

An Evaluation of Three Wound Measurement Techniques in Diabetic Foot Wounds

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Approximately 80% of diabetes-related amputations are preceded by a diabetic foot ulcer (1,2). Wound measurement is an important component of successful wound management (3–6). Accurate identification of the wound margin and the calculation of wound area are crucial (7–9). Although more complex methods of wound measurement exist (planimetry, digitizing techniques, and stereophotogrammetry) (4,10–14), current practice focuses on wound measurement using simple ruler-based methods or by wound tracing. Ruler-based schemes tended to be less reliable in wounds $>5 \text{ cm}^2$ (11). Various mathematical formulae (including the calculation of area based on the formula for an ellipse) have been proposed to improve accuracy in wound surface area calculation in wounds $<40 \text{ cm}^2$ in size (10,11,15–17). The aim of this study was to evaluate and compare three wound measurement techniques: the Visitrak system (Smith and Nephew Healthcare, Hull, U.K.), a digital photography and image processing system (Analyze, version 6.0; AnalyzeDirect, Lenexa, KS), and an elliptical measurement method using the standard formula (πab) for the calculation of the area of an ellipse.

RESEARCH DESIGN AND METHODS

Patients ($n = 16$) with neuropathic and neuroischemic diabetic foot wounds were recruited from the Diabetic Foot Clinic in the Royal Hospitals Trust, Belfast. Ethical obligations were

fulfilled, and patients received standard multidisciplinary care.

Validity and repeatability within each method were investigated and determined by measuring images of a known size 20 times each. Repeatability and comparability were considered between each method of measurement on the wounds. Each wound was traced and measured a total of nine times; wound surface area was calculated in squared millimeters and means and SDs calculated.

Statistical analysis

Validity was analyzed using a one-sample t test. Repeatability within each wound measurement method was investigated by calculating a coefficient of variation (CV) for each wound measurement. Using SPSS (version 11.0 for Windows), Friedman's test was used to determine whether any one method was consistently more repeatable than another.

To compare wound measurement between the methods, a mean wound size was calculated for each wound using each measurement method, a logarithmic conversion of the data was performed, and an ANOVA was used to complete a calculation of comparability. A Bland and Altman plot supported by a paired t test was used to examine differences between the elliptical and Visitrak methods.

RESULTS— Validity varied across the three methods but was deemed to be acceptable overall (Table 1). The Visitrak

method inaccurately measured images $<25 \text{ mm}^2$ ($P < 0.001$), and the elliptical method tended to underestimate size in small wounds ($P < 0.001$).

The mean CV ($n = 46$) for all wounds was calculated as 7.0 (Visitrak), 4.7 (image processing), and 8.5 (elliptical), indicating that repeatability was acceptable overall. Friedman's test indicated that no one measurement method was consistently more repeatable than another ($P = 0.15$).

Analysis of comparability indicated that there were some differences between the three methods. Graphical analysis reported three outlying values (both high and low) using the image processing method; thus, wound measurement could be inaccurate either way compared with the other two methods. Differences were shown between the Visitrak and elliptical methods when analyzed alone (t test = -2.72 , $P = 0.017$).

CONCLUSIONS— The main advantages of the Visitrak method were that the tracings were quick, easy, and inexpensive to perform and noninvasive for the patient. Foot curvature was considered, and the subjectivity associated with manual square counting was removed. The method was both valid and repeatable in the measurement of wounds $>25 \text{ mm}^2$ in size. The main disadvantages were the inability to accurately measure small wounds $<25 \text{ mm}^2$ ($P < 0.001$). When compared with the other methods, the Visitrak method tended to underestimate wound size and statistical significant differences were found ($P = 0.017$) when compared with the elliptical method alone.

The image processing method was advantageous in allowing unique calibration of each image thus eliminating subjective wound tracing. The method was repeatable. The main disadvantage was that validity of this method was questionable.

Elliptical wound measurement had some of the advantages of the Visitrak method (tracings were quick, easy, inexpensive, and noninvasive to perform). The main disadvantages described in using ruler-based mathematical methods

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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Table 1—Summary of results reported on the validity and repeatability of three wound measurement methods in diabetic foot wounds

	Validity/reliability				Repeatability	
Definition (in relation to wound measurement)	The ability of an instrument to measure what it is supposed to measure (wound area) in a precise way over a short period of time				The ability of the same operator using the same instrument to measure the same wound over a short period of time repeatedly	
Statistical analysis	One-sample <i>t</i> test on images of a known size				CVs calculated for each wound measurement method; Freidman's test used to determine if one method was consistently more repeatable than another	
Method	Image of a known size (mm ²)	Mean area measured by each method (mm ²)	Percent difference	<i>P</i>	Calculable CVs for wound area measured by each method	<i>P</i>
Visitrak	25	19.5	−22.0	<0.001	Mean CV 7.0%	
	100	98.5	−1.5	0.27		
	1,600	1,580.5	−1.2	0.06		
Image processing	20	20.02	0.1	0.64	Mean CV 4.7%	
	20	20.01	0.0	0.73		
Elliptical	37	34.3	−7.3	<0.001	Mean CV 8.5%	0.15
	883	883.0	0.0	1.0		
	5,361	5,338.2	−0.4	0.26		

are that they have been shown to overestimate wound area by 10–25% (16,18) in wounds >5 cm². By contrast, in this study, the elliptical method of measurement was shown to underestimate wound size in smaller wounds (*P* < 0.001) compared with the other two methods.

This study does have limitations. The sample size was small, and conclusions can only be drawn for a specific type of wound. There is no gold standard method of wound measurement. The authors conclude that the elliptical method is a suitable measurement tool for use in studies investigating diabetic foot wounds, as it is simple, inexpensive, valid, repeatable, and easy to use.

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