

# An Equitable Vision For Wound Assessment: A Comparative Case Study Of AI And Human Wound Tissue Assessment Across Skin Tones

**Heba Tallah Mohammed PhD MD, Sheila Wang PhD, Samia Rahman BSc, Ryan SQ Geng MSc, Kaitlyn Ramsay PhD, Samantha Bestavros BSc, Katerina Bavaro HBSc, Robert DJ Fraser MN RN WOCOC NSWOC**

**Abstract:** Accurate wound assessment is crucial for effective wound management, but visual assessment can be inconsistent due to various clinician (e.g., knowledge, skill) or patient (e.g., skin tone) factors. This study compares clinicians' subjective assessments of wound tissues with those made by an artificial intelligence (AI) model (SmartTissue™) across different skin tones. The study highlights the subjective nature of manual wound assessments and the potential value of AI-driven documentation in clinical practice. The integration of AI technology could offer clinicians real-time data aiding in standardizing measurements across diverse populations to reduce racial disparities in wound care. By providing consistent, standardized measurements across diverse patient populations, AI can support clinical judgment in evaluating wound healing, monitoring treatment efficacy and revising care planning.

**Key words:** *wound assessment, wound tissue, skin tones, artificial intelligence (AI), real time data*

**How to cite:** Mohammed HT, Wang S, Rahman S, Geng R, Ramsay K, Bestavros S et al. An equitable vision for wound assessment: a comparative case study of AI and human wound tissue assessment across skin tones. *Limb Preservation Journal*. 2025;6(1): 37-43. DOI: [10.56885/061916taiknw](https://doi.org/10.56885/061916taiknw)

Chronic wounds pose a significant challenge in health care, affecting millions of people worldwide and placing a substantial burden on health-care systems. An estimated 1-2% of the population in developed countries are affected by chronic wounds, with prevalence rates as high as 6% reported in some studies.<sup>1,2</sup> These treatment-resistant wounds, such as venous and arterial ulcers, impact patients' quality of life and impose a considerable financial burden on society.<sup>3</sup>

The accurate assessment of wound healing trajectory is crucial for effective wound management. This process relies heavily on the clinician's ability to identify and quantify different tissue types present in the wound bed, including slough, eschar, epithelialization, and granulation tissue.<sup>4</sup>

Despite the importance of accurately identifying and quantifying tissue types within wounds, several factors contribute to variability in clinician visual assessment, including knowledge gaps, visual perception limitations and skin colour.<sup>5</sup>

Clinicians may have varying expertise and training in identifying different tissue types, leading to inconsistent assessments.<sup>5</sup> Furthermore, wound care assessment training is often tailored to fair skin colour, while darker skin tones may influence the appearance of tissue colours within the wound bed.<sup>6</sup> Additionally, the human eye and brain are unsuited for accurately quantifying and segmenting tissue types, especially in complex, irregular shapes like wounds.<sup>7</sup> These limitations can hinder subjective assessments in accurately assessing tissue types.

These challenges can lead to inconsistent assessments, potentially impacting treatment decisions and patient outcomes. The variability in human assessment of wound tissues is a significant concern, as it can result in suboptimal care and delayed healing.<sup>8</sup> Therefore, there is a growing interest in developing more objective and consistent methods for wound assessment. Artificial intelligence (AI) and machine learning techniques have shown promise in improving the accuracy and consistency of wound evaluation.<sup>9,10</sup>

Swift Medical's (Toronto, Canada) AI tissue classification model (SmartTissue™) used 17,000 labelled images and 465,187 training images to predict tissue types to develop a classification algorithm.<sup>11</sup> Validation of the model found a high degree of intersection of the areas clinicians traced using software to estimate tissue types and rated 91% of reviewed SmartTissue™ predictions as 'very good to fair'.<sup>11</sup> These technologies have the potential to overcome the limitations of human visual assessment and provide more reliable data for clinical decision-making.<sup>11</sup> Research on creating a wound severity score using machine learning compared models and made better predictions when using AI model predictions for wound tissue types as inputs compared to clinician's assessment data.<sup>12</sup>

This exploratory case study aims to emphasize the variability in clinical assessment of wound tissues by assessing clinicians' subjective assessments and ratings of tissue types compared to those made by an AI model, demonstrating the potential benefits of integrating technology into wound care practice.

