Empowering Patients and Caregivers to Use AI and Computer Vision for Wound Monitoring: A Feasibility Study

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Table of Contents

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Abstract

Background: Chronic wounds affect 1-2% of the global population, and pose significant health and quality-of-life challenges for patients and caregivers. Advances in artificial intelligence (AI) and computer vision (CV) technologies present new opportunities for enhancing wound care, particularly through remote monitoring and patient engagement. A Digital Wound Care Solution (DWCS) that objective wound tracking using AI/CV was redesigned as a patient-facing mobile application to empower patients and caregivers to actively participate in wound monitoring and management.

Objective: This study aimed to evaluate the feasibility, usability, and preliminary clinical outcomes of the Patient Connect application in enabling patients and caregivers to remotely capture and share wound data with healthcare providers.

Methods: A feasibility study was conducted at two outpatient clinics in Canada between May 2020 and February 2021. Twenty-eight patients with chronic wounds were recruited and trained to use the Patient Connect app for wound imaging and secure data sharing with their care teams. Wound images and data were analyzed using AI/CV models integrated into the app. Clinicians reviewed the data to inform treatment decisions during follow-up visits or remotely. Key metrics included app usage frequency, patient engagement, and wound closure rates.

Results: Participants captured a median of 13 wound images per wound, with images submitted every 8 days on average. The study cohort included patients with diabetic ulcers, venous ulcers, pressure injuries, and post-surgical wounds. A median wound closure rate of 80% was achieved across all patients, demonstrating the app's clinical potential. Feedback from patients and clinicians highlighted the app's usability, data security features, and ability to enhance remote monitoring.

Conclusions: The Patient Connect application effectively engaged patients and caregivers in chronic wound care, demonstrating feasibility and promising clinical outcomes. By enabling secure, remote wound monitoring through AI/CV technology, the app has the potential to improve patient adherence, enhance care accessibility, and optimize clinical workflows. Future studies should focus on evaluating its scalability, cost-effectiveness, and broader applicability in diverse healthcare settings.

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1. Introduction

Chronic wounds are commonly defined as wounds that fail to heal through normal, timely and orderly stages [1]. These wounds pose a major public health challenge, with 1-2% of the global population estimated to experience a chronic wound during their lifetimes [2]. Diabetic ulcers (DU), venous ulcers (VU), and pressure injuries (PI) are especially prevalent, making up over 90% of all chronic wounds [3] and often requiring significant wound care management and resources. However, due to their low rate of complete healing, chronic wounds have major impacts on both the health and quality of life of patients and their families, leading to significant issues such as severe and prolonged pain, loss of function and mobility, amputation, mental health deterioration, social isolation and embarrassment, financial burden, and chronic morbidity or death [4]. Recently, there has been a significant transformation in healthcare delivery, focusing on remote access through telemedicine that leverages the widespread availability of smartphones and their applications. Technologies that facilitate telemedicine and ensure continuity of care for chronic wound patients are urgently needed, as high risk of wound-related complications exist for those without access to consistent follow-ups [5].

The rise of artificial intelligence (AI) has shown great promise, particularly in the field of wound care. These technologies provide healthcare professionals with novel tools that contribute towards many improvements in treatment efficiency and efficacy, including early detection, risk factor analysis, prediction, diagnosis, intelligent treatment, outcome prediction, and prognostic evaluation [6]. Additionally, AI-powered tools have been shown to empower patients to take control of their own health and wellbeing. For instance, AI tools can provide patients with information regarding their conditions and treatment options, thereby enabling them to make informed decisions while also strengthening patient-healthcare provider relationships through trust-building [7]. Computer vision (CV) is a particular form of AI that extracts information from digital images or videos in order to recognize content from visual data [8]. These technologies are especially promising in the field of wound care, as they can help classify wound severity, provide accurate predictions of wound healing, and track changes in wounds over time through image analysis [9-10]. CV technologies have previously been shown to provide significant time savings during wound assessments [11], decrease costs and days needed for wound healing [12], and improve data capture reproducibility and accuracy [13]. Notably, patients have also been found to exhibit positive perceptions towards the use of wound photography in their treatment journeys by helping them track their wound progress or increasing their involvement within their own care [14].

