

A Contemporary Review of Hydrogel Dressings for Wound Care

Abhishek Sharma*

Faculty Medical and Administrative Head, Medical Superintendent, Director of Plastic Surgery Services, Department of Plastic Surgery,
ALL IS WELL Multispecialty Hospital, Burhanpur, Madhya Pradesh, India

Received: 2025-09-02;

Revised: 2025-10-07;

Accepted: 2025-11-18

Abstract

Chronic wounds are considered a burden for healthcare and do not progress through the wound healing process in a timely manner. They are also the most common reason for a decrease in the quality of life in patients. Hydrogel dressings have become essential in the realm of wound management and care. Traditional wound dressings (e.g., gauzes and bandages) require regular application and are effective for dry to mild, exuding wounds; however, although they are highly absorbent, they can cause pain upon dressing change. In addition, they cannot provide enough drainage and have poor adhesion properties for wounds. Modern dressings, such as hydrogels, are aimed at solving these issues. They create a moist environment that not only encourages tissue healing but also works well with a variety of wound types. At the same time, unlike other types of modern dressings (foams, films, and hydrocolloids), hydrogels have positive degradation properties, which makes them the perfect choice for the targeted delivery of bioactive substances to the wound if needed. Hydrogel dressings hold considerable promise in the field of wound management. Continuous research is crucial to address challenges, resolve current controversies, and improve the efficacy and sustainability of these dressings for superior wound care. This mini-review is focused on the advantages of hydrogels over different types of traditional and modern wound dressings.

Keywords: Chronic wound; Hydrogel dressing; Advantage; Other dressing; Wound care

Citation: Sharma A. A Contemporary Review of Hydrogel Dressings for Wound Care. *Acad J Surg*, 2026; 9(1): 12-18.

Introduction

The management of wounds represents a critical area of focus, demanding comprehensive approaches to facilitate optimal healing, reduce complications, and improve patient outcomes. Wounds, whether acute or chronic, pose a significant challenge in clinical practice, requiring tailored interventions to expedite the healing process and mitigate potential risks such as infection, impaired healing, and discomfort. Among the many options out there, hydrogel dressings have emerged as a versatile and promising tool in wound care [1-5]. What is the best available option or evidence related to the effectiveness of hydrogel dressings without any additional therapeutic additives in wound management? These dressings have unique qualities that make them particularly suitable for different types of wounds.

Their high moisture content, ability to maintain a moist environment, and compatibility with the body are key factors that contribute to their effectiveness in promoting healing (Figure 1). Hydrogels are made to rehydrate a wound or enhance the wound's moisture levels as per the condition of the wound. They are available in different forms, including impregnated gauze, amorphous gels, and sheets [1-7]. They are best used in wounds with minimal or no exudate, as they do not absorb large amounts of exudate because they have up to 96% water content. This literature review aims to thoroughly analyze and synthesize the existing knowledge about hydrogel dressings in wound management, while also emphasizing their importance in clinical practice as a valuable addition to the strategies used in treating wounds, with a particular emphasis on recent advances, applications, and future directions.

* **Corresponding author:** Abhishek Sharma

Faculty Medical and Administrative Head, Medical Superintendent, Director of Plastic Surgery Services, Department of Plastic Surgery, ALL IS WELL Multispecialty Hospital, Burhanpur, Madhya Pradesh, India.

