Journal of Diabetes Science and Technology
Volume 4, Issue 4, July 2010

SYMPOSIUM

Digital Planimetry Results in More Accurate Wound Measurements: A Comparison to Standard Ruler Measurements

Lee C. Rogers, D.P.M.,[1] Nicholas J. Bevilacqua, D.P.M.,[2] David G. Armstrong, D.P.M., M.D., Ph.D.,[3] and George Andros, M.D.[1]

Abstract

Background:

Cutaneous wound measurements are important to track the healing of a wound and direct appropriate therapy. The most commonly used method to calculate wound area is an estimation by multiplying the longest length by the widest width. Other devices can provide an accurate and precise measurement of the true area (TA). This study aim was to compare wound areas calculated by computerized planimetry with standard area estimation by multiplying the longest length by the widest width ($l \times w$).

Methods:

We reviewed the wound records of 10 patients with circular or oval wounds and estimated the area with the $l \times w$ method. We compared this with the TA obtained by a specialized planimetric camera.

Results:

Average wound size was 4.3 cm^2 by $l \times w$ estimation and 3 cm^2 by TA calculation. We found the $l \times w$ method overestimated wound area an average of 41%.

Conclusions:

Standard, manual ($l \times w$) measurement of cutaneous wounds inaccurately overestimates wound area by roughly 40%.

J Diabetes Sci Technol 2010;4(4):799-802

Introduction

Cutaneous ulcers of various etiologies are common and can be problematic and costly to treat. One of the most basic determinations of wound improvement is a reduction in size from visit to visit. The reduction in wound area over time has been shown to predict wound healing in both venous leg ulcers[1] and diabetic foot ulcers.[2,3] There are many techniques used to measure the area or volume of wounds. The most simple and

Author Affiliations: [1]Amputation Prevention Center, Valley Presbyterian Hospital, Los Angeles, California; [2]North Jersey Orthopaedic Specialists, P.A., Teaneck, New Jersey, and [3]Southern Arizona Limb Salvage Alliance (SALSA), Department of Surgery, College of Medicine, University of Arizona, Tucson, Arizona

Abbreviation: (TA) true area

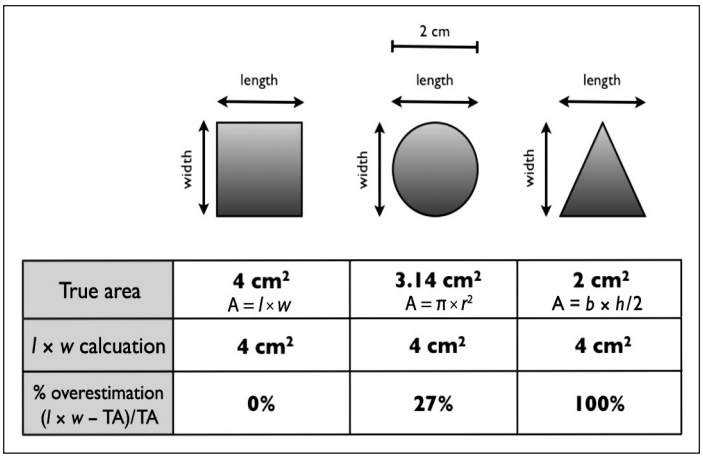
Keywords: planimetry, Silhouette, ulcer, wound measurement

Corresponding Author: Lee C. Rogers, D.P.M., Amputation Prevention Center, Valley Presbyterian Hospital, 15107 Vanowen Street, Los Angeles, CA; email address Lee.C.Rogers@gmail.com

standard technique calculates the area by multiplying the longest length by the widest width ($l \times w$) as measured by a ruler or tape measure. This technique is limited by subjective interpretation and interobserver variability.[4,5]

Another deficiency with this method is that wounds of various shapes and areas fit into the same linear $l \times w$ dimensions.[6] The measurement of $l \times w$ is only mathematically accurate for a square or rectangle. **Figure 1** illustrates the difference in $l \times w$ area estimation and true area (TA) for a square, a circle, and a triangle. The $l \times w$ calculation of area overestimates the TA of a circle by 27% and is double the TA of a triangle. Additionally, there are concerns with the possibility of unpredictable human error in the measurement of wounds with rulers.