## Methods

An exploratory case study was conducted by administering an online survey to 20 wound care clinicians with varying levels of expertise in wound care. We employed purposive non-random sampling to recruit clinicians at the Nurses Specialized in Wound, Ostomy and Continence Canada (NSWOCC) conference. The survey encompassed questions about clinicians' clinical experience, practice, education and wound care training. Subsequently, clinicians evaluated non-

identified wound images from patients with diverse skin tones and wound complexities. Each clinician was tasked with identifying and estimating the different tissue types within each wound, such as granulation, slough, eschar and epithelialization, and their percentage composition.

Clinicians were asked to estimate the proportions of each tissue type within a wound, and these estimates were aggregated and averaged. The mean rating of each tissue type within a wound was then compared to ratings previously recorded for the same wound image using SmartTissue™ (referred to as the AI model or AI). Wounds were categorized as complex if they displayed a combination of diverse tissue types, and as non-complex if the wound presented with one or more tissue types. The Fitzpatrick scale was used to describe skin tone, with images classified as type I/II group for light/fair skin tone or type V/VI group for dark-darkest brown skin tone.

## Results

Of the 20 clinicians surveyed, 70% (14/20) were nurses, while the remaining 30% (6/20) comprised physicians and medical residents. Location of practice included 50% (10/20) hospitals, 40% (8/20) ambulatory clinics and 10% (2/20) home care and long-term care facilities. Additionally, 75% (15/20) of the clinicians were wound care specialists and 65% (13/20) of the participants had received advanced wound and ostomy training, with an average of 13.75 years of wound care experience.

## Study Overview

Exploratory case study comparing clinician assessments of wound tissues with AI-driven SmartTissue™ technology

20 wound care clinicians, with an average of 13.75 years of wound care experience, evaluated wound images from patients with a range of skin tones

### Key Findings

- Clinicians frequently overestimated slough and granulation tissue
- Epithelialization was often underestimated, particularly in patients with darker skin tones
- Eschar was commonly reported by clinicians, even when not detected by AI

### Implications for Practice with AI integration

- AI can enhance accuracy in wound assessments by correctly identifying tissue types across diverse skin tones, leading to more reliable evaluations
- Offers potential to reduce racial disparities in wound care by providing more precise and unbiased assessments, enabling more effective treatment planning

### Future Directions

- Longitudinal studies are needed to evaluate the impact of AI technology on wound healing outcomes
- Emphasizes the need to develop educational tools that address diverse skin tones in wound care training and assessment

### Take-Home Message

- AI-driven wound assessment tools hold promise for standardizing wound evaluations, reducing bias, and improving care for patients of all skin tones.

**Table 1:** Summary of AI and clinicians' outputs and differences in observations

	<b>Patient 1: Complex wound (Light skin tone)</b>	<b>Patient 2: Complex wound (Dark skin tone)</b>	<b>Patient 3: Non-complex wound (Dark skin tone)</b>
<b>Clinicians Assessment</b>			
Granulation	35.04% (10 - 50%)(±12.80)	23.30% (3 - 60%) (±14.26)	81.00% (0 - 100%) (±26.98)
Slough	61.78% (17 - 90%) (±18.33)	52.80% (20 - 90%)	7.70% (0 - 74%)
Eschar	5.20% (2 - 41%)	10.71% (0 - 30%)	0.00% (0 - 100%)
Epithelialization	36.94% (0 - 26%)	8.53% (0 - 36%)	7.15% (0 - 56%)
<b>AI Prediction</b>			
Granulation	30.64%	13.25%	44.00%
Slough	47.94%	41.22%	0.30%
Eschar	0.00%	0.00%	0.00 %
Epithelialization	21.42%	45.53%	55.50%
<b>Difference</b>			
Granulation	+4.40%	+10.05%	+37.00%
Slough	+13.84%	+11.58%	+7.40%
Eschar	+5.20%	+10.71%	0.00%
Epithelialization	+15.20%	-36.98%	-48.35%

Table 1 provides a comparative analysis of wound tissue assessments for the three patients with varying wound complexities and skin tones. The table displays the mean percentages of four tissue types (granulation, slough, eschar and epithelialization) as estimated by 20 clinicians and predicted by the AI model. Clinician assessment includes mean, minimum and maximum values (mean% [standard deviation]), reflecting variability across clinicians' evaluations. AI predictions are shown as a single percentage (%), derived from one measurement. The differences in the mean value of the clinician assessment compared to the AI prediction (clinician – AI) are also shown, highlighting discrepancies across wound types and skin tones

### Patient 1: Complex Wound In A Light Skin-Tone Patient



**Figure 1:** Patient 1 is an example of a non-complex wound in a patient with light skin tone (Fitzpatrick type I/II)

In the first case, the AI model was used to assess a complex wound in a patient with a light skin tone. The AI analysis predicted that the wound consisted of 30.64% granulation tissue, 47.94% slough, 0% eschar and 21.42% epithelialization.

