Using Combination Hydrogels and Stem Cells to promote healing in second-degree burns

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Author Note

My name is Josue Cogtla-Castillo, a student at Stony Brook University. I am majoring in Biomedical Engineering. For that reason this paper has been for the interest I have taken in hydrogels and potentially working in the burn unit to help first responders. Correspondence concerning this article should be addressed to Josue Cogtla-Castillo, Contact: josuecogtla45@gmail.com

Abstract

Burn injuries, particularly second-degree burns, are physically taxing and often lead to severe complications if not treated effectively. Current research highlights the potential of combining polyethylene glycol (PEG) hydrogels with stem cells to improve burn treatment outcomes. This study focuses on utilizing adipose stem cells (dsASCs) isolated from debrided skin to create a vascularized dermal equivalent, leveraging collagen-PEG bilayer hydrogels. Key findings show that dsASCs maintain stem cell markers, proliferate, and differentiate within the hydrogels. These advancements in regenerative medicine and tissue engineering promise to enhance wound healing, reduce scarring, and improve recovery for burn patients. The comprehensive review of preclinical and clinical studies underscores the significance of early excision, and stem cells in reducing inflammation and promoting tissue regeneration. The successful implementation of this innovative treatment could revolutionize burn care, reduce healthcare costs, and offer new avenues for treating other tissue damage and degenerative diseases. This research not only improves health outcomes but also drives innovation, education, and sustainability in the medical field.

Introduction

Burn injuries are physically taxing on the body and can often lead to further compilations if not treated correctly. Second-degree burns are the most common and can be extremely severe. There is a need to find faster and safer ways to heal burns. Advancements in treatment options, such as the combination of PEG hydrogels and stem cells, can significantly improve the quality of life for burn victims. Additionally, this approach represents a significant leap forward in regenerative medicine, with potential applications beyond burn care—innovations in tissue engineering and regenerative medicine.

This innovative treatment primarily affects patients suffering from second-degree burns, which are characterized by damage to both the outer layer (epidermis) and the underlying layer (dermis) of the skin. The combination of polyethylene glycol (PEG) hydrogels and stem cells represents a cutting-edge approach in treating second-degree burns. PEG hydrogels provide a supportive scaffold that promotes cell growth and tissue regeneration, while stem cells accelerate the healing process by differentiating into various cell types needed for skin repair. Together, they enhance wound healing, reduce scarring, and improve the overall recovery experience for burn patients. On a global scale, the successful implementation of this treatment could revolutionize how burn injuries are managed, leading to faster recovery times, reduced healthcare costs, and better long-term outcomes for patients. Furthermore, it highlights the potential of combining biomaterials and cellular therapy to address various medical conditions, paving the way for future

Current research on adipose tissue-derived stem cells (ASCs) and polyethylene glycol (PEG) hydrogels for burn treatment has shown promising results (Burmesiter et al., 2018). However, there are still areas that need further exploration, such as the healing efficiency of stem cells from different types of tissues, and the long-term effects on skin regeneration, scarring, and speed. To address these areas, proposing a comprehensive approach that includes studies, long-term outcomes, enhanced hydrogel formations, and other like investigations. However, PEG and ASCs have been so far effective. We will investigate the use of PEG Hydrogel and stem cell combination to enhance the healing process in second-degree burns.

Methods

Identifying the specific ways that hydrogels help in the healing process and how the stem cells work and their contribution. Second degree burns are also important as they are breaking through the dermal layer and the severity is important to note. The existing literature states what each part of the combination contributes and how it works together to be successful. Using sources from academic journals, making sure it is specific to PEG hydrogels and second degree burns. Google scholar was used, with words such as PEG hydrogels, stem cells and second degree burns.

To analyze the information from the literature, we will conduct a comprehensive search using databases such as Google Scholar, focusing on keywords like " second degree" and "Hydrogels and stem cells." (Burmeister, et al, 2018) We will extract key data points, including study objectives, methods, results, and conclusions, and organize this data for easy comparison. Thoroughly investigating the facts and researching more than one article ensures reliability. Synthesizing the data involves grouping studies by treatment type and outcomes, performing analyses for quantitative data, and analyses for qualitative data to identify patterns and trends. Finally, we will integrate these findings to draw meaningful conclusions, highlighting the advantages of new treatments and identifying areas for future research.

