Fabrication of Antimicrobial Silver Nano Particles in Wound Healing

Rajeev Kumar Bhaskar[1], Balasubramaniam Kumaraswamy[2]

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

The development of nanotechnology is crucial to the treatment of bacterially resistant illnesses. Due to their unique antibacterial capabilities and increased surface area, nanoscale metal particles like silver nanoparticles (AgNPs) have become promising therapeutic options. AgNPs' antimicrobial qualities have raised demand in recent years for their use in medical applications, such as artificial implants, wound dressings, and anticancer drugs, particularly those used to treat infectious open wounds. The increased antibacterial action, decreased toxicity, and ease of integration of AgNPs have researchers very interested. AgNPs also have improved bioavailability and a larger surface area, which are desirable qualities. This study suggested using silver nanoparticles to treat wounds.

Keywords: public health, Nano technology, Nano structured material.

1. Introduction

A wound is a disruption of the basic skin tissue's structure and function as well as a break in the epithelial organisation of the skin [1]. A wound can be caused by a cut, surgery, accident, laceration, bites, burns, or abrasion, among other things that upset skin tissue. Figure 1 illustrates the progression of a wound from stage I to stage IV (biodermis).

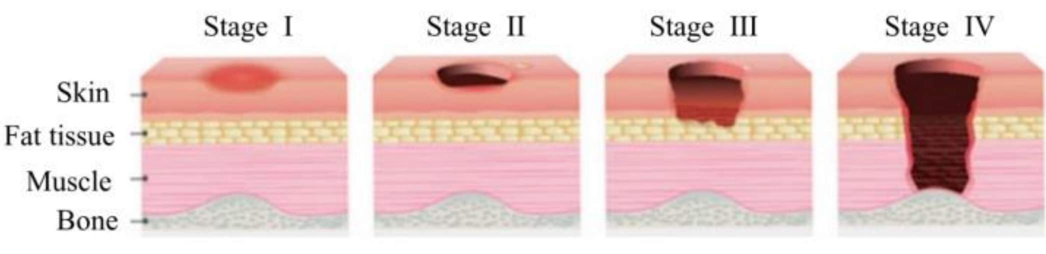

Figure 1: Various stages of wound formation (Biodermis)

Every bodily tissue is the starting point for the ongoing process of wound healing. While many restoration progressions are typical, they are haphazardly categorised as distinct phases to give context for comprehending the biological process of wound healing at the site of the injury. Skin integrity is restored by the complex physiological process of wound healing, which involves the coordinated interactions of multiple cellular components [2]. Acute and chronic wound repair involve different interactions and healing times, even if the basic stages of wound healing are the same. The process of wound healing (biodermis) is depicted in Figure 2.

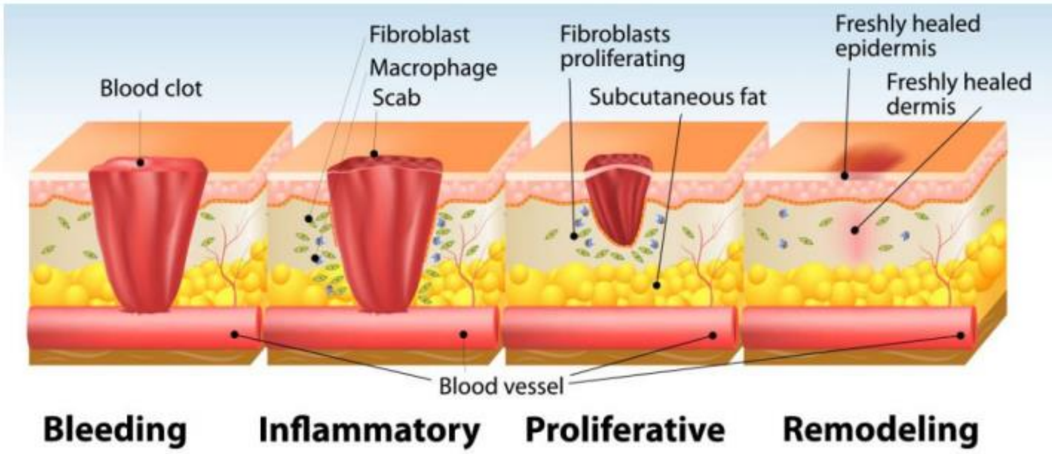

Figure 2: Wound healing process (Biodermis)

The process of wound healing entails carefully planned actions that correspond to the appearance of various cell types at the wound site at various points during the process. Although the essential steps of wound healing are the same for both acute and chronic wounds, there are differences in the timing and interactions among the processes involved. Acute tissue repair involves four sequential phases that are triggered by injury at the tissue site: coagulation and haemostasis, inflammation, proliferation, and remodelling. [3].