Email: drabhisheksharma7@gmail.com



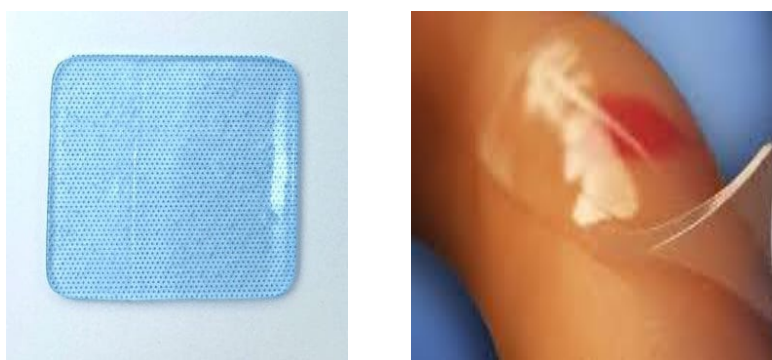


Figure 1: Hydrogel dressing and its application

Methodology

In conducting this literature review, we adopted a meticulous and organized strategy to compile a thorough collection of academic articles and research studies. Our search encompassed databases recognized for their extensive coverage in the biomedical and scientific fields, such as PubMed, Web of Science, Scopus, and pertinent peer-reviewed journals that concentrate on wound care, biomaterials, and surgical practices. We employed a blend of essential search terms including “hydrogel dressings,” “wound management,” “biocompatible polymers,” “smart hydrogels,” and “3D printing in wound care” to enhance the breadth and depth of the search. We prioritized articles published in English from peer-reviewed journals, particularly those that included empirical research, systematic reviews, meta-analyses, and clinical trials. Conversely, we excluded articles that were not peer-reviewed, duplicates, publications in languages other than English, and those that did not specifically pertain to hydrogel dressings in wound care. This stringent set of criteria was established to guarantee the quality and relevance of the literature we gathered for a comprehensive and targeted review.

Historical aspect of hydrogel dressings

Hydrogels represent intriguing three-dimensional structures created by the chemical or physical cross-linking of hydrophilic polymers [1,2]. Hydrogel dressings are utilized for a wide range of wounds, such as burns, pressure ulcers, and diabetic ulcers. These dressings have been in existence for several decades, motivated by the demand for improved wound care options. The term “biomaterials” was first introduced in 1967 during the inaugural International Biomaterials Symposium held at Clemson University in South Carolina. The application of synthetic polymers as biomaterials actually traces back to the early 1900s. Clinical bottom line [2-10].

It was not until the latter part of the 20th century that synthetic polymers really started to shine in the world of biomaterials. Since then, their use has skyrocketed, becoming vital in a variety of biomedical applications like wound dressings, drug delivery systems, and tissue engineering. The story of hydrogel dressings for managing wounds is particularly fascinating, beginning in the mid-20th century with the development and exploration of hydrophilic polymer-based materials [3-10].

Back in the day, some groundbreaking research unveiled hydrogels made mainly from hydrophilic polymers like polyvinyl alcohol (PVA) and polyethylene glycol (PEG). This was a significant step forward in the evolution of wound dressings. These trailblazing hydrogel dressings demonstrated remarkable moisture-retaining capabilities, effectively creating a moist environment that fosters tissue repair and speeds up the healing process. However, researchers faced some initial hurdles in finding the right balance between the mechanical strength of hydrogel dressings and their moisture-retaining features. The early versions often did not have the necessary strength for practical use. To tackle this challenge, there was a gradual move towards developing hybrid hydrogel dressings, which included reinforcing agents like nanofibers or other polymers to boost their mechanical strength while keeping the desired hydrophilic qualities. This era of innovation led to significant enhancements in the durability and versatility of hydrogel dressings for various types of wounds [5-11].

Key milestones and breakthroughs in hydrogel dressing technology really took off with the introduction of cross-linking techniques. These innovations not only boosted the structural integrity of hydrogels but also kept their hydrophilic properties intact. The arrival of various cross-linking agents and methods opened up a whole new world of applications, making hydrogel dressings more durable and customizable for wound care. Plus, incorporating natural polymers like alginate and chitosan, along with

