Nanotechnological Based Efficient Collagen in Wound Dressing

Dr. Nidhi Mishra[1], Ghorpade Bipin Shivaji[2]

[1]Assistant Professor, Department of CS & IT, Kalinga University, Raipur, India.
[2]Research Scholar, Department of CS & IT, Kalinga University, Raipur, India.

The great biocompatibility and biodegradability of natural polymers, such proteins, make them useful as biomaterials. However, because proteins mimic extracellular matrix (ECM), the synthesis of nanoscale materials from them can also be advantageous for biomedical purposes. The creation of nanofibers from fibrous proteins like collagen and silk fibroin for use in wound healing applications is one of the thesis's goals. The addition of plant-based chemicals endows the nanofiber matrix with bioactive properties that expedite the healing of wounds. There aren't many research that examine how these plant components combined with nanofibers affect in vivo animal models. Additionally, the goal of this research is to understand how natural polymers, such collagen molecules, can aid in the healing of wounds.

Keywords: public health, Nano technology, Nano fibres.

1. Introduction

The largest organ system in the human body, the skin is made up of three main layers: (i) the outermost layer, the epidermis, which is composed of non-vascularized epithelium and ranges in thickness from 75 µm to 150 µm; (ii) the dermis, which is an underlying connective tissue with a mixture of fibroblasts and a thickness of 2 mm to 4 mm; and (iii) the subcutis, also known as hypodermis, which is fatty connective tissue that allows the dermal skeletal attachment. Because skin is defensive in nature, it is often subjected to various damage from the external environment. Damage to the skin's natural anatomical structure and function is referred to as a wound. Skin wounds can be as minor as a break in the epithelium or as severe as a wound that extends to the subcutaneous tissue and damages surrounding tissues such as muscles, tendons, and bones. defence against heat dysregulation, fluid imbalance, mechanical stresses, and pathogens [1]. Figure 1 depicts the timeline of events that take place during the wound healing process. The process of wound healing is a multifaceted and intricate physiological process that relies on a multitude of cell types and mediators interacting in a highly organised way. Multiple biological mechanisms are triggered and synchronised to respond immediately after an injury. All organs experience three overlapping but separate phases in the mammalian reaction to injury: inflammation, new tissue formation and

Remodelling [2]. When the skin is injured, dead and devitalised tissue is left behind. This causes bodily fluids to seep from the blood and lymphatic vessels at the wound site, which is then followed by the invasion of germs [10]. Depending on the conditions around the wound, wound contraction can begin four to five days after the injury and last for up to two weeks. Cells control this process. At this stage, myofibroblasts predominate because of their contractile characteristics.

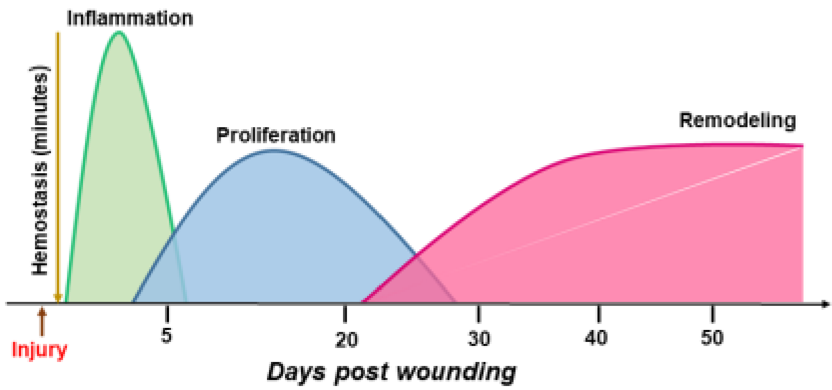

Figure 1 Timeline of events during the wound healing process

Because proteins are very biocompatible and biodegradable, they are frequently employed as biomaterials. However, because proteins mimic extracellular matrix (ECM), the synthesis of nanoscale materials from them can also be advantageous for biomedical purposes [5]. The creation of nanofibers from fibrous proteins from collagen for use in wound healing applications is one of the goals of this work [3].