Swift Medical™ Skin & Wound (hereafter referred to as Digital Wound Care Solution (DWCS)) developed a mobile application and dashboard, specifically designed to accurately and reliably measure and document wound characteristics. The system, which is already available and is a privacy-compliant (HIPPA and PHIPA), Health Canada registered and FDA Class I medical device, uses CV technology to automatically focus and calculate wound dimensions from images acquired by the mobile device's camera, allowing users to obtain precise and consistent measurements. These capabilities have been demonstrated to reduce the time needed to assess the wounds of patients in a more accurate manner [11,15]. In addition to viewing a wound's image series over time, additional information such as healing-associated metrics, wound-bed information, anatomical location and patient identifiers are captured. While the app has provided doctors and wound-care specialists with a powerful assessment solution and a dashboard to remotely monitor and collaborate for an effective wound management strategy, in order to fully realise the system's potential, patients themselves will need to be able to acquire and securely share images and other relevant information with their care-providers. By actively engaging patients in their own wound care journeys through a patient-centric application, individuals may feel empowered to be more active in the treatment process.

Understanding the importance of innovative technologies in improving health outcomes for chronic wound patients, the DWCS have recently developed a stream-lined, patient-facing version of the AI-powered application called Patient Connect. Patient Connect is designed for easy use by patients and/or their care-providers using their own personal smartphones, ensuring a more patient-centric approach to wound management (Figure 1). Patients are authorized directly by their healthcare provider and can only access their own records through their personal device. This requires a 2-step verification via email or a cell-phone number and their date of birth. Like the standard version of the app, it automatically focuses and calculates wound dimensions from the images acquired. Images and other measurements are not stored on the phone camera roll of the patient's personal devices, instead they are encrypted within the application and securely transmitted to healthcare providers on the same secure, web-based servers from the DWCS. The patient's healthcare provider can access the patient's generated images and patient-reported data using their application or the web dashboard; thereby, enabling the remote monitoring of wound progression.

The objective of this report is to present results of a feasibility study of early adopters of our patient-centric AI-powered wound assessment technology within two outpatient clinics in a university-affiliated hospital and a community hospital to determine overall feasibility, usability, and preliminary outcomes of the Patient Connect application.

2. Methods

A feasibility study was conducted between May 2020 and Feb 2021. The study received multisite ethics approval provided by the Scarborough Health Network research ethics board (SUR-21-007). A nurse practitioner at Scarborough Health Network and two physicians at Montreal Jewish General Hospital were the primary clinicians engaged in the project, and both had previous experience using AI/CV-enabled wound care documentation in clinical practice. Standardized training was provided on enrolling patients, enabling access, and reviewing patient-submitted wound images and information in the clinician application and dashboard. Training materials were provided to support patient onboarding to use the service. Clinicians had access to review images submitted through the dashboard on a weekly basis and during follow-up visits.

A purposive sampling technique was employed to recruit patients or caregivers from the Montreal Jewish General Hospital and the Rouge Valley Scarborough Hospital for early testing of the Patient Connect app. Patients were the primary focus for the inclusion criteria, and caregivers consider an alternative if the patient consented. Inclusion criteria to the cohort were (1) patients' attending staff were already a user of the DWCS, (2) the patient or a close relative possessed and was familiar with a smartphone device, and (3) the patient had a stable wound, as assessed by their healthcare provider. Caregivers were suitable alternatives if the wound was in an area that was difficult to image (e.g., sacrum, back) or the patient had limitations that made them unable to use the application (e.g., mobility, technology literacy). Exclusion criteria were Android phone users as the Patient Connect app currently only runs on iOS devices.

Enrolled participants were encouraged to use the application when their dressing was being changed by themselves, caregivers or other healthcare professionals outside of the participating organizations (e.g., home health). Two case series displaying the measurement and progress tracking of patient-captured and caregiver-captured wound images on the Patient Connect app are shown in Figures 2 and 3, respectively. Due to the variation in wound-changing protocols and the feasibility design, there was no set requirement for imaging completion by the patients per week. The clinicians collected additional feedback during follow-up appointments. User experience, facilitators, and barriers were documented and shared with the project manager and software development team to support quality improvement and ensure app performance and stability.

The patients were followed until the closure of their wounds or February 2021, whichever occurred first. Wound closure was defined as a wound measurement of 0 cm^2. All data reported in this report was obtained from the solution's deidentified servers, allowing for data retrieval while maintaining the confidentiality of patients' personal information.

3. Results

A total of 28 patients adopted the Patient Connect App as early users. The characteristics of the wounds are presented on Table 1. The cohort included patients with varied wound types, including diabetic foot ulcer (DFU), venous leg ulcer (VLU), PI, and surgical wounds.