A comparison of the AI measurements with those taken by clinicians revealed significant variations. On average,

clinicians estimated 4.40% more granulation tissue, 13.84% more slough and 15.52% more epithelialization tissue than the AI. Furthermore, clinicians reported the existence of eschar, while the AI detected none, estimating a 5.20% composition.

Overall, clinicians consistently reported more slough and less granulation and epithelialization. The deviation of clinicians' measurements to the AI ratings indicated a high degree of variability and inconsistency in their assessments of tissue types when in comparison, the AI model provided consistent, standardized measurements.

### Patient 2: Complex Wound In A Dark Skin-Tone Patient

In this case, the AI model analyzed a complex wound in a dark-skin tone patient and estimated 13.25% granulation tissue, 41.22% slough, 0% eschar and 45.53% epithelialization.

The clinicians' assessments showed wide variations. The average of the clinicians' measurements for granulation tissue was 23.30%, a 10.05% increase

from the AI's estimate. Clinicians' estimates of slough were 52.80%, which was 11.58% higher than the AI's estimate. Eschar was identified by clinicians at an average of 10.71%, while the AI model did not report eschar as present. Clinicians estimated epithelialization at 8.53%, which was 36.98% lower than the AI model's measurement.

Consistent with Patient 1's assessment, clinicians reported higher levels of eschar, slough and granulation tissue, and less epithelialization, highlighting discrepancies when compared to the AI model's assessments.



**Figure 2:** Patient 2 is an example of a complex wound in a patient with dark skin tone (Fitzpatrick type V/VI)

### Patient 3: Non-Complex Wound In A Dark Skin-Tone Patient

This patient presented with a non-complex wound and had a dark skin tone (Fitzpatrick type V). Upon analysis by the AI model, the wound was found to have 44% granulation tissue, 0.3% slough, 0% eschar and 55.5% epithelialization.

The clinicians' assessments differed notably from the AI's findings. Clinicians reported 37% more



**Figure 3:** Patient 3 is an example of a non-complex wound in a patient with dark skin tone (Fitzpatrick type V/VI)

granulation tissue than the AI's assessment. Their estimation of the slough was 7.4% higher than the AI's findings. Epithelialization was notably different, with clinicians reporting 48.35% less than the AI model.

Overall, clinicians tended to provide higher estimates of eschar and consistently lower estimates of the percentage composition of epithelial tissue. This case underscores the considerable variability in how clinicians assess wound tissue types, even in less complex wounds.

## Discussion

This case series presented data on the differences in clinician manual wound assessments versus evaluations conducted by the AI wound assessment technology. Across all cases, clinicians frequently identified the presence of eschar when it was not predicted by the AI, overestimating its occurrence in wounds. Additionally, clinicians consistently noted elevated levels of slough and granulation tissue. This pattern of frequently reporting specific tissue types, especially eschar, along with the significantly wide standard deviation among clinicians, underscores the inconsistencies and variations among clinicians. Such discrepancies could result in unnecessary interventions or the adoption of more aggressive treatment strategies than necessary. Conversely, epithelialization, a crucial indicator of wound healing progress often characterized by subtle colour changes in the wound bed, was consistently underestimated by clinicians – particularly in darker skin tones. This highlights the need to acknowledge the potential inaccuracies in visual assessment across diverse skin tones and their potential effects on evaluating healing in patients with darker skin tones. This aligns with the existing literature indicating that clinicians might face more challenges in visually differentiating between different tissue types in people with darker skin tones.<sup>13,14</sup> This difficulty arises from the challenges in identifying discolouration and other subtle changes on dark skin, which makes it harder to distinguish between necrotic and healthy tissue.<sup>13,14</sup>

On the other hand, the AI model was trained

with deep learning on hundreds of thousands of images to consider complex wound tissue characteristics, wound bed and background.<sup>11</sup> Using a consistent model, which can continue to be improved with new clinical data, can address subjective visual cues susceptible to the human bias of the clinician (e.g., knowledge, skill, experience, fatigue, previous cases) and patient factors (e.g., skin tone, environment) to offer more precise segmentation and quantification of tissue types. This underscores the potential for AI to be used to standardize wound assessments across diverse skin tones. AI models can also be improved by using additional training data and algorithm performance enhancing techniques. The provision of access to standardized assessment tools that can be improved over time, as can assessment skills that were previously constrained by educational programs.