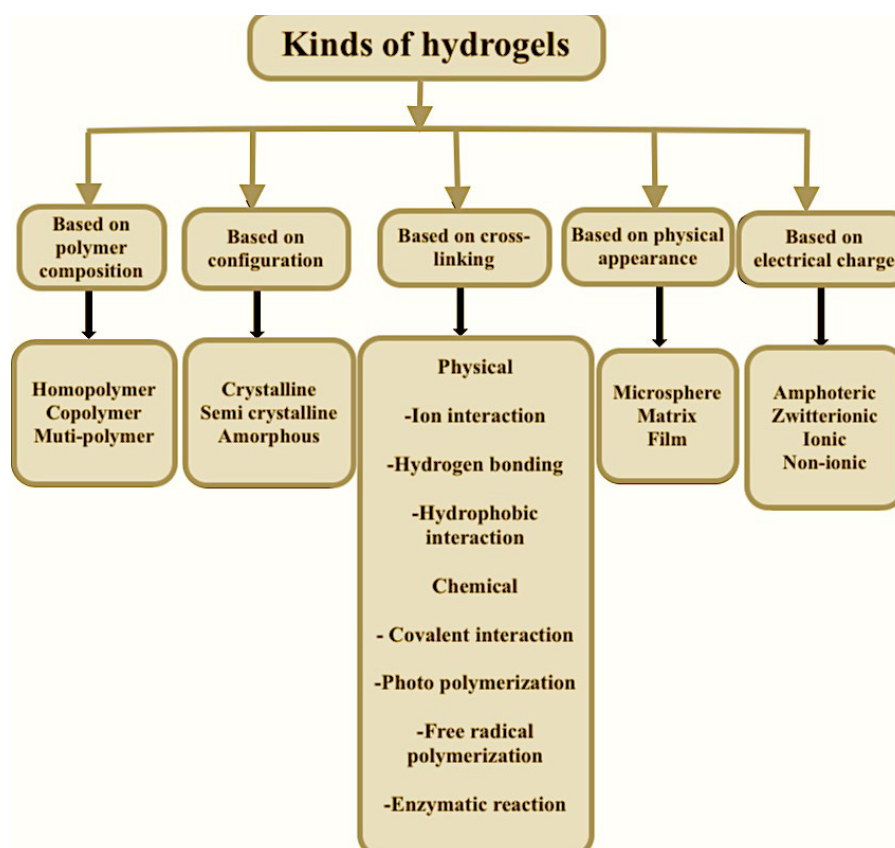


Figure 2: Categorization of hydrogels

synthetic options, expanded the variety of hydrogel dressings available. This approach catered to specific wound healing needs and introduced more bioactive components that support tissue regeneration. This period truly represented a major advancement in the customization and effectiveness of hydrogel dressings, solidifying their role as essential tools in contemporary wound management practices [6-12].

Types and characteristics of hydrogels

In the realm of wound care, hydrogel dressings are distinguished by their essential characteristics, notably their elevated water content and remarkable biocompatibility. These dressings, made from cross-linked hydrophilic polymers, effectively maintain moisture in the wound, which is essential for fostering an environment conducive to healing. The plentiful water content replicates the natural conditions required for cells to migrate, proliferate, and generate the extracellular matrix, all of which are crucial for the process of tissue repair.

Hydrogel dressings exhibit high biocompatibility, significantly reducing the likelihood of adverse reactions, which renders them appropriate for a diverse range of wounds, including those in sensitive regions.

Hydrogel dressings can be categorized according to their composition and functionality (Figure 2). Regarding composition, they are divided into two primary types: synthetic and natural. Synthetic hydrogels are generally composed of polymers, which provide a substantial degree of customization concerning their physical and chemical characteristics [13,14]. Conversely, natural hydrogels are derived from biomaterials such as alginate sourced from brown algae, chitosan obtained from shrimp shells, or collagen, utilizing their inherent compatibility and potential healing advantages (Figure 2). Functionally, hydrogel dressings cover a broad spectrum, including smart hydrogels and drug delivery systems [16].

Smart hydrogels are particularly intriguing; they incorporate elements that react to various stimuli, altering their properties in response to environmental factors such as pH, temperature, light, electric fields, magnetic fields, biological signals, chemical signals, or the presence of specific molecules [17]. Smart hydrogels are remarkable materials that possess a range of chemically and structurally responsive attributes. These advanced dressings can adjust to the specific conditions of a wound, providing tailored therapeutic responses that facilitate the healing process [17]. The different classifications and