Approximately half of the patients were diabetics with plantar ulcers (52%). There was a balanced gender mix in this study, with 52% of patients reporting as males and 48% as females. The sample population had a range of wound sizes from 0.48 cm^2 to 27.91 cm^2 and a median size of 3.71cm^2. Wound measurement was captured from photographs using AI/CV models, so wounds outside of the photograph (i.e., circumferential) had limitations to their data. This suggested that single-surface wounds were optimal for patient and caregiver imaging and automated AI/CI analysis of the wound. Wound imaging was found to be ideally suited for patients with images on a single surface. However, it was possible to upload multiple images if wounds were circumferential.

The median follow-up was 3 months, with a median of 13 images aquired by the patient or caregiver per wound. Images were captured on average every 8 days. Interestingly, despite a general infrequency of in-person follow-up visits, the median rate of wound closure as registered in the app was 80%.

4. Discussion

In this report, we demonstrate that the DWCS's regular use by a group of selected patients allowed the remote monitoring of their wounds, successfully capturing medical-grade images that were subsequently used by clinicians for treatment decisions. This capability is not only crucial for maintaining continuity of care but also for enhancing patient engagement and treatment adherence, as evidenced by the increase in image sharing and self-monitoring behavior. The Patient Connect application facilitated the collection and analysis of data, which was instrumental in improving patient behaviour and health outcomes by providing real-time feedback and enabling timely communication through wound status updates with healthcare professionals.

Patients using the DWCS application exhibited a high frequency of engagement with the AI software, submitting an average of 13 pictures, or one image every 8 days to clinicians throughout the duration of their wound care. Additionally, a median wound closure rate of 80% was achieved across all patients and wound types. These results illustrate both the Patient Connect application's usability, thereby enabling for better adherence and health outcomes, in addition to its diverse applicability across varying chronic wound types. Clinical decisions within wound care may be delayed without adequate history. Patients in the study enabled a better record of the wound's response or lack of response to treatment that may support more timeline adjustments in care, which could be better understood through future research.

Interestingly, our results align with findings from other smartphone-based AI treatment platforms. For instance, Labovitz and colleagues demonstrated that, among patients with recently diagnosed ischemic strokes receiving anticoagulants, real-time monitoring via a smartphone-based AI application led to significantly improved medication adherence [16]. This intervention resulted in a 50% increase in adherence rates compared to the standard care control group, as measured by plasma drug concentration levels.

Our findings also align with previously published results demonstrating the potential of the patient-centered digital wound care technology for remote wound monitoring. For example, a case study by Kong et al. (2021) highlighted the successful application of the DWCS technology in the management of a male patient with type 1 diabetes and multiple comorbidities, including chronic kidney disease and a prior toe amputation [17]. Initially managed for osteomyelitis of a chronic foot ulcer via text and email, the patient transitioned to using the DWCS Patient Connect app for monitoring and management between June 2020 and January 2021. Over seven months, the patient submitted 39 wound images—a nearly twenty-fold increase in the sharing of wound-related data compared to the situation before using the application—enabling the tracking of accurate measurements of two additional wounds. The app fostered patient engagement through weekly assessments, promoting self-examination and preventive behaviours such as infection and trauma monitoring and off-loading of wound pressure through orthotics. Remote follow-ups reduced healthcare visits, alleviating patient anxiety by minimizing direct contact and enhancing physicians' confidence to deliver effective care remotely. Streamlined workflows and the use of images captured during dressing changes further saved time and costs, demonstrating the app’s potential to optimize wound management and expand care capacity. The patient also found the app “educational and empowering”, highlighting the ability of patient-centred technology to improve patient sentiment and better engage individuals with their wound care treatments.

In Kong and colleagues' case study [17], patients expressed concerns about sharing wound images via standard messaging platforms, highlighting a common issue with smartphone-based remote care strategies: the security of patient data [18]. Before transitioning to the app, the patient, despite having direct access to their physician, felt that sending images could impose on the physician’s time. Additionally, the patient was uncomfortable with the idea that the images would be transmitted through standard messaging and stored on the physician's smartphone, raising privacy and data security concerns. In contrast, by storing images captured using the app on secure cloud-based servers, this reduced the patient’s anxiety towards sharing images and facilitated the physician’s ability to rapidly and securely receive images.

While the sample size is small, this pilot study provides promising results regarding the generalizability of the Patient Connect app. Our findings demonstrate that the app can be effectively used across various types of wounds and healthcare settings. It has been utilized in hospital departments, such as the Division of Infectious Diseases at the Jewish General Hospital, as well as in ambulatory settings, including ostomy care and pressure ulcer prevention at Centenary Hospital, Scarborough Health Network, and Ontario Health at Home.