The differences in how clinicians assess wounds compared to the AI model, especially when identifying eschar and epithelialization, raise concerns about the subjective nature of these evaluations. These disparities exist because many wound care protocols and educational tools primarily focus on lighter skin tones, resulting in gaps in clinical training for assessing wounds on darker skin.<sup>6</sup> These inconsistencies could potentially impede accurate tracking of wound progress, leading to delayed interventions or inappropriate treatments, especially for patients with darker skin tones.<sup>6</sup>

It is important to address racial disparities and strive for equity in wound care. Previous studies have highlighted that patients with darker skin face a higher risk of misdiagnosis and delayed wound healing due to perceptual challenges.<sup>15</sup> Recent studies have highlighted that AI technologies play a valuable role in improving diagnostic accuracy and minimizing variability in clinician assessments, particularly in the field of wound care.<sup>16</sup> The integration of AI technology into clinical practice can offer more consistent and unbiased wound assessments across diverse skin tones, potentially playing a crucial role in reducing racial disparities in wound care outcomes. By incorporating such features, health-care providers can ensure that all

patients receive accurate assessments irrespective of their skin tone, thus promoting equitable wound care.

The future of clinical practice increasingly relies on integrating AI models to enhance clinical expertise, providing a more nuanced and data-driven approach to patient care.<sup>17</sup> These tools will not replace clinicians and instead can empower clinicians to make better treatment decisions and provide more effective care.

### Limitations

The case study's exploratory nature and limited sample size make it difficult to generalize findings to a broader population or various wound types. Furthermore, while the study recruited clinicians with wound care training and experience in wound care assessment, the study was unable to account for clinicians' familiarity with identifying tissue types in diverse skin tones.

Additionally, the study only utilized wound images, which may not fully capture the complexity of wounds in clinical practice where factors such as depth and exudate can also influence tissue type identification.

A limitation of this study, and of the field of wound assessment in general, is the lack of a universally accepted gold standard for wound tissue classification. While the AI model shows promise in providing consistent measurements, further research is needed to establish a reliable gold standard against which both human and AI assessments can be validated.

In the future, it would be beneficial to conduct longitudinal studies to assess different tissue types using AI technology and to track wound healing progress over time. These studies could offer valuable insights into how AI technology can enhance clinician assessment and its impact on clinical outcomes.

### Conclusion

This case study underscores the inherent subjectivity in visual wound assessments and emphasizes the critical importance of accurate tissue typing. It reveals the pressing need for

more objective clinical tools, especially when assessing diverse patient populations where skin colour variations can significantly impact visual evaluations.<sup>5</sup> The integration of AI-driven wound documentation into clinical practice offers a promising solution, providing clinicians with real-time, standardized data that can enhance the accuracy of tissue identification across all skin tones. This technological advancement has the potential to significantly improve wound care assessment and delivery for patients of all racial backgrounds. By augmenting clinical judgment, AI allows health-care professionals to focus their expertise on crucial aspects of patient care, including evaluating wound healing trajectories, monitoring treatment effectiveness and optimizing care planning and delivery. Ultimately, the adoption of AI in wound care represents a step towards more equitable, consistent and effective wound management practices.

**Heba Tallah Mohammed PhD MD** is with Swift Medical Inc., Toronto, Ontario, Canada.

**Sheila Wang PhD** is with Swift Medical Inc., Toronto, Women's College Hospital, Toronto and University of Toronto, Ontario, Canada.

**Samia Rahman BSc** is with the Faculty of Medicine and Dentistry, University of Alberta, Edmonton, Alberta, Canada.

**Ryan SQ Geng\* MSc** is with the Temerty Faculty of Medicine, University of Toronto, Ontario, Canada.

**Kaitlyn Ramsay\* PhD** is with the Temerty Faculty of Medicine, University of Toronto, Ontario, Canada.

**Samantha Bestavros\* BSc** is with the Temerty Faculty of Medicine, University of Toronto, Ontario, Canada.

**Katerina Bavaro\* HBSc** is with the Michener Institute of Education at University Health Network, Toronto, Ontario, Canada.

**Robert DJ Fraser MN RN WCCC© NSWCCC** is with Swift Medical Inc., Toronto, Ontario, Canada and Western University, London, Ontario, Canada.

