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Advancement on Digestive Tract Biomedical Stents, A Review

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Abstract

Biomedical stents for the digestive tract address many of the limitations associated with traditional surgical treatments for gastrointestinal diseases. This paper provides a review of the performance requirements, complications, and limitations of stent materials in the treatment of common digestive tract diseases. The advantages and disadvantages of different materials and processing technologies for digestive tract stents are discussed. Furthermore, considering the diverse requirements for ideal alimentary canal stent materials, the challenges that require further research are outlined in detail, providing strategic references for the development of biomedical stents for the digestive tract.

Keywords: Biomedical Stents; Digestive Tract; Biodegradable; Functionalization

1 Introduction

Esophageal cancer, gastric cancer, bowel cancer, liver cancer, and other cancers, as well as postoperative stenosis, gastrointestinal obstruction, stones, chronic inflammation, and other diseases, can severely impact both the physiological and psychological well-being of patients, greatly reducing their quality of life. Stents have emerged as an effective treatment option for these conditions, and the choice of stent materials significantly influences patients' experience [1]. An ideal digestive stent should possess the following characteristics: (1) good biocompatibility to minimize the risk of rejection; (2) adequate plasticity and flexibility for easy placement at the site of lesion; (3) easy expandability, sufficient support strength, and excellent geometric stability and mechanical durability.

This paper provides an overview of digestive tract stents in the context of digestive tract diseases, treatment methods, and clinical needs, as well as material combinations and new engineering innovations. The performance requirements, complications, and future development trends of stent-assisted therapy are discussed. Additionally, the advantages and disadvantages

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of various materials and processing technologies used in stents are reviewed, aiming to promote improved applications of digestive tract stents in the treatment of digestive tract diseases in the future.

2 Digestive Tract Stents

2.1 Esophageal Stents

Lesions such as esophageal cancer, anastomotic stricture after esophageal surgery, stenosis after chemical corrosive burns, and congenital esophageal stenosis can severely impair esophageal peristaltic function and reduce patient survival rates. Currently, in addition to fully covered esophageal stents, radioactive particle stents and drug-eluting esophageal stents can also be placed to treat dysphagia, addressing both feeding challenges and local tumor treatment. These research-stage stents can be categorized into non-degradable and degradable stents, both of which are pre-fabricated. In addition to conventional stents, tissue engineering is emerging as a new solution to such problems, with the ability to inject material into the affected area to fill various defect shapes and sizes more easily [2].

Nickel-titanium alloy stents [3] are the most commonly used metal stents in clinical practice. They offer good morphological memory function, flexibility, and biocompatibility compared to traditional stainless-steel stents. However, stent placement can also result in complications such as chest pain, bleeding, perforation, stent migration, and restenosis.

Biodegradable materials are a class of polymeric materials that include naturally degradable polymers, microbially synthesized polymers, and synthetic degradable polymers. The degradation principle of biodegradable materials is based on the presence of groups that are unstable to water, such as ester bonds, which can be broken by water molecules in a physiological environment. Natural degradable polymers, such as chitin and chitosan, have better biocompatibility but poor mechanical properties, solubility in water or weak acids and bases, and faster degradation after cross-linking. Currently, synthetic degradable polymers, such as poly(lactic acid) (PLA), poly(propylene glycol) (PGA), polycaprolactone (PCL), poly(p-dioxanone) (PPDO), and poly(levulinic acid) (PLLA), are commonly used, as they offer more flexibility in designing molecular structures to achieve desired material properties through copolymers and blends. The morphology of the biodegradable stent also plays an important role in its therapeutic effect.

3D printing and decellularized tissue engineering are emerging solutions for esophageal conditions, and animal experiments have shown that these new technologies offer improved biocompatibility and therapeutic effects, addressing common challenges faced in the past. The exploration of these new technological fields has become a major direction and focus for researchers in recent years. Decellularized tissue scaffolds are used to reduce the immunogenicity of organs or tissues by removing cellular components while preserving the mechanical and bioactive properties of the organ [4]. One study utilized aminolytic glutaraldehyde cross-linking to graft filamentous proteins onto the scaffold surface, enhancing the hydrophilicity and biocompatibility of the substrate [5].

2.2 Gastric Stents

Gastric cancer is the fifth most common malignancy worldwide, with approximately 1 million