Future studies are needed to rigorously evaluate the time savings associated with the use of the app, such as reductions in days lost due to unplanned hospital admissions or the average number of missed workdays. Additionally, research should investigate whether incorporating the app as part of a remote wound care strategy can deliver care that is comparable to or even superior to standard in-person appointments by measuring median days to heal and wound complication rates. Beyond clinical outcomes, the app's potential to reduce patient costs related to travel, time off work, and other logistical burdens associated with frequent healthcare visits highlights its value in remote care settings. Such insights will be critical in validating the app’s role in enhancing accessibility, efficiency, and cost-effectiveness in wound care. Additionally, we are currently exploring the potential use cases of our technology for post-surgical sites, aiming to evaluate the effectiveness and feasibility of patient-centred wound images to detect infection. Understanding the potential use cases of generative AI for patient support may also be a worthwhile avenue for further exploration, for example, summarizing the AI/CV analysis of the images captured by patients and providing information on the next steps (e.g., clinician follow-up or continued self-management). AI and CV technology may offer patients and caregivers meaningful tools that empower them to understand better their condition, treatment options, and progress addressing gaps that chronic wounds face due to falling outside of a medical specialty.

5. Limitations

This study was limited to a targeted patient group of 28 individuals across two hospitals, which may restrict the generalizability of our findings. Additionally, images were collected from various types of wounds; however, further research is needed to evaluate the applicability of the technology for complex versus simple wounds and location of wounds. For example, situations may exist where caregiver support would be necessary like for wounds in inaccessible locations that may require caregiver support for picture capturing and wound monitoring. Furthermore, the application's usability may have been influenced by the varying levels of experience that patients and caregivers had with technology. Differences in technological proficiency were neither standardized nor accounted for in this study. Additionally, the study only included patients using iOS devices, potentially excluding the experience from a broader population who use Android or other platforms.

6. Conclusion

AI-powered medical tools exhibit tremendous potential in their ability to promote treatment optimization, patient satisfaction, treatment adherence, and overall health outcomes. Our pilot study found numerous clinical benefits using the novel patient-centred, CV-powered mobile application for chronic wound assessment. Similarly, the regular image capture by patients enabled physicians to conduct real-time wound assessments, thereby increasing patient adherence to management plans, as evidenced by an 80% wound closure rate within the participating sample. Considering the potential for technologies like the Patient Connect app to positively impact patient behaviour and involvement within their own healthcare treatment journeys by collecting data that benefits their own self-awareness and clinical decision-making, future research should be conducted to understand the clinical, operational, and financial outcomes impacted by patient self-monitoring of wounds and chronic wounds. Factors that would help the widespread adoption of this innovation include more evidence-based research from larger patient populations to demonstrate the application’s effectiveness and benefits in helping deliver remote care, patient education on the use of applications and general improvements in specific populations (e.g. the elderly) familiarity with technology; and access to high-speed internet, especially for rural populations.

7. Figures and Tables

Table 1: Patient characteristics. Data is presented as mean ± sd, median and range, or proportions

Variable	N = 28
Age	66.4 ± 18.5
Gender	Female = 14 (52%) Male = 13 (48%)
Type of lesion	Diabetic ulcer = 14 (52%) Venous ulcer = 7 (26%) Pressure ulcer = 4 (15%)

	Postsurgical = 2 (7%)
Median initial wound size (cm²)	3.71 (range 0.48 to 27.91)
Median follow up time (months)	3 (range1 to 9)
Median number of images submitted	13 (range 4 to 45)
Average time between images (days)	8 (range 3 to 14)
Percentage of wound closure achieved	80% (range 15 to 100%)