\*These authors contributed equally to this work

**Corresponding author:** Robert D.J. Fraser, MN RN, Swift Medical, 1 King St W Suite 4800 .Toronto, Ontario, M5H 1A1 Canada.  
Email: Rob.fraser@swiftmedical.com

## References

1. Järbrink K, Ni G, Sönnergren H, Schmidtchen A, Pang C, Bajpai R, et al. The humanistic and economic burden of chronic wounds: A protocol for a systematic review. *Syst Rev*. 2017;6(1):15.
2. Phillips CJ, Humphreys I, Fletcher J, Harding K, Chamberlain G, Macey S. Estimating the costs associated with the management of patients with chronic wounds using linked routine data. *Int Wound J*. 2016;13(6):1193-7.
3. Sen CK, Gordillo GM, Roy S, Kirsner R, Lambert L, Hunt TK, et al. Human skin wounds: A major and snowballing threat to public health and the economy. *Wound Repair Regen*. 2019;17(6):763-71.
4. Lazarus GS, Cooper DM, Knighton DR, Margolis DJ, Pecoraro RE, Rodeheaver G, et al. Definitions and guidelines for assessment of wounds and evaluation of healing. *Wound Repair Regen*. 1994;2(3):165-70.
5. Dhoonmoon L, Harikrishna KR, Abbas Z. Wound care and skin tone: Addressing skin tone bias in wound assessment. *Wounds Int*. 2023.
6. Edwards K, Hurd Y. Addressing racial disparities in pressure injury care. *J Wound Care*. 2019;28(9):604-10.
7. Vera MD. Wound assessment and documentation: practical guidance for health care professionals. Woundsource. Available from: [https://www.woundsource.com/sites/default/files/whitepapers/wound\\_assessment\\_and\\_documentation.pdf](https://www.woundsource.com/sites/default/files/whitepapers/wound_assessment_and_documentation.pdf).
8. Stotts NA, Rodeheaver GT, Thomas DR, Frantz RA, Bartolucci AA, Sussman C, et al. An instrument to measure healing in pressure ulcers: development and validation of the pressure ulcer scale for healing (PUSH). *J Gerontol A Biol Sci Med Sci*. 2001;56(12).
9. Wang C, Yan X, Smith M, Kochhar K, Rubin M, Warren SM, et al. A unified framework for automatic wound segmentation and analysis with deep convolutional neural networks. In: 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); 2015. p. 2415-8.
10. Kim RB, Moscoso-Kingsley W, Hirata R, Voronov L, Patel J. Utilization of smartphone and tablet camera photographs to predict healing of diabetes-related foot ulcers. *Comput Biol Med*. 2020;126:104042.
11. Ramachandram D, Ramirez-GarciaLuna JL, Fraser RDJ, Martínez-Jiménez MA, Arriaga-Caballero JE, Allport J. Fully automated wound tissue segmentation using deep learning on mobile devices: cohort study. *JMIR Mhealth Uhealth*. 2022;10(4).
12. Gupta R, Goldstone L, Eisen S, Ramachandram D, Cassata A, Fraser RDJ, et al. Towards an AI-based objective prognostic model for quantifying wound healing. 2022.
13. National Pressure Injury Advisory Panel (NPIAP), European Pressure Ulcer Advisory Panel (EPUAP), Pan Pacific Pressure Injury Alliance (PPPIA). Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. 2019.
14. Yap TL, Kennerly SM, Simmons MR. The economic impact of deep tissue injury in healthcare systems: litigation and beyond. *J Wound Care*. 2021;30(3):171-9.
15. Levine JM, Ayello EA, Zulkowski K. Preventing pressure ulcers in women: sex-specific interventions based on risk assessment. *Adv Skin Wound Care*. 2013;26(4):161-5.
16. Shamloul A, Daskalopoulou SS, Daskalopoulos G. The surge of digital wound care technologies: an emerging tool in clinical practice. *Br J Dermatol*. 2019;181(6):1155-7.
17. Subbiah V. The next generation of evidence-based medicine. *Nat Med*. 2023;29:49-58.

## SUBMIT YOUR POSTER ABSTRACT FOR THE **2025 WOUNDS CANADA** **NATIONAL HYBRID CONFERENCE** OCTOBER 2-4, 2025 | TORONTO, ON

We invite you to share information about activities/projects related to the promotion of skin health, and/or the assessment, prevention and management of wounds in a broad range of areas:

**RESEARCH | EDUCATION**  
**HEALTH POLICY | CLINICAL PRACTICE**

Abstract content should represent new findings and/or recent work that has not been previously published.

**SUBMISSION DEADLINE:**  
**JUNE 16, 2025 AT 11:59 P.M. EDT**

**CLICK HERE FOR MORE INFORMATION >**

**NOW  
OPEN!**



**WoundsCANADA**.ca  
30 years supporting skin health and wound care