ACCURACY AND RELIABILITY OF WOUND AREAS AND PERIMETERS MEASURED FROM DIGITAL IMAGES USING COMPUTERIZED PLANIMETRY

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BACKGROUND and GOALS

Tracking wound 'size' is an essential part of treatment. Because wounds have varying shape factors, complexity and because a wound's initial size may affect apparent healing rate, its surface area (S) and surface area to perimeter (P) ratio (S/P) are both useful to document healing. These can be determined by computerized planimetry whereby a wound's margin is outlined on a computer screen and its perimeter and enclosed area are automatically determined by easy to use and readily affordable software. Wounds are often treated and evaluated by different caregivers at different times. Thus, accuracy, reliability and the measurement time with which S and S/P can be routinely determined are important considerations. Our goal was to determine these parameters when 4th year student nurses used this method to measure images recorded by digital photography.

METHODS

Six test images with various shape factors were measured in triplicate by 20 student nurses during two sessions one week apart. Images (**Figure 1**) included; an ellipse (1), two traced venous ulcers (2-3), and photos of a sacral pressure ulcer (4), a diabetic plantar ulcer (5) and a venous leg ulcer (6). To obtain images 1-3 the shapes and horizontal calibration bars were drawn with a computer and then printed on heavy photographic paper. To obtain image 4-6, a calibration bar was placed on a photo of the wound and then printed. All printed images with imbedded calibration bars were then photographed with a digital camera. Absolute areas were determined by weight of cutouts to an accuracy of ±0.15 cm^2. Image measuring software was a modified version of an inexpensive wound area determination program (WoundAreas Professional, (**www.clinsoft.org**). The modification was that the normally visible values that would be shown for wound areas and perimeters were electronically masked. Thus students had no knowledge of the values they obtained. An example of a traced image is shown in **Figure 2**. Accuracy was determined as % difference between weight - planimetry determined areas. Precision is reported as coefficient of variations (CV%) among students for each session. Test-retest reliability (between sessions 1-2) is reported as the smallest meaningful percentage change (SMPC) in wound area that can be usefully and reliably detected.
SMPC = 100 x [1.96 x $SDdiff_{12}$/(overall mean)].
The shape factor concept is shown in **Figure 3**.

IMAGES AND EXAMPLES

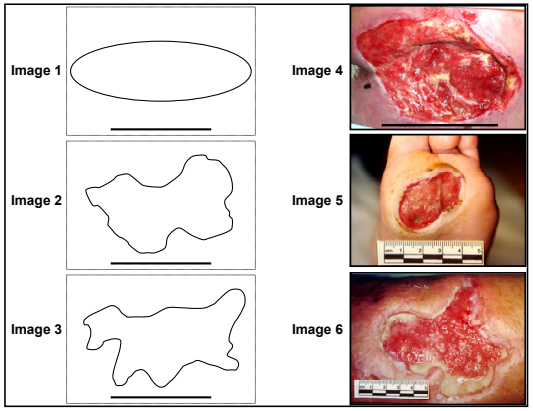

Figure 1. Test images for which area was determined. Calibration bars for images 1-4 are 10 cm and scale lengths for images 5-6 are 5 cm. Areas and shape factors of each image are shown in table 1.

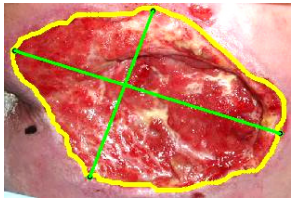

Figure 2. Example wound tracing using the wound area software. Maximum length and width are shown in green for reference but not used in the present analysis. Measurement time at test 1 was 93.4±35 sec which was reduced to 67.7±24.2 seconds at test 2

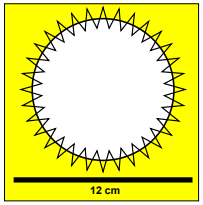

Figure 3. Shape factor (SF = $4\pi S/P^2$) is an index of the amount of smoothness of a shape's perimeter. The two shapes shown have equal areas (70.8 cm^2) but the SF is 1.0 for the pure circle and 0.118 for the irregular margin

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MAIN RESULTS

IMAGE	SF	Area by weight (cm^2)	Area by planimetry (cm^2)		Area Error (%)	
			Test 1	Test 2	Test 1	Test 2
1	0.600	84.0±0.15	83.5±2.1	83.4±1.9	0.31±2.50	0.75±2.30
2	0.571	87.0±0.15	85.4±1.2	84.9±1.9	1.87±1.41	2.44±2.24
3	0.395	86.7±0.15	86.4±1.7	86.0±1.1	0.33±1.96	0.75±1.27
4	0.792	81.4±0.15	81.4±1.3	81.9±1.8	0.01±1.55	-0.53±2.21
5	0.773	6.47±0.15	6.38±0.29	6.26±0.47	1.40±4.43	3.25±7.31
6	0.442	41.0±0.15	42.5±2.9	41.9±2.9	-3.80±6.98	-2.11±7.12

Table 1. Area parameters and measurement accuracy estimates. Planimetry values are mean ± SD. SF is the Shape factor of the measured area. Test 1 and Test 2 data are for values obtained one week apart. Neither planimetry areas nor errors differed significantly between test 1 and test 2.

Image	Area CV%		Perimeter CV%		SMPC (%)	
	Test 1	Test 2	Test 1	Test 2	Area (S)	S/P
1	1.50	1.81	1.33	1.48	2.51	2.45
2	1.44	2.30	2.01	2.07	2.52	2.51
3	1.96	1.28	1.72	2.14	2.42	2.35
4	1.55	2.20	2.47	2.41	2.62	3.17
5	7.49	7.56	4.26	3.90	10.79	10.05
6	6.72	6.98	2.43	2.64	7.14	6.25

Table 2 Repeatability estimates. Area and Perimeter coefficients of variation (CV%) reflect variability of measurements among students for each test session. SMPC is the smallest meaningful percentage change based on test-retest variability.

DISSUSSION AND CONCLUSIONS

One new result of this study relates to characterizing expected errors when using simple digital planimetry of photographic images to assess wound area. Results show that mean area measurement errors achieved by the test group of 20 student nurses for all images was less than 4% at each test session and was less than 3% for combined sessions. A second new finding relates to the repeatability of digital planimetry for the assessment of area the area/perimeter (S/P) parameter. Here the most important result was the determination of the smallest meaningful percentage change (SMPC). This parameter ranged from about 2.5% to almost 11% depending on the specific image being measured. Originally it was thought that the SMPC would be related to wound complexity as characterized by its shape factor. This proved not to be true. Close examination of each image's features suggests that a more important aspect is the level of ambiguity with which the wound margin could be determined by the students. We suspect that this is the largest source of variability and main determinant of a wound's specific SMPC. This ambiguity of wound margin selection among evaluators is likely to be less problematic for experienced wound care specialists.

In summary, the composite results indicate that computerized planimetry of digitized wound photographs using the present software is an accurate, reliable and timely way to measure and document wound areas and the S/P ratio.