Wound Measurement, Score

Katherine M. Marsh and Ersilia L. Anghel

1 Introduction

Wound assessment is an important aspect of monitoring wound progression to healing and the efficacy of treatment. There are many aspects that contribute to wound assessment including wound size, wound edge, site, wound bed, the presence of necrotic tissue, wound depth, surrounding skin, the presence of infection, and pain [1]. Of these variables, wound measurement is a helpful quantitative finding that provides a practical approach to track wound healing. In fact, specific measurements such as wound measurement were the most frequently used outcome measure across research studies involving chronic wounds [2]. Changes in wound measurement can also be used as a predictive tool for wound resolution, particularly if used early in the course [3, 4].

Though there is currently no gold standard technique to quantitatively evaluate wound healing, manual metric measurement has historically been most often utilized. More recently, software-based and advance device-based methods were developed to provide more accurate and precise measurements. Digital alternatives including digital planimetry, stereophotogrammetry, and other digital imaging methods have now become preferred measurement techniques over traditional manual metric measurement.

K.M. Marsh, M.D.
Department of Surgery, University of Arizona, Tucson, AZ, USA

E.L. Anghel, M.D. (✉)
Division of Plastic Surgery, Oregon Health and Sciences University, Portland, OR, USA
e-mail: eanghel@email.arizona.edu

2 Techniques

In general, there are six main approaches for measuring wound area (Table 1). These include manual metric measurement, mathematical models, manual planimetry, digital planimetry, stereophotogrammetry, and digital imaging methods [5]. Other less common methods include the volume-based method [6], bipolar bioimpedance measurement [7], histogram planimetry [8], or high-frequency ultrasound [9, 10].

2.1 Manual Metric Measurement

Wound measurement has traditionally been completed using a ruler-based technique. This method typically involves using a ruler to measure the longest length and widest width of a wound and then multiplying these two numbers to estimate wound area. It is quick, convenient, simple, and inexpensive. However, manual metric measurement not only has shown poor inter-rater reliability [11], but it is also inaccurate and tends to overestimate wound size [12, 13]. Furthermore, the measurements tend to become even less reliable as wounds became larger and more irregularly shaped [14].

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Table 1 Summary of the advantages and disadvantages of the six most common wound measurement techniques

Technique	Advantages	Disadvantages
Manual		
Manual metric measurement	Cost efficient Time efficient	Unreliable Overestimates size
Mathematical models	Cost efficient Time efficient	Unreliable Underestimates size
Manual planimetry	Accurate and reliable	Requires wound contact Time-consuming
Digital		
Digital planimetry	Accurate and reliable	Time-consuming
Stereophotogrammetry	Accurate and reliable	High cost Time-consuming
Digital imaging	Accurate and reliable Time efficient	Poor depth measurement

Regardless of the evidence against manual metric measurement, there is no current gold standard for wound measurement. Therefore, most studies are compared to this technique, and it is still widely in use today.

2.2 Mathematical Models

Manual metric measurement typically involves multiplying the measured length and width of the wound. This formula assumes the wound is a rectangular or square shape. Mathematical models such as the elliptical method apply basic geometric principles to calculate the area of an elliptical instead, as most wounds are closer to an elliptical shape. This method involves measuring the shortest and longest radii of the wound and using the following formula: $\text{Area}\,(\text{mm}^2) = \text{Length}\,(\text{mm}) \times \text{Width}\,(\text{mm}) \times 0.25 \times \pi$ [15]. While manual metric measurement generally overestimates size, the elliptical method often underestimates size in small wounds [16].

2.3 Manual Planimetry

Another manual measurement technique method is acetate tracing/contact planimetry. Manual planimetry involves placing a transparency with a metric grid above a wound and counting the number of square centimeters within the wound perimeter. Inter- and intrarater reliability are higher than the manual metric measurement, though still inferior to computerized or digitalized methods overall [17]. Since this method involves direct contact with the wound, several disadvantages exist including contamination of the wound bed and discomfort to the patient [18].

2.4 Digital Planimetry

Digital planimetry is similar to manual planimetry, though it involves using a computer to perform calculations instead of manually counting squares on a metric grid [19]. Overall, digital planimetry is more accurate and precise than manual planimetry, though both can be more time-consuming than other measurement methods [5, 20]. Digital planimetry devices such as Visitrak™ require contact with the wound and come with the same disadvantages of doing so [5]. This process involves tracing the wound onto a transparent sheet and then retracing the outline onto a digital device that calculates the surface area. However, some digital planimetry techniques require minimal or no wound contact [21, 22]. Noncontact digital planimetry is discussed further in the digital imaging section below.