In this instance, section 1 of the article examines the introduction, while section 2 examines the application of nanofibers. The purpose of the nano structured material is explained in Sections 3, and the project is concluded in Section 4.

2. Wound Dressings

By avoiding infection and regaining the skin's natural structure and functions, wound dressings help speed up the healing process. The primary purpose of traditional wound dressings, which include cotton wool, gauze, natural or synthetic bandages, and lint, is to keep the wound dry by enabling wound exudates to evaporate. Recent studies, however, have demonstrated that wound healing can be sped up by maintaining a warm, humid environment [4]. The following are significant characteristics of wound dressings that support improved wound healing:

1. The wound bed's exudates being absorbed

2. Supplying the necessary thermal insulation to protect the wound bed from bacterial and mechanical damage.

3. Enabling the fluid and gas exchange

4. Traumatic during the extraction
5. Non-allergenic and non-toxic

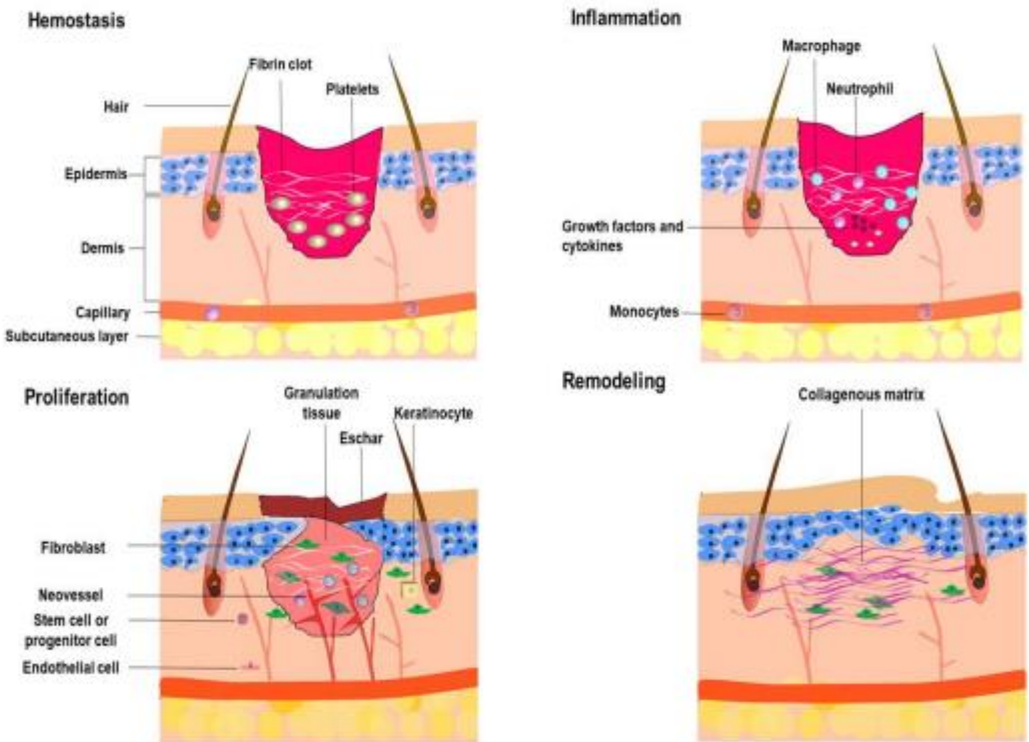

Figure 2 Phases involved in the wound healing process

The length of time it takes for wounds to heal in wound treatment depends on the type of wounds and how well the dressing is applied. Due to their wide range of active ingredients, including phenolic compounds, essential oils, fatty acids, and alkaloids, as well as their easy availability, affordability, and low toxicity, collagen-based compounds may help improve the effectiveness of wound dressings. Promising properties such as antioxidant, anti-inflammatory, antibacterial, and anti-cancerous properties are demonstrated by the active components in plant extracts. These active ingredients have the potential to be therapies that improve the effectiveness of wound healing when used in wound dressings. By combining them into nanostructures or shrinking them to the nano range, their effectiveness can be further enhanced. [11].

