

**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, digitising 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 Ltd., Hull), a digital photography and image processing system (IP) (Analyze Version 6.0. Lenexa, Kansas, US) and an elliptical measurement method using the standard formula ( $\pi ab$ ) for the calculation of the area of an ellipse.

### Research Design and Methods

Patients (n=16) with neuropathic and neuroischaemic diabetic foot wounds were recruited from the Diabetic Foot Clinic in the Royal Hospitals Trust, Belfast. Ethical obligations were fulfilled and patients received standard multi-disciplinary 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 9 times; wound surface area was calculated in  $\text{mm}^2$  and means and standard deviations calculated.

### Statistical Analysis

Validity was analysed using a 1-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), the Friedman's test was used to determine if any one method was consistently more repeatable than another.

In order 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 Analysis of Variance (ANOVA) was used to complete a calculation of comparability. A Bland and Altman Plot supported by a paired t-test were 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 measured images  $<25\text{mm}^2$  inaccurately ( $p<0.001$ ), 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 (IP) and 8.5 (Ellipse) 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 3 outlying values (both high and low) using the IP method and so wound measurement could be inaccurate either way compared to the other two methods. Differences were shown between the Visitrak and Elliptical methods when analysed alone (t-test = -2.72, p=0.017).

### **Discussion**

The main advantages of the Visitrak method were that the tracings were quick, easy, inexpensive to perform and non-invasive 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 measure small wounds of  $<25\text{mm}^2$  accurately (p<0.001). When compared to the other methods, the Visitrak method tended to underestimate wound size and statistical significant differences were found (p=0.017) when compared to the elliptical method alone.

The IP method was advantageous in allowing unique calibration of each image, and so eliminated 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 non-invasive to perform). The main disadvantages described in using ruler-based mathematical methods are that they have been shown to over-estimate wound area by 10-25% (16,18) in wounds  $>5\text{cm}^2$ . By contrast, in this study the elliptical method of measurement was shown to under-estimate wound size in smaller wounds (p<0.001) compared to 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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**Table 1. Summary of results reported on the validity and repeatability of 3 wound measurement methods in diabetic foot wounds.**

	<b>Validity/ Reliability</b>				<b>Repeatability</b>	
<b>Definition</b> (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	
<b>Statistical Analysis</b>	1-sample t-test on images of a known size				Coefficients of Variation (CV's) calculated for each wound measurement method	
					Freidman's test used to determine if one method was consistently more repeatable than another	
<b>Method</b>	<b>Image of a known size (mm<sup>2</sup>)</b>	<b>Mean area measured by each method (mm<sup>2</sup>)</b>	<b>% difference</b>	<b>p-value</b>	<b>Calculable CV's for wound area measured by each method</b>	<b>p-value</b>
<b>Visitrak</b>	25	19.5	-22.0	<0.001	Mean CV 7.0%	p=0.15
	100	98.5	-1.5	=0.27		
	1600	1580.5	-1.2	=0.06		
<b>IP</b>	20	20.02	+0.1	=0.64	Mean CV 4.7%	
	20	20.01	0.0	=0.73		
<b>Elliptical</b>	37	34.3	-7.3	<0.001	Mean CV 8.5%	
	883	883.0	0.0	=1.0		
	5361	5338.2	-0.4	=0.26		