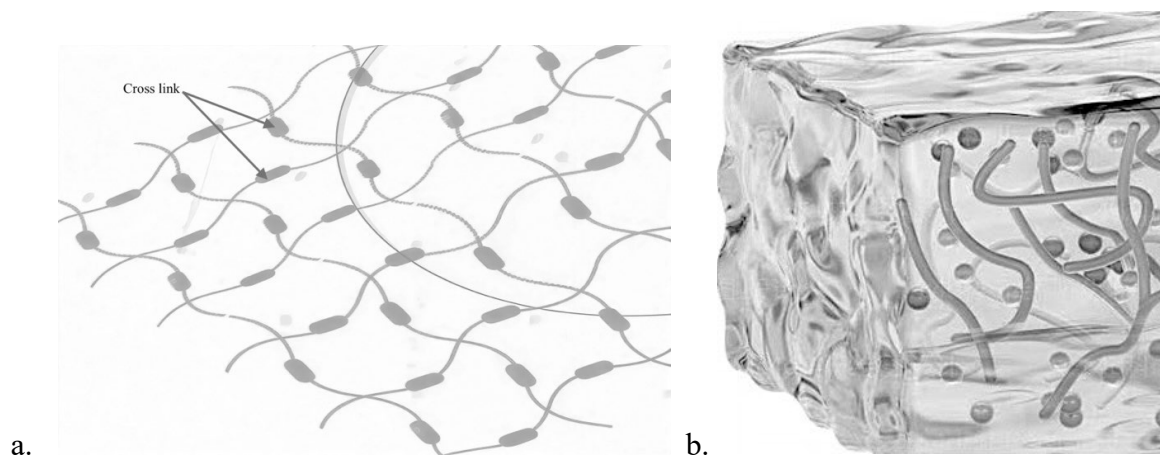


Figure 3: Fundamental characteristics of Hydrogels a. Nature of cross-linking and b. Observation under a microscope

functionalities of these hydrogels are essential for personalizing wound care to meet individual patient requirements and accommodate various types of wounds, representing a significant advancement in the field of wound management [18].

Incredible potential of hydrogel dressings in wound management!

With the swift advancements in materials science, we are witnessing the emergence of a variety of innovative wound dressings. Although traditional bandages and gauzes effectively halt bleeding, they possess certain disadvantages, such as being non-biodegradable, susceptible to infections, and not conforming well to irregularly shaped wounds [12-18]. These standard dressings typically fulfill a singular function, which may restrict their efficacy in wound treatment. Hydrogel represents an intriguing three-dimensional configuration composed of hydrophilic polymers that can absorb water and expand. Hydrogels based on polysaccharides are not only biocompatible and biodegradable but also nontoxic [18]. Conversely, hydrogels derived from synthetic polymers can be easily modified and exhibit remarkable mechanical strength. In contemporary times, hydrogel wound dressings are not merely antibacterial and biodegradable; they are also responsive and can be injected [10-18].

Hydrogel dressings have demonstrated exceptional versatility in wound management, proving effective for both acute and chronic wounds [12-18]. In the treatment of acute wounds, hydrogel dressings are frequently utilized in various situations, including postsurgery, abrasions, and burns. Their capacity to maintain a moist environment accelerates the healing process and facilitates wound closure, thereby minimizing the risk of scarring and infection.

For chronic wounds, such as diabetic ulcers and pressure injuries, hydrogel dressings have shown significant effectiveness in establishing an optimal healing environment, assisting in the removal of necrotic tissue, and promoting the regeneration of new tissue [2]. Numerous clinical cases and research studies highlight the efficacy of hydrogel dressings across a broad spectrum of applications.

Recent Developments in Hydrogel Dressings

The application of 3D printing technology in the development of hydrogel dressings has brought about a significant transformation. It enables the creation of dressings that can be customized to conform to the distinct shapes of various wounds [2-16]. Research on these 3D-printed hydrogel dressings has demonstrated that they are highly versatile and effective, particularly in covering wounds with irregular shapes [3-18]. This enhanced fit improves contact with the wound bed, potentially leading to superior healing outcomes. Furthermore, the integration of bioactive molecules such as growth factors and antimicrobial agents into these dressings has yielded encouraging results in accelerating tissue regeneration and preventing infections, as indicated by animal studies that reported quicker wound closure rates [6-15].

The function of hydrogel dressings as drug delivery systems represents a notable advancement in wound care. Research has underscored the advantages of these systems, which facilitate a sustained and controlled release of therapeutic agents directly at the wound site. By encapsulating growth factors, antimicrobial agents, or anti-inflammatory compounds, these drug-infused hydrogel dressings exhibit improved healing properties. Clinical trials have suggested that they can hasten wound closure

and diminish infection rates. The tailored release mechanisms provided by these drug delivery systems open avenues for more precise and effective wound management strategies, establishing a foundation for a more personalized approach to healing both chronic and acute wounds.