In this instance, section 1 of the article examines the introduction, while section 2 examines the relevant literature. The purpose of the nano structured material is explained in Sections 3, and 4, and the project is concluded in Section 5.

2. Literature Review

An easy way to create AgNPs is by chemically reducing silver nitrate in the presence of sodium borohydride, as described in [11]. The developed nanoparticles' particle size was determined to be 47 nm. Transmission Electron Microscopy (TEM) analysis was used to characterise the synthesised AgNPs and obtain information on their shape. TEM scans revealed uniformly sized AgNPs with a spherical shape.

The author in [6] used chitosan, polyvinyl pyrrolidone (PVP), and silver oxide nanoparticles to create a dressing for wound healing. In a nutshell, the sodium citrate reduction process was utilised to create the silver oxide nanoparticles using AgNO3. A 1:1, v/v mixture of chitosan and PVP was made, and after adding varying amounts of silver oxide nanoparticles, the material was cast onto ceramic plates [4].

By lyophilising and then incorporating Ag/ZnO nanomaterial into chitosan sponge, [7] created a sponge-like nano Ag/ZnO-loaded chitosan composite dressing [9]. The results showed that the composite dressing's formulation verified high porosity, increased swelling, better blood coagulation, and exceptional antibacterial activity [5]. The new formulation exhibited very little harmful behaviour in an in vitro test [10]. Additionally, re-epithelialization, collagen deposition, and wound healing were all enhanced in invivo tests conducted on animals. These results supported the deployment of innovative nanocomposite dressings for wound healing.

3. Wound Classification

Wound classification is carried out using many criteria. The most important factor in managing injuries and wounds is the healing time [8]. Therefore, wounds can be categorised as acute, chronic, or complicated depending on how long they take to heal.

- Acute Wound

An acute wound is one that heals completely, regaining all of its anatomical and functional characteristics, and progresses normally as a result of a planned, methodical healing procedure. Wound healing normally takes five to ten days, or less than a month. In the case of surgical operations, tissue loss usually follows the acute wound. For instance, due to severe tissue weakness in the surrounding area, a surgical procedure to remove a soft tissue mass from the skin may occasionally result in a large, non-infected wound that is difficult to heal with standard care. These kinds of severe injuries are frequently observed. They may be limited to the soft tissue or they may be connected to fractures in the bone. The Association for the Study of Internal Fixation (AO Foundation) has classified all of these combined wounds (Velnar et al.). The AO Foundation's classification system is one of the most comprehensive and widely utilised ones in use today. This grading system includes both open and closed fractures while taking into account the impact on neurovascular damage, tendon, muscles, and skin. The benefit of this classification system is that it sheds light on the extent of damage to the tendon and the muscle that support it, which is important information for determining the damaged limb's medical status.

- Chronic Wound

Wounds that are unable to mend during the entire healing process. Furthermore, a wound is considered chronic if it cannot be cured using a methodical method. Chronic wounds are mostly caused by insufficiencies in the naturopathic, venous and arterial systems, burns, and vasculitis. An overabundance of inflammatory cytokines, necrosis, exuding wounds, low oxygen levels at the site of tissue damage, and infection all contribute to the disruption of the healing process. The healing process is ultimately delayed by all of these elements, which lengthen its stages such as haemostasis, inflammation, proliferation, or remodelling. Extended periods of inflammation at the site of the incision set off a sequence of tissue reactions that prevent the lesion from healing. Consequently, the cycle of wound healing is disrupted, which leads to weakened anatomical and functional reactions and, ultimately, a worsening of the wound condition.