Discussion

The research focuses on utilizing stem cells isolated from discarded skin obtained during debridement of severely burned patients to develop a vascularized dermal equivalent using collagen and fibrin-based scaffolds. The methodology involves isolating adipose stem cells (dsASCs) from the debrided skin, incorporating them into collagen-PEG bilayer hydrogels, and analyzing their growth, differentiation, and effect on wound healing in vitro and in an athymic rat excision wound model (Natesan, et al, 2013). Key findings show that dsASCs maintain their stem cell markers, proliferate, differentiate within the hydrogels, and form a microvascular network in the PEGylated fibrin. The primary objective is to create a clinically viable, vascularized dermal substitute for large surface area wounds using autologous stem cells (Natesan, et al, 2013).

The study explored various strategies in tissue engineering and regenerative medicine to improve burn wound healing, addressing the challenges of infection, scarring, and speed of healing. Research questions focus on the efficacy of pharmacological agents, biomaterials, and cellular-based therapies in enhancing burn care. Methodologies include pre-clinical and clinical trials of topical treatments, surgical management techniques, and the use of mesenchymal stem cells (MSCs) (Bullock, et al. 2010) (Surowicka, et al. 2022) . Key findings highlight the advantages of early excision and grafting, the benefits of silver-based dressings, and the promising role of MSCs in reducing inflammation and promoting tissue regeneration. The primary objectives are to restore barrier function, reduce infection rates, and improve overall healing outcomes (Stone, et al. 2018).

Both of these studies emphasize the idea of using stem cells. The first looks at using DsASC’s and the second uses MSCs but both agree the idea of stem cells is important. Both show the importance of pre clinical and clinical evaluations by combining in vivo and in vitro methods. The objectives of both studies remain the same. To restore the barrier function, reduce infection rates, and overall enhance the healing process (Surowoieca, et al. 2022).

The findings from studies on stem cells and hydrogels for burn wound healing significantly inform the future of my research, which aims to develop a hydrogel using adipose stem cells from debrided skin. The demonstrated ability of dsASCs to proliferate, differentiate, and form a microvascular network in hydrogels aligns with the promising potential of MSCs in reducing inflammation and promoting tissue regeneration. By building on these advancements, my research could address gaps in large surface area wound healing and infection control, offering a clinically viable solution. Future directions will focus on refining scaffolds and optimizing stem cell integration to enhance the clinical efficiency of dermal substitutes (Surowoieca, et al. 2022)(Burmesiter, et al. 2018).

Conclusion

Overall, research on the combination of PEG hydrogels and stem cells for treating second-degree burns has the potential to revolutionize burn care. With the capabilities of stem cells and the supportive environment provided by PEG hydrogels, this approach can speed the healing process, reduce scarring, and improve many people's lives. Reducing the physical and emotional burden associated with prolonged healing and visible scarring. This research could set new standards in burn treatment protocols, making advanced regenerative therapies more accessible and effective for patients worldwide.

Beyond immediate burn care, the implications of this research can be used to show that Hydrogels are useful and can be used on other things, such as the injectable hydrogel to help people that suffer Achilles tendon injuries. The successful application of PEG hydrogels and stem cells could pave the way for similar treatments in other types of tissue damage and degenerative diseases. This could lead to groundbreaking advancements in tissue engineering, potentially offering solutions for conditions that currently have limited treatment options. Furthermore, as this technology evolves, it could lead to more personalized and precise medical interventions, enhancing the overall efficacy of regenerative therapies and broadening their applications in medical practice.

The educational impact of this research is also profound. By integrating cutting-edge scientific discoveries into medical curricula, we can better prepare future healthcare professionals to implement these advanced treatments. Additionally, the research underscores the importance of collaboration, combining science, cellular biology, and clinical medicine, which can inspire new educational programs and research initiatives. Environmentally, the use of biocompatible materials like PEG hydrogels promotes sustainable medical practices, reducing the reliance on synthetic and potentially harmful substances. Overall, this research not only improves health outcomes but also drives innovation, education, and sustainability in the medical field.

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