In the realm of hydrogel dressings, which show considerable promise for wound care, several challenges and limitations may hinder their broader application in clinical environments [7-18]. One of the primary obstacles is the relatively high cost and limited availability, particularly in suburban and rural regions where healthcare resources may be scarce. In these areas, certain advanced or customized hydrogel dressings can be quite expensive, rendering them less accessible in various healthcare settings [10-18].

Types of wounds and effectiveness of hydrogel dressing

Hydrogel dressings may heal partial- or superficial-thickness burns more quickly than silver sulfadiazine dressings, paraffin gauze, or paraffin gauze with antibiotics (a mean of 12.5 days compared to 14.55 days); however, the evidence was collected as being of low quality due to the perceived risk of bias [3].

Another systematic review of the advantages of hydrogel dressings for the treatment of diabetic foot ulcers of lower grade concluded that there was some evidence that hydrogel dressings were more effective than other basic dressing products, such as cotton absorbent dressings and paraffin gauze [4].

A systematic review of randomized controlled trials of grade 2 or above pressure injuries or ulcers compared hydrogel dressings to a number of alternative dressings (e.g., foam, hydrocolloids, and topical treatment) [4]. The size of the pressure ulcers or injuries and their anatomical location were not stated. With two exceptions, the included studies were conducted in the 1990s. The quality of the evidence was rated as very low, as the studies were very small and poorly reported; thus, the risk of bias was unclear. The authors' conclusion was that there was no strong evidence to suggest that hydrogel dressings were either more or less effective than observed in the studies mentioned above. In a couple of reviews on dressings in the healing of pressure injuries or ulcers, a small randomized controlled trial of pressure injuries compared the effectiveness of povidone-iodine gauze and hydrogel sheet dressings in the treatment of pressure ulcers [4-10]. The location of the pressure injuries varied anatomically.

Adverse effects: Hydrogel dressings are composed of up to 96% water, resulting in limited

absorbency [2]. An important consideration in using hydrogel dressings concerns the amount of wound exudate that is present, which may contribute to peri-wound maceration [5]. This dressing should not be used when autolytic debridement is not the desired effect (e.g., diabetic foot ulcers where the goal of care is to keep the eschar dry). The second review focused on the benefit of hydrogel dressings on diabetic foot ulcers [4], and the third reviewed the use of hydrogel dressings for treating pressure injuries or ulcers [2]. A prospective randomized controlled study compared the effectiveness of a povidone-iodine gauze and an occlusive hydrogel dressing in the treatment of pressure ulcers. Additionally, an observational study on chronic wounds demonstrated the effectiveness of hydrogel dressings [5].

Skin maceration

In the observational study by Zoellner et al., skin maceration was the only reported occurrence resulting from hydrogel sheet dressings [5]. As a result, six patients (7.4%) withdrew from the study following the second dressing change [5]. No data were reported on the amount of wound exudate assessed on entry to the study or on pain levels. Also in the aforementioned observational study, the authors noted that hydrogel sheet dressings increase patient comfort because they can be left in situ for several days and removed easily for dressing changes [5]. Regarding the effectiveness of reducing infection, a systematic review of studies on superficial and partial-thickness burns showed no difference between hydrogel dressings and the comparison dressings with respect to infection with *P. aeruginosa* requiring antibiotic treatment.

Advantages

In the observational study by Zoellner et al., skin maceration was the only reported occurrence resulting from hydrogel sheet dressings [5]. As a result, six patients (7.4%) withdrew from the study following the second dressing change [5]. No data were reported on the amount of wound exudate assessed on entry to the study or on pain levels. Also in the aforementioned observational study, the authors noted that hydrogel sheet dressings increase patient comfort because they can be left in situ for several days and removed easily for dressing changes [5]. Regarding the effectiveness of reducing infection, a systematic review of studies on superficial and partial-thickness burns showed no difference between hydrogel dressings and the comparison dressings with respect to infection with *P. aeruginosa* requiring antibiotic treatment.

