating material is easy to release. In the traditional coating process, drugs or other active ingredients may be released in large quantities in a short period of time due to the uneven or unstable coating, resulting in excessive drug concentration and adverse reactions [7-8]. Through the fiber weaving technology, the drug can be evenly distributed between the fibers to achieve slow and continuous release, so as to better play the efficacy and promote wound healing.

2.2 Performance optimization and customized design

In the medical field, the R&D team has made significant progress in optimizing the performance and customizing the design of sutures for different stages of wound healing. As a key material for wound closure, the precise regulation of the absorption time of sutures is crucial for the realization of personalized medical solutions [9]. For skin surface wounds that heal quickly, shortening the absorption cycle of sutures can reduce the residence time of foreign bodies in the body, reduce the risk of infection, and avoid patients' discomfort and anxiety caused by suture removal [10]. For example, some new absorbable suture materials, such as polyglactin 910 (fast Vicjo thread), begin to "fall off" within 7-10 days and are suitable for sites that need to remain sutured for a week or more.

For deep tissue wounds or special wounds that heal slowly, extending the absorption time of sutures can ensure adequate support and protection during the healing process. Some sutures, such as polycapron 25 (single Cho thread), maintain significant tensile strength for 3-4 weeks and are fully absorbed by 60-90 days. The customized design of such sutures not only meets the needs of different wound healing stages, but also provides clinicians with more choices, which helps to improve the treatment effect and patient satisfaction [11-12].

3 Application research on absorbable medical sutures of mulberry bark

3.1 Promote wound healing

In animal experiments, the absorbable medical sutures of mulberry bark showed excellent effect in promoting wound healing. Healthy animals of similar age and weight were randomly divided into two groups: one group was sutured using mulberry bark absorbable medical sutures, and the other group was sutured using traditional sutures. The results showed that the wound healing speed of the experimental group of animals using mulberry bark suture was significantly accelerated, and the healing time was shortened by about 20%-30% compared with the control group. During the postoperative observation period, inflammation such as wound swelling and exudation in the experimental group was relatively light, epithelial cells at the wound edge were more active in proliferation and migration, granulation tissue grew well, and collagen fibers were arranged in an orderly manner, indicating that the natural components of white bark sutures have good anti-inflammatory effects, can effectively reduce postoperative inflammation and create a good microenvironment for wound healing.

Further research found that a variety of bioactive ingredients in mulberry bark played a key role in this process. The flavonoids contained in it have antioxidant and anti-inflammatory properties, which can inhibit the release of inflammatory factors, reduce the damage of inflammatory reactions to tissues, promote local blood circulation, and provide adequate nutrition and oxygen for wound healing. Polysaccharides have a certain immunomodulatory effect, enhance the body's immunity, help the body better resist infection, accelerate the wound repair process. In addition, some components of mulberry bark also have analgesic effects, which can effectively reduce postoperative pain, make animals more quiet during postoperative recovery, reduce the stress response caused by pain, and contribute to the overall rehabilitation. This natural anti-inflammatory and analgesic effect not only improves the postoperative quality of life of animals, but also reduces the risk of infection and shortenes the rehabilitation cycle of patients, providing a solid foundation for the application of absorbable medical sutures in clinical medicine.

3.2 Reduce scarring

In the process of wound healing, the metabolic balance of extracellular matrix is crucial. Under normal circumstances, the synthesis and degradation of extracellular matrix are in a dynamic balance to ensure the normal structure and function of tissues. However, in some bodies with poor wound healing or prone to scar formation, this balance is disrupted and the extracellular matrix is over-synthesized, resulting in abnormal hyperplasia of scar tissue. Mulberry bark can absorb active components in medical sutures to regulate the metabolic process of extracellular matrix, promote its normal degradation, and reduce excessive extracellular matrix deposition in the wound site.

Fibroblasts are one of the key cell types in wound healing, and their overactivation is an important factor leading to scar hyperplasia. After receiving specific signal stimulation, fibroblasts proliferate and synthesize extracellular matrix. The absorbable medical sutures of mulberry bark can inhibit the over-activation of fibroblasts through specific signaling pathways, and keep them in a relatively static state, thereby reducing the excessive synthesis of extracellular matrix.

4 Challenges and future prospects

Mulberry bark can absorb medical sutures as innovative medical materials, integrating the wisdom of traditional Chinese medicine and modern technology, showing great application potential. Its advantages in promoting wound healing and reducing scar formation are expected to bring innovative changes to surgery. Despite the current challenges, with the continuous progress of technology and the continuous deepening of research, its future development prospects are broad, and it will provide patients with better quality, safe and efficient treatment options. It can be predicted that in the near future, with the continuous breakthrough of related research and the acceleration of industrialization process, mulberry bark absorbable medical sutures will certainly play an important role in the field of clinical medicine and make positive contributions to the cause of human health.

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