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Clinical Aspects Of Surgical Suture Material Selection

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Abstract
Surgical suture material is an integral component of any operative intervention and has a direct impact on the reliability of the formed suture, the course of the wound healing process, and the incidence of postoperative complications [1,3–6]. In modern surgical practice, clinicians are faced with the necessity of selecting from a wide range of suture materials that differ in structure, physicomechanical properties, biocompatibility, and the presence of functional coatings [4,5,18]. The aim of this review is to provide an expanded analysis of the clinically significant properties of various types of surgical suture materials and their role in the development of inflammatory responses, prevention of infectious complications, and optimization of wound healing processes. Based on data from domestic and international literature, the advantages and limitations of mono- and multifilament sutures, absorbable and non-absorbable materials, as well as the potential of antibacterial coatings and physical methods of exposure for improving surgical outcomes are discussed.
Keywords: surgical suture material, clinical selection, surgical site infection, tissue reaction, wound healing.

Introduction

Despite continuous improvement in surgical technologies and the introduction of modern operative techniques, postoperative complications associated with suture failure and surgical site infections remain a relevant problem across all fields of surgery [3,5,14]. A substantial contribution to the development of these complications is attributed to the interaction between suture materials and biological tissues, which determines the nature of local inflammatory responses and the rate of reparative processes [4,18].

At present, the range of available surgical suture materials includes more than 250 types of sutures produced by various manufacturers and differing in chemical composition, filament structure, and surface treatment methods [3–6,16]. On the one hand, this diversity expands the surgeon's choice; on the other hand, it complicates clinical decision-making, particularly in emergency surgery and in patients with a high risk of infection. In this context, a systematic analysis of the clinical aspects of using different types of surgical suture materials is of considerable practical importance.

Materials and Methods

This study was conducted as a narrative review of the literature. The analysis was based on data from domestic and international publications addressing the structural, physicochemical, and biological characteristics of surgical suture materials. The review included findings from experimental and clinical studies, as well as monographs, proceedings of scientific conferences, and analytical reports.

Particular attention was given to studies describing the interaction between suture materials and biological tissues, mechanisms of tissue response, and modern approaches to suture modification aimed at reducing the incidence of postoperative complications and optimizing wound healing.

Results

Structure of Suture Materials and Tissue Response

The structural characteristics of surgical sutures represent one of the key factors determining their interaction with wound tissues [14,18]. Monofilament sutures have a smooth surface, which reduces microbial adhesion and attenuates the intensity of inflammatory reactions. This makes them preferable for surgical procedures performed in potentially contaminated areas, as well as in patients with compromised immune status [3,14].

At the same time, monofilament sutures are characterized by lower flexibility and require more reliable knot fixation, particularly when closing tissues subjected to significant tension [5]. In contrast, multifilament sutures exhibit greater elasticity and tensile strength, facilitating their use in multilayer wound closure and reconstructive surgical procedures [4,18]. However, the presence of interfilament spaces creates conditions for capillary fluid transport and microbial colonization, which may contribute to the development of inflammatory and infectious complications [14,18].

Thus, the clinical choice between mono- and multifilament sutures should be based on an assessment of the surgical field, degree of contamination, and the expected mechanical load on the suture line [5,14].

Absorbable and Non-Absorbable Sutures: Clinical Indications

Absorbable suture materials are widely used for closure of internal organs, mucosal surfaces, and soft tissues where suture removal is difficult or undesirable [3–5]. Their use reduces the risk of chronic foreign-body reactions and promotes a more physiological course of wound healing [14]. At the same time, degradation of absorbable sutures is accompanied by a gradual loss of tensile strength, which requires careful consideration of tissue regeneration timelines and the potential risk of suture failure [14,22].

Non-absorbable sutures retain stable mechanical properties over prolonged periods and are used in situations requiring long-term tissue fixation, such as tendon repair or vascular surgery [4,18]. However, their persistent presence in tissues may sustain chronic inflammation and necessitates subsequent suture removal [14].

An individualized approach to suture material selection, taking into account the anatomical region and regenerative potential of tissues, is an essential condition for preventing postoperative complications [5,18].

Antibacterial Coatings and Prevention of Infectious Complications

Surgical site infections remain among the most frequent causes of unfavorable surgical outcomes and prolonged hospitalization [3,9,11,14]. The presence of suture material in tissues creates a potential substrate for microbial adhesion, which has driven the development of sutures with antibacterial properties.

Among these, triclosan-coated sutures are the most extensively studied and widely used, with their effectiveness demonstrated in cardiac, thoracic, and general surgery [9,12,14,21]. The use of such sutures is particularly justified in surgical interventions performed in patients at high risk of infectious complications.

