



(REVIEW ARTICLE)



Medical devices based on natural substances: Applications and perspectives

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Abstract

The growing interest in natural and biocompatible solutions has led to the development of medical devices based on natural bioactive substances offering safe and effective alternatives to synthetic products. This review examines the current state of research and technological advances in the field of medical devices based on plants and natural bioactive substances, focusing on their applications in wound healing and transdermal drug delivery.

Wound-healing devices using plant extracts such as *Centella asiatica* and *Curcuma longa* are showing promising results in accelerating the repair of damaged tissue. In addition, transdermal delivery systems based on natural compounds enable controlled and targeted administration of active ingredients, increasing therapeutic efficacy while reducing side effects.

The advantages of these devices include enhanced biocompatibility and biodegradability, as well as improved therapeutic efficacy. However, challenges remain, not least the regulatory aspect, especially with regard to the variability of natural compounds and the difficulties of standardisation. Ongoing research and rigorous clinical trials are needed to overcome these obstacles and maximise the clinical benefits of medical devices based on natural bioactive substances.

Keywords: Medical devices; Natural bioactive substances; Biocompatibility; Biodegradability; Therapeutic efficacy

1. Introduction

Medical devices have always been at the heart of technological innovation in healthcare [1]. However, a growing interest in more natural and biocompatible solutions has led to the development of medical devices based on natural substances [2]. These devices exploit the intrinsic properties of biological materials to offer safe and effective alternatives to synthetic products [3]. Medical devices based on natural bioactive substances and plants are a promising avenue for modern healthcare, particularly in wound healing and transdermal drug delivery [4]. This review explores the current state of research and technological advances in this field [5].

2. Fields of application for medical devices based on natural substances

2.1. Dressings and Bandages

- Honey-based dressings: Honey has antibacterial and healing properties. Honey-based dressings are used to treat chronic wounds, burns and ulcers [6].

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- Calcium alginate dressings are widely used to treat chronic wounds. They promote a moist environment conducive to healing and have haemostatic properties [7].
- Arnica compresses: Arnica is a plant renowned for its anti-inflammatory and analgesic properties. Compresses impregnated with arnica are used to relieve muscle and joint pain [8].

2.2. Implants and prostheses: several examples of this use

- Dentures made from natural resin: Some dentures are made from natural resins derived from plants, offering a more environmentally-friendly alternative to synthetic materials [9].
- Collagen orthopaedic implants are used for their ability to support bone regeneration and to be gradually absorbed by the body, reducing the need for removal surgery [10].

2.3. Nicotine patches

Used in smoking cessation, these patches contain nicotine extracted from the tobacco plant (*Nicotiana tabacum*) [11].

2.4. Healing devices based on natural extracts

Herbal wound healing devices use a variety of mechanisms to accelerate the repair of damaged tissue. For example, plants such as *Centella asiatica* and *Curcuma longa* are renowned for their wound-healing properties [12]. *Centella asiatica* extracts promote epithelialisation and collagen synthesis, while Curcumin from *Curcuma longa* is used to treat inflammation and wound infections [13].

Devices incorporating plant extracts such as tea tree oil or neem extract offer natural antibacterial properties, reducing the risk of nosocomial infections [14].

2.5. Inhalation devices based on essential oils

Some inhalation devices use essential oils extracted from plants to treat respiratory symptoms such as nasal congestion or cough [15].

2.6. Ozone sterilisers for medical devices

Ozone, produced from oxygen, is used as a sterilising agent in certain medical devices for its antimicrobial effectiveness [16].

3. Benefits and innovations

The use of natural bioactive substances offers a number of advantages and innovations:

- Biocompatibility and biodegradability: Natural materials are generally non-toxic and degrade easily, reducing the risk of adverse reactions [17].
- Improved efficacy: Plant-based devices can offer faster healing and better tissue regeneration [18].
- Advanced Technologies: Recent innovations include advanced isolation and purification techniques, as well as the development of new drug delivery devices that optimise the release of active compounds [19].

4. Regulatory aspects

Medical devices based on natural substances face a number of challenges. The natural variability of raw materials can affect the consistency and efficacy of devices [20]. In addition, production processes must be rigorously controlled to ensure the purity and safety of the end products [21].

In terms of regulation, these devices are subject to strict standards to ensure their safety and efficacy. Regulatory bodies, such as the FDA in the US and the EMA in Europe, require rigorous clinical trials and full documentation before approval [22].

The main directives and regulations in force include :

- Council Directive 93/42/EEC of 14 June 1993 concerning medical devices [23].

- Directive 2004/27/EC of the European Parliament and of the Council of 31 March 2004 amending Directive 2001/83/EC on the Community code relating to medicinal products for human use [24].
- Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 concerning medical devices, which amends Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 [25].
- European Commission DG Enterprise and Industry. Directorate F, Unit F3 Cosmetics and Medical Devices. Medical devices. Borderline products, drug-delivery products and medical devices incorporating as an integral part, an ancillary medicinal substance or an ancillary derivative [26].

5. Future prospects

Although promising, these devices still have to overcome a number of challenges, including the variability of natural compounds and difficulties in standardization. Continued research and clinical trials will be essential to establish standardised protocols and maximise the clinical benefits of plant-based medical devices. Medical devices based on natural bioactive substances and plants are increasingly used due to their therapeutic potential and safety of use [27]. Here are a few examples:

5.1. Transdermal drug delivery

Transdermal drug delivery (TDD) systems based on natural compounds are becoming increasingly popular. These systems allow controlled and targeted administration of active ingredients, improving treatment efficacy and reducing side effects. Natural compounds such as gums and mucilage's are commonly used for their biocompatibility and biodegradability, making these systems safer and more effective [28].

5.2. Vascular prostheses made from natural materials

Some vascular prostheses are made from natural materials such as silk or plant-derived collagen, offering biocompatible alternatives to synthetic materials [29]. Stents made from natural polymers such as polylactic acid (PLA) are used in interventional cardiology for their ability to provide temporary support to blood vessels while being gradually degraded and absorbed by the body, offering innovative and often less invasive therapeutic solutions [30].

6. Conclusion

Medical devices based on natural bioactive substances and plants represent a significant advance in healthcare, with huge potential to improve wound healing and transdermal drug delivery. Continued research in this area could lead to safer and more effective treatments for a variety of medical conditions. It is important to note that, although plants often have medicinal properties, herbal medical devices still need to meet regulatory safety and efficacy standards to be marketed and used safely.

Compliance with ethical standards

Disclosure of conflict of interest

The authors and all co-authors declare that they have no conflicts of interest in connection with this document, and the material described is not in the process of being published nor is it intended for publication elsewhere.

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