Other more accurate devices utilized to measure the area of wounds are typically used in research trials. Planimetry uses a transparent film placed over the wound while the margins are traced. The investigator then calculates the area manually by counting the number of grid boxes filled or partially filled by the wound or the area is calculated by computer after digitally scanning the tracing.[7] Digital imaging is a noncontact method using photography and computed area, which has been shown to be both accurate and have low interobserver variation.[8] Three-dimensional wound measurement devices include stereophotogammetry,[9] digital videometry,[10] ultrasound measurement, and laser scanning.[11] The ideal wound measurement device would be able to record irregular surfaces in a three-dimensional nontouch technique.[9] While the ideal instrument does not exist, we have worked with several computer-based planimetric systems. The purpose of this study was to evaluate one of these devices as a "gold standard" to evaluate the differences in standard length by width wound measurements.



True area	4 cm² A = $l \times w$	3.14 cm² A = $\pi \times r^2$	2 cm² A = $b \times h/2$
$l \times w$ calcuation	4 cm²	4 cm²	4 cm²
% overestimation ($l \times w$ – TA)/TA	0%	27%	100%

Figure 1. The manual $l \times w$ calculation of a square, circle, and triangle compared with the TA. Note that all shapes would calculate to 4 cm² by $l \times w$, despite their obvious differences in TA. A, area; *r*, radius; *b*, base; *h*, height.

Methods

We reviewed the wound records of 10 consecutive patients who presented over two clinic days with round- or oval-shaped wounds of varying etiologies for area calculations by the standard method ($l \times w$) and SilhouetteMobile™ (ARANZ Medical, Christchurch, New Zealand) camera. One investigator used a ruler to measure the longest length of the wound and then the widest width at a line perpendicular to the length axis. Another investigator calculated the wound area with the SilhouetteMobile.

The SilhouetteMobile camera comprises a portable handheld computer with an integrated high-resolution digital camera and an embedded laser light. To calculate area, the laser emits two fan beams that the user places at the margins of the wound. The laser lines curve based on the surface topography of the object to be measured. The curvature computed by the handheld device is used to create a three-dimensional surface model of the wound. The wound margins are indicated by the user with a stylus on the digital image and the computer calculates the area of the wound (**Figure 2**). If desired, the user can take a second image with a single laser line through the middle of the wound to calculate the depth. The device has been shown to be accurate to within 2% of surface area on wound models[12] and has demonstrated low intra- and inter-user variability of only 2–5% in clinical use.[13]

Figure 2. Using the SilhouetteMobile camera to measure a cutaneous ulcer.

Results

The wound measurements from both methods are presented in **Table 1**. There were 10 wounds that measured between 1.5 and 10.2 cm^2 (mean 4.3 cm^2) manually and 1.1 and 6.5 cm^2 (mean 3 cm^2) TA with the SilhouetteMobile. The percentage of overestimation was calculated by the formula ($l \times w$ – TA)/TA. The $l \times w$ method overestimated wound area by an average of 41% (21–87%).

Discussion

Our data show that standard wound area calculations are inaccurate when compared to a validated handheld system employing lasers to create a topographical wound model. We standardized the shapes of wounds studied to round or oval since the shape causes significant variation on the manual calculation by $l \times w$.[14] In our study, the standard manual measurement overestimated wound area by 41%. **Figures 3** and **4** show a clinical example of how $l \times w$ calculations overestimate wound area and the preciseness of measurement by the SilhouetteMobile image. The inaccuracy and variability of manual measurements could cause a failure to recognize subtle healing or worsening in cutaneous wounds. The impact of which might lead a clinician to change from a successful treatment or fail to alter an ineffective treatment. The SilhouetteMobile device has shown utility both in wound healing centers and the home care setting.[15]

Table 1.
Manual ($l \times w$) Measurement and SilhouetteMobile Measurement of 10 Wounds with the Percentage of Overestimation by Manual Methods