A promising direction involves sutures modified with silver nanoparticles, which exhibit pronounced antimicrobial activity by affecting microbial cell membranes and DNA [14,17,21,24].

Physical Methods for Reducing Tissue Reaction

An additional approach to optimizing suture–tissue interactions involves the use of physical methods aimed at reducing inflammation and stimulating reparative processes [2,7,8,23]. Low-intensity laser and light-emitting diode (LED) irradiation improve microcirculation, reduce tissue edema, and accelerate wound healing [7,8,23].

The application of these methods appears particularly promising when multifilament sutures are used and in clinical situations associated with an increased risk of postoperative complications [2,23].

Discussion

The analyzed literature data convincingly demonstrate that surgical suture materials should be regarded not only as mechanical tools for tissue approximation but also as active biological factors exerting a substantial influence on the wound healing process. Direct contact between sutures and biological tissues creates a specific microecological environment in which inflammatory, immune, and reparative processes take place. In this context, the structural characteristics of suture materials, their degradation behavior, and the presence of functional surface modifications acquire critical importance for surgical outcomes.

The structure of surgical sutures determines not only their mechanical strength and handling properties but also the degree of tissue response. Monofilament sutures, due to their smooth surface and low capillarity, are less prone to microbial adhesion and excessive inflammatory reactions. At the same time, multifilament sutures provide high mechanical reliability and secure knot formation; however, interfilament spaces may facilitate microbial colonization and biofilm formation, especially in contaminated wounds. Therefore, selection of suture structure should be guided by wound localization, degree of contamination, and anticipated mechanical stress.

Degradation properties of absorbable sutures play an equally important role in shaping tissue responses. A mismatch between the rate of suture degradation and the pace of tissue regeneration may result either in premature loss of suture strength and wound dehiscence or in prolonged persistence of foreign material accompanied by chronic inflammation and fibrotic changes. Consequently, modern approaches to absorbable suture development focus on precise regulation of degradation mechanisms and timelines, thereby enhancing the safety and predictability of clinical outcomes.

Functional surface modifications, particularly antibacterial coatings, represent another key aspect discussed in this review. Sutures coated with triclosan or modified with silver nanoparticles have demonstrated the ability to reduce the risk of infectious complications by suppressing microbial adhesion and disrupting biofilm formation. Nevertheless, the implementation of such technologies requires careful evaluation of their biocompatibility, potential cytotoxicity, and long-term effects on tissue regeneration.

Current trends in the development of surgical suture materials are directed toward the creation of multifunctional systems combining high mechanical reliability with biological activity. These include drug-eluting sutures, bioactive coatings, and materials designed for combined use with physical therapeutic modalities. However, widespread clinical adoption of these innovations is currently limited by the need for additional experimental and clinical studies, the establishment of standardized evaluation criteria, and assessment of long-term outcomes.

Overall, the results of this review highlight the necessity of an individualized and scientifically grounded approach to surgical suture material selection. Consideration of structural, biological, and functional characteristics of sutures in conjunction with clinical conditions allows optimization of wound healing and improvement of surgical effectiveness.

Conclusion

Surgical suture material is not a passive element of operative intervention but an active factor that significantly influences the course of wound healing and the final outcome of surgical treatment [4,5,18]. Its physicomechanical and biological properties determine the intensity of local inflammatory reactions, the risk of microbial contamination, and the rate and quality of tissue regeneration at the surgical site.

Rational selection of suture materials based on filament structure, surface characteristics, and degradation behavior can substantially reduce the incidence of inflammatory and infectious complications. Monofilament sutures, characterized by a smooth surface and low capillarity, are preferable in procedures associated with a high risk of infection, whereas multifilament materials are justified in situations requiring enhanced strength and elasticity of the suture line, particularly when closing tissues subjected to significant mechanical loads [14,18].

The use of modern functional modifications of surgical sutures, including antibacterial coatings and drug-containing components, expands the possibilities for preventing wound-related complications and contributes to a more favorable postoperative course [9,12,14]. Additional application of physical therapeutic methods, such as low-intensity laser and LED irradiation, reduces inflammatory responses and accelerates reparative processes, thereby increasing the effectiveness of comprehensive surgical wound management [23].

Thus, an individualized and scientifically justified approach to the selection of surgical suture materials, taking into account the clinical situation, wound localization, and biological characteristics of tissues, represents an essential condition for optimizing surgical outcomes. Further progress in this field is associated with interdisciplinary collaboration between surgeons, materials scientists, and biomedical engineers, as well as with the introduction of next-generation suture materials combining mechanical reliability with biological activity.

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