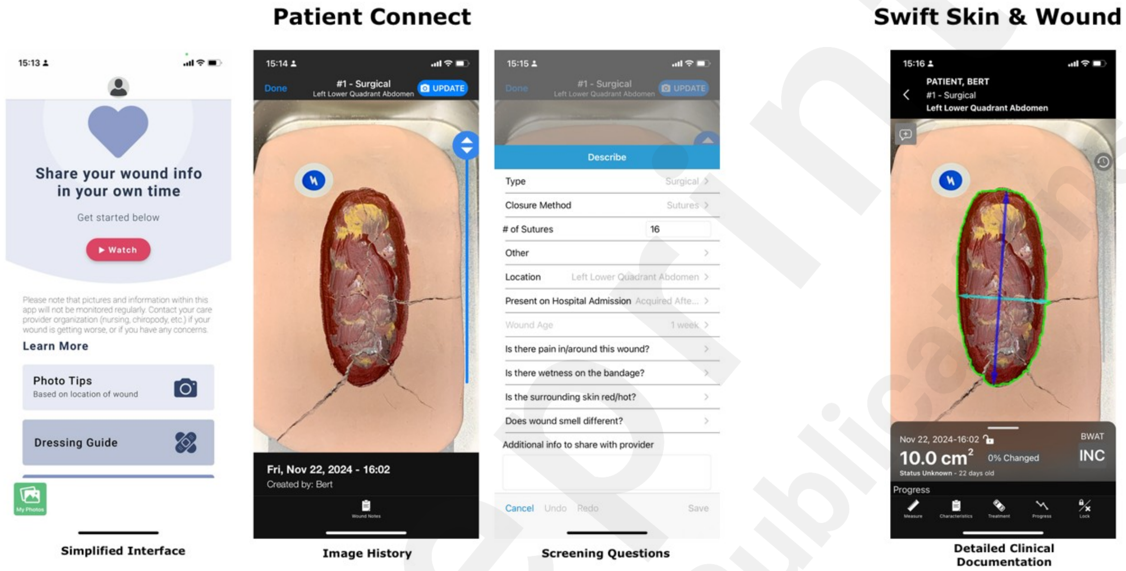

Figure 1. A simulated wound is used to illustrate the difference between the patient-facing mobile application and the clinician mobile applications. The patient user experience is simplified and provides educational content to support image capture and wound care best practices. The patient image history shows only images and access to information the patient submitted in the documents section, which includes basic screening questions for signs of infection and a free text (third image from the right). The clinician app has standardized documentation for wound assessment, treatment and progress to be documented. The AI/CV outputs are displayed to support clinical decision making.

Figure 2. A case series of a post-operative wound. First image on the left was captured by the clinician. Then the patient was taught to capture images and a second image the same day was documented. The two images on the right half show follow up monitoring submitted by the patient as the wound closed.

