WoundCareBot: A Robotic System for Automated Wound Cleaning

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Introduction

In recent decades, robots have been playing an increasingly important role in field of medicine. This project focuses on the task of wound cleaning. The objective is to develop a robotic system, named "WoundCareBot," designed to automate and precisely execute the wound cleaning process.

Clinical importance

Wound cleaning plays a critical role in the wound care process, contributing significantly to the healing and preventing infections.

Importance of wound cleaning:

Wounds, defined as injuries that break the skin or underlying tissues, demand meticulous attention to prevent complications such as infections and delayed healing. Effective wound cleaning is essential for the removal of contaminants, bacteria, dead tissue, and excess fluid from both the wound and its surrounding skin. This proactive measure accelerates the natural healing process and minimizes the risk of infection [1].

Diversity in wounds and cleaning approaches:

Different types of wounds necessitate customize cleaning methods. For instance, surgical wounds (Fig. 1A) benefit from a linear cleaning movement starting from the wound's center and moving outward [2, 3]. Conversely, burn wounds (Fig. 1B), characterized by increased fragility, require gentler mechanical force, often involving circular movements or successive, gentle pushing contacts [4]. In cases of foot ulcers (Fig. 1C), prevalent among individuals with diabetes, a specific circular motion from the innermost point outwards is employed to remove necrotic tissue, reducing the risk of bacterial contamination [5, 6].

This knowledge serves as the basis for the design and implementation of the WoundCareBot, ensuring its adaptability and precision in addressing diverse wound scenarios.

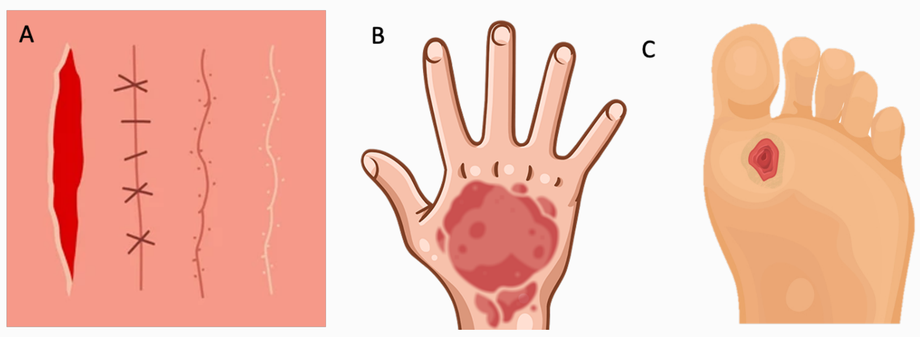


Figure 1. Different wounds. A:Surgical wound; B: Foot ulcer; C: Burn wound

Key points of the WoundCareBot

The significance of the WoundCareBot lies in its potential to revolutionize and enhance the wound cleaning process through automation:

- **Pressure-Sensitive Navigation:** Equipped with pressure sensors, the robot ensures consistent and precise wound cleaning tailored to individual patients. This feature maintains a prescribed cleaning path with constant pressure, enhancing both safety and efficacy
- **Precision and Consistency:** Automation ensures precise and consistent movements
- **Reduced Infection Risk:** Precise removal of bacteria and necrotic tissue, minimizing the risk of infections
- **Customized Approach for Different Wound Types:** Adaptability for surgical, burn, and ulcer wounds, optimizing cleaning methods
- **Enhanced Healing Acceleration:** Specific movements contribute to an optimal environment for tissue regeneration
- **Minimized Human Error:** Reduction of errors through automated protocols, standardizing the cleaning process