2.5 Stereophotogrammetry

Unlike some planimetry methods, stereophotogrammetry using structured light devices does not require contact with the wound. In this method, a stereographical camera is used to take an image of the wound. The camera is linked to a computer, where the clinician then traces the wound perimeter using a cursor. The wound area, length, and width are calculated via the computer software, and wound size can be measured in two or three dimensions. Stereophotogrammetry with the 3D LifeViz™ camera was found to be as accurate as digital planimetry, and the wound measurements were taken significantly quicker [23]. However, overall stereophotogrammetry is still a time-consuming method, especially when compared to newer measurement methods.

2.6 Digital Imaging Methods

Digital imaging methods are similar to stereophotogrammetry and digital planimetry, where an image of a wound is captured and transferred to a computer. If the computer software uses a scale placed near the wound in the photo to estimate the area of the wound and then calculate the wound area, this is sometimes referred to as noncontact digital planimetry. This and other noncontact photographic methods have been found to be as accurate as traditional digital planimetry [24].

In addition to noncontact digital planimetry, there are multiple other types of digital imaging methods including optical imaging, hyperspectral imaging, thermal imaging, laser Doppler imaging, confocal microscopy, optical coherence tomography, and NIR spectroscopy imaging [25]. Other innovative wound measurement techniques involve a structured light or laser approach. Laser-assisted wound measurement devices do not require wound contact and involve the use of a digital camera and projected laser beams. The main limitation of this method is an artificially low measurement of wound depth, likely attributed to the decreasing resolution of imaging shallow wounds [26].

One laser-assisted device in particular has recently shown encouraging results [27]. The 3D wound measurement device, inSight (eKare Inc., Fairfax, VA), demonstrated high inter-rater and intra-rater values for both wound area and volume. It functions by retrofitting a standard iPad with an infrared laser and utilizing associated software to measure the wound. Similar to other laser-assisted wound measurement devices, the major limitation of the device is an accurate measurement of wound depth.

Besides the inSight (eKare Inc., Fairfax, VA) 3D wound measurement device, multiple other devices are also now in use. Other devices include Silhouette Mobile® system (ARANZ Medical, Christchurch, New Zealand) [28, 29], a smartphone wound measurement device (WMD) [30], SilhouetteStar™ (System E; ARANZ Medical, Christchurch, New Zealand) [26], VeV MD Vista Medical (Winnipeg, Manitoba, Canada) [31], and the TeleDiaFoS® (Nalecz Institute of Biocybernetics and Biomedical Engineering, Warsaw, Poland) [32, 33], to name a few. Overall, digital imaging devices have been superior to most other wound measurement methods by reducing clinician measurement variability and improving accuracy and reliability. Additionally, many of the devices are inexpensive and have the potential to integrate into patients' electronic medical records.

3 Discussion

Wound measurement is of particular value in the setting of diabetic foot ulcers, venous ulcers, pressure ulcers, burns, ostomy sites, and other postoperative sites such as amputations. Ideally, measurement techniques should maximize inter-rater and intra-rater reliability, account for anatomical variations, and allow for sequential wound assessment and documentation. Tracking wound area over time allows clinicians to assess responses to treatment and tailor intervention accordingly. Proper wound assessment is vital, particularly within the first 1–4 weeks of treatment. The total reduction in wound area during this time is a strong predictor of healing [3, 4, 34]. When assessing healing rate, the wound size measurements do not necessarily need to be accurate as long as they are reliable and the percent change can be followed [35]. Early identification of wounds with less percentage change and therefore less healing potential with standard therapy could ultimately direct clinicians to provide earlier or more aggressive interventions. Identifying these at-risk patients would likely lead to improved outcomes and lower cost, though these particular questions have not yet been studied.

The number of risk factors for poor wound healing is increasing as the population ages and lives with more comorbidities. These risk factors include diabetes, smoking, alcohol use, older age, male sex, heart failure, the inability to stand or walk without help, end-stage renal disease, larger wound size, history of poor wound healing, peripheral neuropathy, and peripheral artery disease [36–38]. Patients with the potential for poor healing can be identified, perhaps more aggressive treatments initiated, and wound progress tracked. Ideally, both treatment and wound monitoring would be individualized, conceivably using more involved wound measurement methods for at-risk patients.

Conclusions

Wound measurement is an important aspect of wound assessment, tracking progression to healing, and identification of at-risk patients. Multiple wound measurement techniques are available, with digital methods preferred due to higher accuracy and reliability. Newer devices significantly reduce clinician measurement variability and show potential for replacing commonly used manual metric measurement. With the emergence of new techniques and technology, there is a possibility of measuring more wound dimensions and is the topic of current study in the field.

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