Patient	Manual measurement (area cm^2)	Silhouette measurement (area cm^2)	Overestimation (%)
1	1.9	1.5	27
2	1.5	1.1	36
3	4.76	3.2	49
4	2.1	1.7	24
5	2.24	1.8	24
6	1.68	0.9	87
7	10.2	6.4	59
8	1.43	1.1	30
9	9.57	6.5	47
10	7	5.8	21
MEAN	4.24	3	41

While wound area measurements are one necessary component in determination of healing progress, other factors like wound bed color, exudate, fibrosis, and edema are clinical predictors of wound improvement.[16] New technologies adapted from other industries are finding

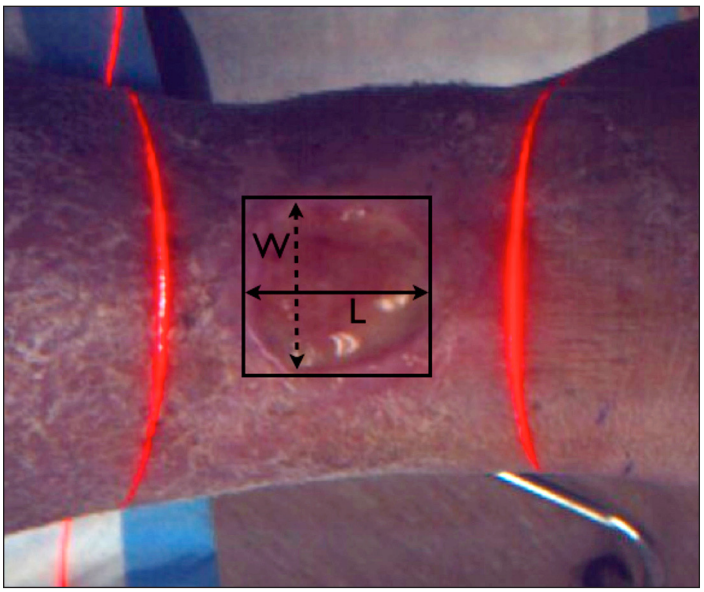


Figure 3. Illustration of length (solid line) and width (dashed line) to estimate the area of a cutaneous ulcer (box). Note the box overlays portions of intact skin. This photograph was taken during scanning with the SilhouetteMobile camera as noted by the laser lines proximal and distal to the wound.

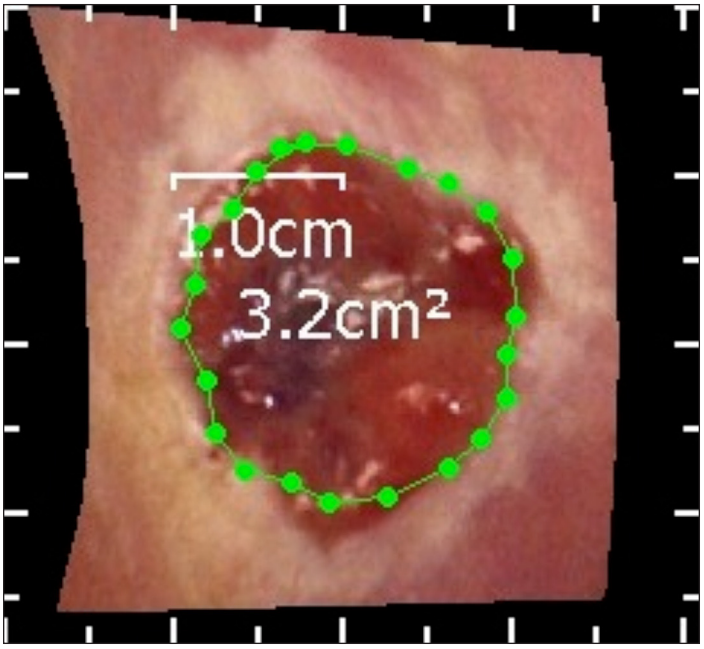


Figure 4. The same wound as **Figure 3** with the area calculated by a digital planimetric camera (SilhouetteMobile). The computer unwraps and flattens the image to calculate the TA. The image should represent the surface topography and can appear slightly distorted.