Frame of the robot

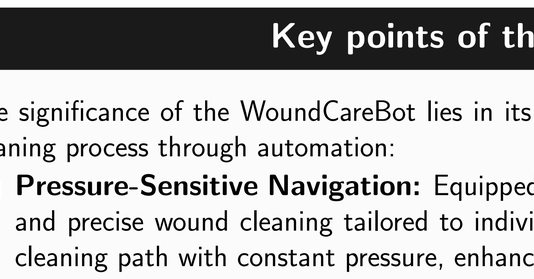


Figure 2. Photo of the frame of the WoundCareBot

Plane of the robot

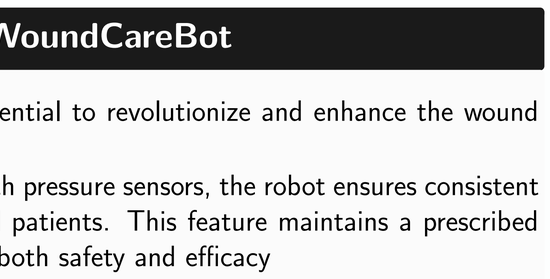


Figure 3. Photo of the plane of the WoundCareBot

Easy to use

The robot has 4 different wound cleaning movements and they are controlled with four buttons from a control panel. After pressing any button, the robot goes to take the gauze and then starts the chosen movement. When the movement is finished, the robot trows away the used gauze.

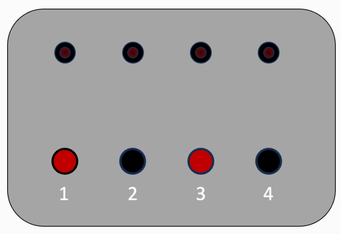
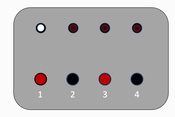


Figure 4. Control panel of the robot without any button pressed

01. Lineal cleaning movement

Ideal for surgical wounds, the linear movement ensures systematic cleaning from the center outwards. This method is designed to eliminate contaminants effectively while minimizing potential damage to the healing tissues.



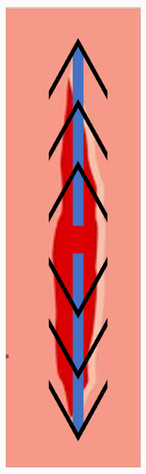
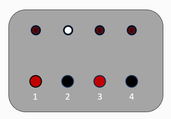


Figure 5. Path followed by the robot to do the lineal movement

02. Circular cleaning movement

Suited for various wound types, the circular movement facilitates cleaning around the wound. This method is adaptable and effective, ensuring removal of debris and contaminants.



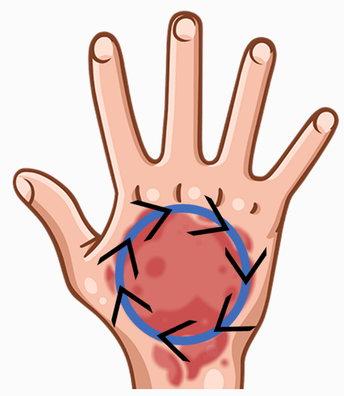


Figure 6. Path followed by the robot to do the circular movement

03. Circular-Push Cleaning Movement

Adapted for delicate burn wounds, this movement applies gentle pressure at different points along a circular path. It minimizes mechanical stress on fragile tissues, promoting effective cleaning without compromising wound integrity.

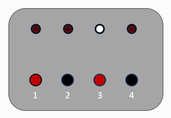
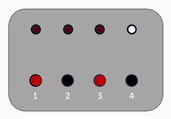


Figure 7. Path followed by the robot to do the circular-push movement

04. Circular-Exterior Cleaning Movement

Designed for foot ulcers, this movement focuses on outward cleaning along the wound's border. It reduces the risk of bacterial contamination from the surrounding skin, addressing the unique requirements of foot ulcer care in individuals with diabetes.



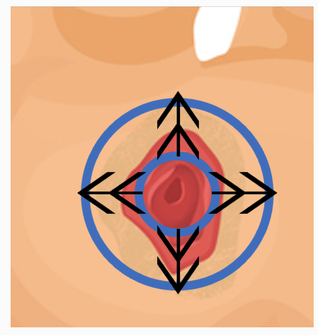


Figure 8. Path followed by the robot to do the circular-exterior movement

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