- Complicated Wound

A complicated wound is a special kind of wound that combines an infected infection with tissue damage. The healed wound is always at risk from infection at the location of the wound. On the other hand, trauma, the prognosis following an infection, or an open tissue excision during tumour treatment are the primary causes of tissue damage. Most wounds, regardless of their size, location, or course of care, are contaminated. Several factors, including the patient's innate resistance and the virulence, quantity, and kind of microbe present in the local blood supply, will determine whether the infection worsens or gets better. The five well-established indicators and symptoms of infected wounds are pain, erythema, fever, oedema, and loss of function at the injured site. The surgical technique and the injured site affect the infection's recurrence rate. It is possible to classify wounds according to a variety of factors, including the wound's morphology, level of contamination, aetiology, and subsequent contact with other organs. Based on the level of contamination, wounds are divided into three groups: contaminated wound (abdominal & lung), septic wound (abscesses & bowel procedures), and aseptic wound (bone & joint). When the original tissue is broken but the skin is not yet seriously wounded, the wound is categorised as a near wound. An open wound is one where the underlying tissue is visible to the outside world and the skin tissues are damaged. Aetiology of the wound, which is based on the trigger elements such as cut, laceration, contusion, abrasion, avulsion, stab, crush, shot, and burn wound, is another method of classifying wounds.

4. Significance of the Silver and Chitosan-Based Nanoparticles

Chitosan is the second most abundant polysaccharide in nature after cellulose (Mourya and Inamdar). Natural sources of chitosan, a chitin that occurs naturally, include the exoskeletons of insects, crustaceans, and certain types of fungi. Chitin, which is mostly obtained from the shell debris of prawns, lobsters, krills and crabs, is harvested annually for commercial use in several crores of tonnes worldwide; as such, this biocompatible and biodegradable polymer denotes a readily available and affordable source [12].

For chitosan, the degree of deacetylation (DD) is essential. The percentage of N-acetyl-D-glucosamine components relative to all components is indicated by the DD. A structural component called DD influences physicochemical properties such as swelling index, tensile strength, percentage elongation, and molecular weight. A rise in chitosan DD causes the chitosan film's% elongation and tensile strength to increase and the swelling index to decrease. It also influences the biological characteristics of chitosan and the created formulations, such as enzyme biodegradation, cell adhesion, proliferation, and wound healing. A substance with a DD of more than 90% is seen to be promising for use in wound healing, tissue regeneration, and cell proliferation.

Due to its high boiling point, silver is a metal that is more effective than organic molecules in high-temperature pharmaceutical operations. Products made from silver that have low silver concentrations are easily found on the market. Since 1996, personal care products have contained silver at a concentration of 50 parts per million. A few instances of commercially available preparations are gels, creams, catheters, wound dressings, dental materials, medical devices, and implants. Particles less than 100 nm in at least one dimension are referred to be nanoparticles. Silver and gold metallic nanoparticles have remarkable characteristics like low in vivo toxicity and antibacterial and bacteriostatic effects. Silver and other metallic nanoparticles exhibit distinct behaviours from larger particles in the micron range, making them suitable for use in medication administration. Silver mostly interacts with the cytoplasm, r-DNA, and components of the bacterial cell wall. The charge, aggregation stage, and antibacterial potential of silver nanoparticles can all be altered by chitosan's interaction with the particles. For the creation of silver nanoparticles, the chemical reduction approach with an aqueous silver nitrate solution is thought to be optimal. By varying the reducing agent's concentration, silver colloids can be produced with a variety of particle sizes and colours. Stabilising agents are essential in halting the development and build-up of produced AgNPs. Variations in the concentration of stabilising agents, such as polyvinyl alcohol (PVA), citrate, and chitosan, impact the size and form of silver nanoparticles necessary for specific drug delivery. When creating a formula for wound healing, the combination of chitosan and silver-based nanoparticles may offer more therapeutic potential.

5. Conclusion

Silver nanoparticles can be produced chemically by reducing substances such as sodium borohydride, glucose, ethylene glycol, and citrate. Nanoparticles' antibacterial efficacy is determined by a number of parameters, including zeta potential, polydispersity index, and particle size and number. Regarding the nature of the biological reaction, particle size and surface chemistry are important factors. Because chemical procedures are simple to apply and can provide vast amounts of the final product, they are frequently employed to make nanostructured materials. When AgNPs are used in place of compounds containing only silver to treat wounds, the active surface area increases considerably, resulting in very remarkable physicochemical features and biological activities. There are two likely explanations for the altered characteristics of metallic nanoparticles: one is that a higher surface to mass ratio would lead to a corresponding increase in chemical reactivity. As particle size drops, the other possible cause could be the prevailing quantum size effect. When the particle size is smaller than 10 nm, the quantum effect exhibits noticeable changes in optical, mechanical, or electrical properties.

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