Future of directions of hydrogels and research gaps

When considering the future of hydrogel dressings and wound management, there is much to investigate. Future studies should thoroughly explore advanced features and innovative applications that can address the existing gaps and ultimately enhance patient outcomes. A concentrated effort on creating multifunctional hydrogel dressings that not only facilitate healing but also assist in infection control and allow for personalized drug delivery is undoubtedly a promising direction. Envision the integration of sensors within these hydrogel matrices to monitor wound conditions and provide real-time updates to healthcare professionals; this would be a transformative development. These “smart” dressings could adapt to the wound’s environment, notifying clinicians of any changes and refining treatment strategies, which would result in more personalized and responsive care.

Furthermore, it is essential to investigate bioactive hydrogels, particularly those that include growth factors, stem cells, or components of the extracellular matrix, to enhance tissue regeneration and accelerate healing. Understanding how these components interact within the wound bed and their effects on cellular responses is vital. We must also consider the environmental implications and biodegradability of hydrogel dressings. Prioritizing the creation of biodegradable options that retain their efficacy while reducing ecological impact is crucial, especially in light of the increasing concerns regarding medical waste.

Identifying gaps in the existing literature is key to guiding research into new domains. One notable gap is the understanding of the long-term effects of hydrogel dressings on chronic wounds. There is a pressing need for more comprehensive longitudinal studies that examine the performance of these dressings over time, including their influence on healing, scar formation, and overall tissue regeneration. Exploring how these elements interact within the wound bed and their effects on cellular responses is a critical area for future research.

Conclusion

For wounds with moderate-to-heavy exudate, hydrogel dressings are not the dressing of choice. If gel-impregnated or amorphous gauze hydrogels are used as a primary dressing material, a suitable secondary dressing should be applied. Observation of the wound should include the status of the periwound skin, maceration of the wound edges, autolytic debridement, chronically infected wounds, and

the use of silver-containing hydrogel dressings. In conclusion, our investigation into hydrogel dressings for wound management highlights their significance as a versatile instrument in contemporary healthcare. These dressings, renowned for their substantial water content and compatibility with biological tissues, establish an optimal environment for wounds, thereby accelerating tissue repair in both acute and chronic cases. Reflecting on the evolution of hydrogel dressings, we observe a path characterized by notable advancements, such as cross-linking techniques and the incorporation of natural polymers, which have significantly improved their efficacy and adaptability.

Recent innovations have introduced smart hydrogels, 3D printing technologies, and drug-delivery systems, providing tailored and responsive solutions that signify a substantial advancement in wound care. Nevertheless, challenges such as cost, accessibility, and potential complications persist, underscoring the necessity of addressing economic considerations and the availability of these dressings. Numerous questions regarding their long-term effects remain unanswered, and ongoing discussions about their efficacy emphasize the need for comprehensive research and a cohesive understanding.

Looking forward, future research should explore multifunctional dressings, smart dressings integrated with sensors, and bioactive hydrogels to further enhance wound healing. It is also vital to consider the environmental implications and strive to develop biodegradable alternatives to tackle sustainability issues. Addressing the gaps in the existing literature, particularly concerning the long-term application of hydrogel dressings, is essential.

In the context of treating chronic wounds, selecting appropriate dressings and comprehending their functionality for various wound types are imperative. By concentrating on this aspect, we can formulate improved protocols and personalized wound-care strategies. This approach not only enhances the effectiveness of hydrogel dressings but also aids in reducing their environmental footprint in wound management.

Acknowledgements

The authors wish to convey their heartfelt appreciation to the members of this institute who have contributed, either directly or indirectly, to the development of this study.

Data Availability

All data produced or examined throughout this research are contained within the present article.

Ethical Statement

The author asserts that this work is based on a previously published article and does not include human subjects; thus, ethical approval is not required.

Conflict of interests

The authors declare no conflict of interest.

Funding

There is no funding in this study.