applications in healthcare settings. The SilhouetteMobile camera was developed from three-dimensional scanners used to create animated objects in the film industry. This adaption of technology and three-dimensional modeling may help to advance the ability of clinicians to examine and diagnose patients by telehealth.[17]

Conclusion

Precise wound healing measurements are necessary to track the progression of a wound over time, which has a direct effect on therapeutic decision making. An accurate method with good inter- and intrarater reliability is most desirable. Cutaneous wounds present in a variety of shapes. Conservatively, if the wound were a perfect circle, manual measurement would overestimate its size by 27%. Other shapes can lead to overestimation by more than 100%. Standard, manual $l \times w$ measurements to estimate the wound area are not accurate, typically overestimating wound area by roughly 40% in the wounds we analyzed.

References:

1. Gelfand JM, Hoffstad O, Margolis DJ. Surrogate endpoints for the treatment of venous leg ulcers. J Invest Dermatol. 2002;119(6):1420–5.
2. Sheehan P, Jones P, Caselli A, Giurini JM, Veves A. Percent change in wound area of diabetic foot ulcers over a 4-week period is a robust predictor of complete healing in a 12-week prospective trial. Diabetes Care. 2003;26(6):1879–82.
3. Lavery LA, Barnes SA, Keith MS, Seaman JW Jr, Armstrong DG. Prediction of healing for postoperative diabetic foot wounds based on early wound area progression. Diabetes Care. 2008;31(1):26–9.
4. Majeske C. Reliability of wound surface area measurements. Phys Ther. 1992;72(2):138–41.
5. Haghpanah S, Bogie K, Wang X, Banks PG, Ho CH. Reliability of electronic versus manual wound measurement techniques. Arch Phys Med Rehabil. 2006;87(10):1396–402.
6. Ahn C, Salcido RS. Advances in wound photography and assessment methods. Adv Skin Wound Care. 2008;21(2):85–93.
7. Gethin G, Cowman S. Wound measurement comparing the use of acetate tracings and Visitrak digital planimetry. J Clin Nurs. 2006;15(4):422–7.
8. Rajbhandari SM, Harris ND, Sutton M, Lockett C, Eaton S, Gadour M, Tesfaye S, Ward JD. Digital imaging: an accurate and easy method of measuring foot ulcers. Diabet Med. 1999;16(4):339–42.
9. Bulstrode CJ, Goode AW, Scott PJ. Stereophotogrammetry for measuring rates of cutaneous healing: a comparison with conventional techniques. Clin Sci (Lond). 1986;71(4):437–43.
10. Wunderlich RP, Peters EJ, Armstrong DG, Lavery LA. Reliability of digital videometry and acetate tracing in measuring the surface area of cutaneous wounds. Diabetes Res Clin Pract. 2000;49(2-3):87–92.
11. Marjanovic D, Dugdale RE, Vowden P, Vowden KR. Measurement of the volume of a leg ulcer using a laser scanner. Physiol Meas. 1998;19(4):535–43.
12. Nixon M, Davey B, Fright R, McCallum B, Preddey J, Kieser D. Comparison between two methods of wound measurement on wound models: manual methods and Silhouette, a hand-held electronic wound measurement and documentation device. Presented at: 13th National District Nursing Conference, Christchurch, New Zealand.
13. Hammond C, Randles J, Lewis D, Roake J, Nixon M, McCallum B, Davey B. Evaluation of a hand held, electronic wound measurement device and documentation device in clincal practice. Presented at: 20th Symposium on Advanced Wound Care, Tampa, Florida.
14. Langemo D, Anderson J, Hanson D, Hunter S, Thompson P. Measuring wound length, width, and area: which technique? Adv Skin Wound Care. 2008;21(1):42–5.
15. Romanelli M, Dini V, Rogers L, Hammond C, Nixon M. Clinical evaluation of a wound measurement and documentation system. Wounds. 2008;20(9):256–64.
16. Falanga V. Measurements in wound healing. Int J Low Extrem Wounds. 2008;7(1):9–11.
17. Armstrong DG. Guest Editorial: time and place-shifting the physical examination: technologies are converging to allow more detailed evaluations of the foot and wound. Int Wound J. 2007;4(4):289–90.