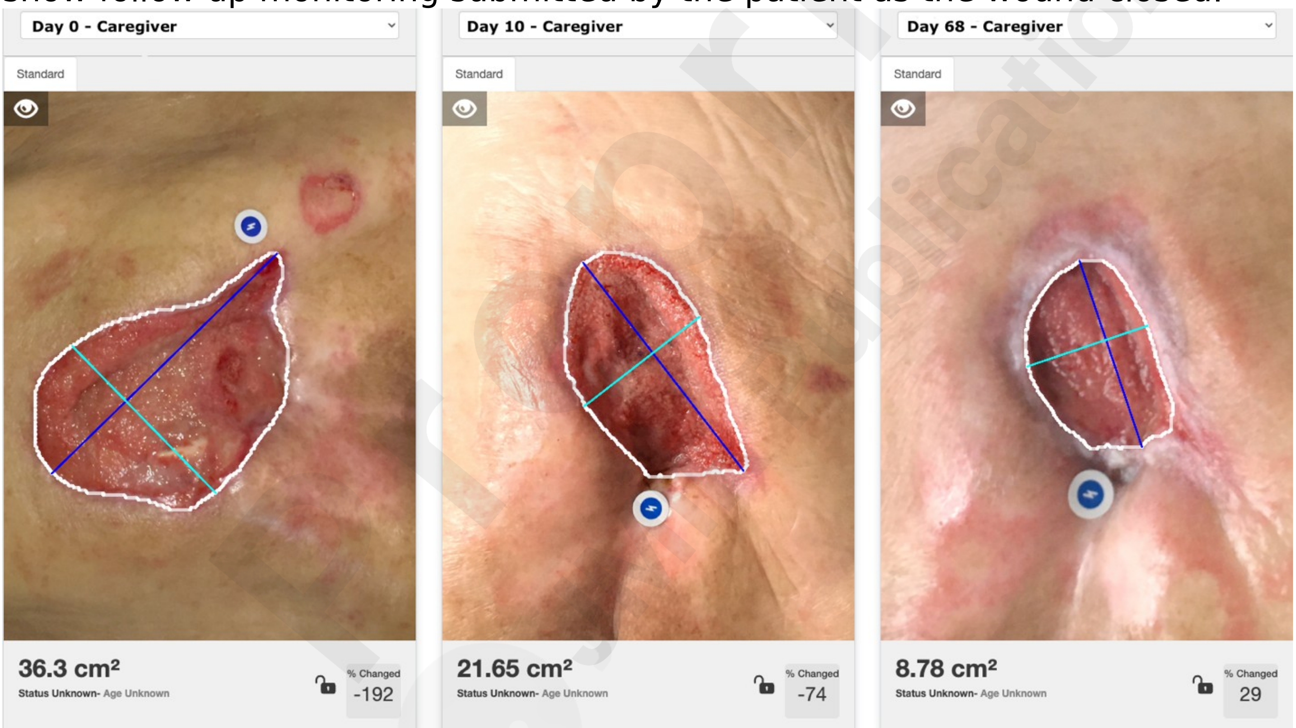

Figure 3. A case series of a hard-to-heal wound on the sacrum imaged by a caregiver during the patient journey. Images have adequate lightening, focus, colour correction, and AI/CV-based measurement is shown to the clinician monitoring the wound remotely.

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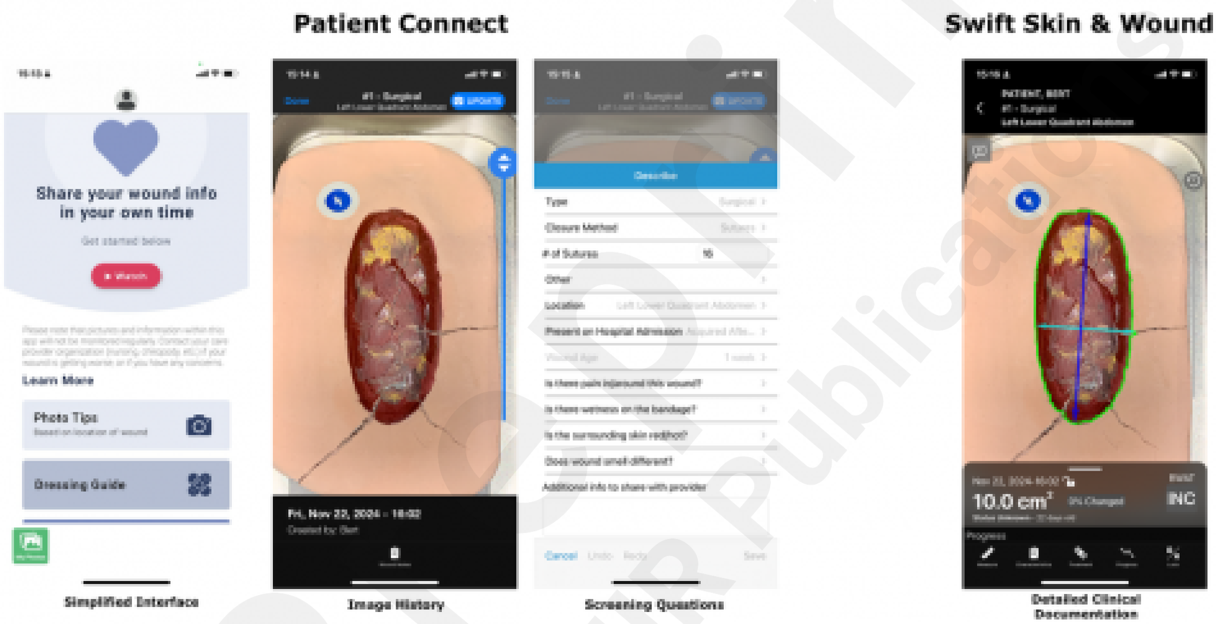
Supplementary Files

Figures

A simulated wound is used to illustrate the difference between the patient-facing mobile application and the clinician mobile applications. The patient user experience is simplified and provides educational content to support image capture and wound care best practices. The patient image history shows only images and access to information the patient submitted in the documents section, which includes basic screening questions for signs of infection and a free text (third image from the right). The clinician app has standardized documentation for wound assessment, treatment and progress to be documented. The AI/CV outputs are displayed to support clinical decision making.



A case series of a post-operative wound. First image on the left was captured by the clinician. Then the patient was taught to capture images and a second image the same day was documented. The two images on the right half show follow up monitoring submitted by the patient as the wound closed.

A case series of a hard-to-heal wound on the sacrum imaged by a caregiver during the patient journey. Images have adequate lightening, focus, colour correction, and AI/CV-based measurement is shown to the clinician monitoring the wound remotely.