3. Significance of Collagen Proteins

Collagen makes up roughly 25% of the overall protein composition and 70–80% of the skin in mammals. It is one of the main ingredients of extracellular matrix and the most prevalent connective tissue protein. Cells such as fibroblasts, osteoblasts, and chondroblasts create it. It is extensively present in blood vessels, tendons, skin, bones, and connective tissues. The most prevalent kinds of collagen are types I–IV, out of the 29 that have been discovered thus far. Collagen subtypes I, II, III, V, and XI have fibrillary quaternary structure, while all other subtypes have triple helical tertiary structure. Collagen is made up of three left-handed polyproline II (PPII) parallel polypeptide chains that are wound around one another to produce a right-handed triple helical shape. Figure 3 illustrates the collagen's structure.

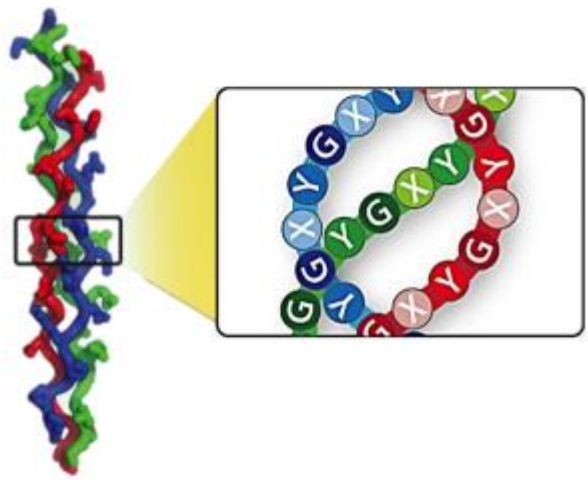

Figure 3 Structure of collagen

3.1 Importance of Collagen as a Biomaterial

Applications for collagen include leather, food, and medicine. In the cosmetic industry, gelatin—a hydrolysed version of collagen—is utilised. Nowadays, collagen-based polymers are widely employed in biomedical applications such as wound healing, medication administration, and tissue engineering. Collagen is the most advantageous biomaterial because it is already involved in the development of tissues and organs. Collagen is readily recovered from living things since it is found in large quantities in nature [6]. It can be made into sheets, films, sponges, fibres, and hydrogels, among other forms. Biodegradability, bioresorbability, and biocompatibility are all rather good. Crosslinking has the power to change collagen's biodegradability. It is non-toxic, increases blood coagulation, and does not cause an antigenic reaction..

Bovine skin, bovine tendon, rat rail tendon, pig skin, swine intestine, or bladder mucosa are popular sources of type I collagen, which is frequently utilised in the creation of biomaterials [7]. The characteristics of the retrieved collagen vary based on the animal and tissue. Because of its strong crosslinking, the natural collagen in the human body is resistant to proteolysis. On the other hand, a class of enzymes known as matrix metalloproteases (MMPases) cleaves it. When compared to other proteins, collagen is a good choice for a biomaterial because it is susceptible to destruction by MMPases in the human body when it is derived from other sources. Additionally, the breakdown products of type I–III collagen cause human fibroblasts to chemotaxise.

3.2 Role of Collagen Based Wound Dressings

Collagen will serve as a dressing that is structurally and functionally similar to skin's natural collagen since it is involved in all three phases of wound healing. When the skin is injured, the blood vessel collagen attaches itself to the circulating platelets, which results in the aggregation [8]. Thus, the exogenous collagen dressing may function as an apparatus for mechanical haemostasis. Collagen-based wound dressings enhance fibroblast chemotaxis and proliferation because collagen contains binding sites for fibroblasts. By drawing fibroblasts, they aid in the directed and ordered deposition of collagen matrix. It supports the preservation of the leukocytes, macrophages, fibroblasts, and epithelial cells as well as the chemical and thermostatic milieu of the wound. They have the ability to compete with MMPases as a substrate, which lessens the pace at which local tissue is broken down by enzymes. Type I collagenase activity is decreased by the breakdown products of collagen.