References

1. Broussard K, Powers J. Wound dressings: selecting the most appropriate type. *J Clin Dermatol*. 2013;14(6):449-459. <https://doi.org/10.1007/s40257-013-0046-4>
2. Dumville J, Stubbs N, Keogh S, Walker R, Liu Z. Hydrogel dressings for treating pressure ulcers. *Cochrane Database Syst Rev*. 2015;(2):CD011226. <https://doi.org/10.1002/14651858.CD011226.pub2>
3. Wasaik J, Cleland H, Campbell F, Spinks A. Dressings for superficial and partial-thickness burns. *Cochrane Database Syst Rev*. 2013;(3):CD002106. <https://doi.org/10.1002/14651858.CD002106.pub4>
4. Dumville J, O'Meara S, Deshpande S, Speak K. Hydrogel dressings for healing diabetic foot ulcers. *Cochrane Database Syst Rev*. 2013;(7):CD009101. <https://doi.org/10.1002/14651858.CD009101.pub3>
5. Zoellner P, Kapp H, Smola H. Clinical performance of a hydrogel dressing in chronic wounds: a prospective observational study. *J Wound Care*. 2007;16(3):133-136. <https://doi.org/10.12968/jowc.2007.16.3.27019>
6. Kaya A, Turani N, Akyuz M. The effectiveness of a hydrogel dressing compared with standard management of pressure ulcers. *J Wound Care*. 2005;14(1):42-44. <https://doi.org/10.12968/jowc.2005.14.1.26726>
7. Wheeler JC, Woods JA, Cox MJ, Cantrell RW, Watkins FH, Edlich RF. Evolution of hydrogel polymers as contact lenses, surface coatings, dressings, and drug delivery systems. *J Long Term Eff Med Implants*. 1996;6(3-4):207-217.
8. Queen D, Orsted H, Sanada H, Sussman G. A dressing history. *Int Wound J*. 2004;1(1):59-77. <https://doi.org/10.1111/j.1742-4801.2004.0009.x>
9. Górská A, Baran E, Knapik-Kowalczyk J, Szafraniec-Szczyński J, Paluch M, Kulinowski P, et al. Physically Cross-Linked PVA Hydrogels as Potential Wound Dressings: How Freezing Conditions and Formulation Composition Define Cryogel Structure and Performance. *Pharmaceutics*. 2024;16(11):1388. <https://doi.org/10.3390/pharmaceutics16111388>
10. Aderibigbe BA. Hybrid-Based Wound Dressings: Combination of Synthetic and Biopolymers. *Polymers (Basel)*. 2022;14(18):3806. <https://doi.org/10.3390/polym14183806>
11. Kaith BS, Singh A, Sharma AK, Dhiraj S. Hydrogels: synthesis, classification, properties and Potential applications-A brief review. *J Polym Environ*. 2021;29(12):3827-3841. <https://doi.org/10.1007/s10924-021-02184-5>
12. Bhuyan MM, Jeong JH. Preparation of Hydrogel by Crosslinking and Multi-Dimensional Applications. *Gels*. 2025;11(11):896. <https://doi.org/10.3390/gels11110896>
13. Ragab A, El-Badry N, Tamer N, Naas A, Hamdy A, Tawaakey SH, et al. Biodegradable chitosan/PVA-based hydrogel incorporating green synthesized silver nanoparticles for wound healing applications. *BMC Chem*. 2025;19(1):190. <https://doi.org/10.1186/s13065-025-01564-5>
14. Bravo JM. Hybrid systems of nanofibers and polymeric nanoparticles for biological application and delivery systems. *Micromachines (Basel)*. 2023;14(1):208. <https://doi.org/10.3390/mi14010208>
15. Nasution H, Harahap H, Dalimunthe NF, Ginting MHS, Jaafar M, Tan OOH, et al. Hydrogel and Effects of Crosslinking Agent on Cellulose-Based Hydrogels: A Review. *Gels*. 2022;8(9):568. <https://doi.org/10.3390/gels8090568>
16. Vigata M, Meinert C, Hutmacher DW, Bock N. Hydrogels as Drug Delivery Systems: A Review of Current Characterization and Evaluation Techniques. *Pharmaceutics*. 2020;12(12):1188. <https://doi.org/10.3390/pharmaceutics12121188>
17. Kwan JC, Pillai S, Munguia-Lopez JG, Kinsella JM, Tran SD. Smart hydrogels for tissue engineering and regenerative medicine: how far have we come. *Regen Med*. 2025;20(11):585-608. <https://doi.org/10.1080/17460751.2025.2583707>
18. Bustamante-Torres M, Romero-Fierro D, Arcentales-Vera B, Palomino K, Magaña H, Bucio E. Hydrogels Classification According to the Physical or Chemical Interactions and as Stimuli-Sensitive Materials. *Gels*. 2021;7(4):182. <https://doi.org/10.3390/gels7040182>