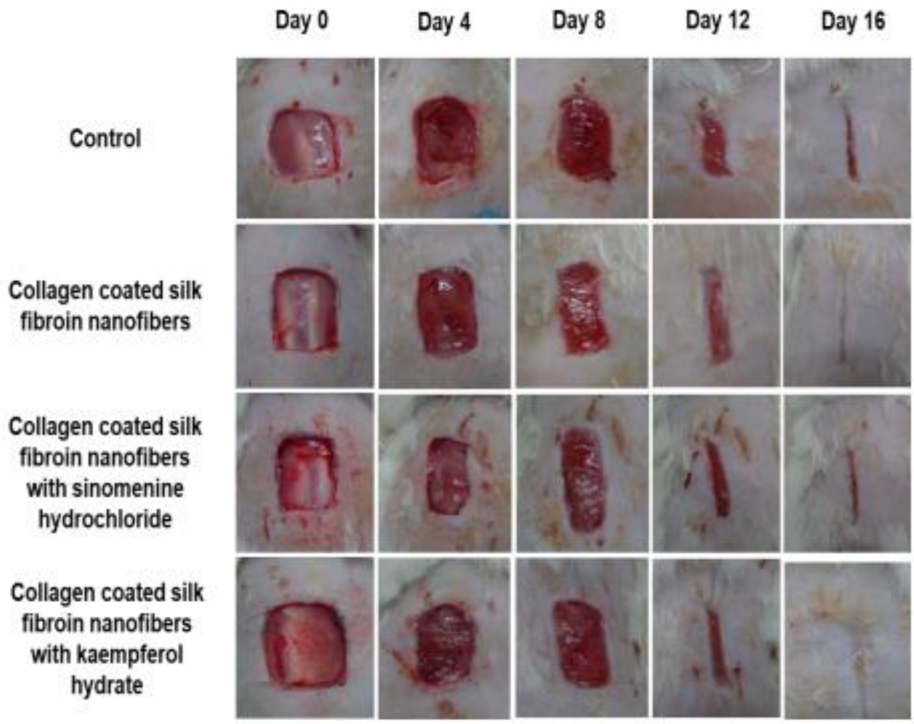

Figure 4 Representative photographs of full thickness wounds treated with gauze and nanofibers

Collagen-coated nanofibers show good biocompatibility and tensile strength. The therapeutic efficiency of the nanofibers has been further evaluated in in vivo wound healing animal model using Wistar rats [9–10]. Wounds have been monitored periodically and the wound margins have been marked. Photographs of the wounds are shown in Figure 4. It is found that the kaempferol hydrate incorporated nanofibers show a faster healing rate when compared to the other three groups. The complete wound closure has been obtained on day 16 for the kaempferol nanofibers treated group whereas the other groups show incomplete healing viz., 81% for control, 95% for collagen-coated silk and 93% for collagen-coated sinomenine nanofibers. The faster wound healing rate is attributed to the antioxidant and anti-inflammatory properties of the kaempferol hydrate.

4. Conclusion

The process of wound healing is intricate and tightly controlled, requiring the application of an appropriate wound care plan that is largely reliant on the type of dressing used. Because of their special qualities, nanostructured wound dressings with antioxidant potential are recommended. Fibrous polymers are used to create biocompatible and biodegradable nanofibers. They facilitate the interactions between the cell and matrix by also imitating the extracellular matrix environment. The high surface to volume ratio of nanofibers makes it easier to load substances with beneficial medical properties. Therefore, by adding plant-based bioactive substances like antioxidants, this work presents on the synthesis of nanofibers from fibrous proteins collagen for wound healing applications.

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