Indian J Surg (March–April 2013) 75(2):111–114
DOI 10.1007/s12262-012-0422-y

ORIGINAL ARTICLE

Digital Photography and Transparency-Based Methods for Measuring Wound Surface Area

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Received: 23 October 2010 / Accepted: 2 March 2012 / Published online: 28 March 2012

Abstract To compare and determine a credible method of measurement of wound surface area by linear, transparency, and photographic methods for monitoring progress of wound healing accurately and ascertaining whether these methods are significantly different. From April 2005 to December 2006, 40 patients (30 men, 5 women, 5 children) admitted to the surgical ward of Shree Sayaji General Hospital, Baroda, had clean as well as infected wound following trauma, debridement, pressure sore, venous ulcer, and incision and drainage. Wound surface areas were measured by these three methods (linear, transparency, and photographic methods) simultaneously on alternate days. The linear method is statistically and significantly different from transparency and photographic methods (P value <0.05), but there is no significant difference between transparency and photographic methods (P value >0.05). Photographic and transparency methods provided measurements of wound surface area with equivalent result and there was no statistically significant difference between these two methods.

Keywords Transparency method · Photographic method · Linear method

Introduction

The ability to accurately and precisely measure the size of the wound is critical in documenting the progress to healing and in assessing the effectiveness of intervention in the healing process in clinical and research settings [1–3]. Several techniques are available for documenting wound size, including measuring the dimensions of a wound using a disposable ruler. Ruler-based assessments of wound size have good reliability [4]. However, deciding which dimensions to measure if the wound is irregular can be difficult [5]. Furthermore, this ruler-based technique tends to overestimate the actual size of the wound, and the reliability of this technique decreases as wound size increases [6].

Therefore, a variety of attempts have been made to assess the volume of wounds. All volumetric measurement methods or techniques have to deal with five general problems, which directly affect their performance:

1. The definition of a wound boundary is often difficult. It always depends on the subjective judgment of the human observer who performs the measurements to define whether a particular part of the area in question belongs to the wound [7].
2. Wound flexibility due to slight movements, following the flexion of a muscle or a change in the patient's position, may significantly change a wound's appearance. Wounds that are undermined, large, or very deep are capable of changing their area significantly.

In such cases the reproducibility of measurements is more a function of the patient's position rather than the accuracy of the respective measurement process itself [7].

3. The natural curvature of the human body may also cause problems. Wounds that may extend around a limb pose problems for techniques based on photography. Even if the wound is fully visible to the measurement device, those methods that ignore surface curvature will produce inaccurate results [7].
4. Some wounds are also extensively undermined and may change their volume with the patient's position. For some wounds such as pressure sores at the heel, volume definition

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is difficult since it is difficult to reconstruct the original healthy surface [7].

5. Wounds that are situated in areas with a thick covering layer of soft issues (e.g., abdominal wounds) also pose a problem. Even after the wound has healed completely due to contraction processes and fibrotic scar formation, a cavity with a significant volume may still be apparent [7].

Two of the most commonly used methods are transparency and photographic methods. In the transparency method, tracing the wound edges onto a transparency is also a popular technique of assessing wound size. The tracings can be placed onto metric grid paper and the number of squared millimeters is counted to document the surface area of the wound [8]. This process is time-consuming especially if the wound is large. The tracing can also be cut out and weighed on a precision scale [9]. This method may be faster than the square-counting method, but the second transfer and cutting out the shape of the wound reduces the accuracy of the technique [9, 10].

Tracing the edge of a wound onto a transparency and using an electronic or a computerized device such as a planimeter to quantify the surface area of the wound appears to be a popular and practical method for assessing wound surface area, and it has been utilized and studied extensively [9, 11, 12]. Excellent interrater and intrarater reliability has been noted with this manual technique [8, 13]. In the photographic method, making a slide of the ulcer and then outlining the ulcer margin from projected slide image are carried out by using a single digital camera and customized computer software [1, 11, 13–15]. This new computerized technique is noninvasive and proved documentation of serial images of a wound for determining both wound dimensions and visual characteristics.

Material and Methods

The study was conducted in 40 patients (30 men, 5 women, and 5 children) admitted to the surgical ward of Shree Sayaji General Hospital, Baroda, from April 2005 to December 2006. The patients under study had clean as well as infected wounds following trauma, debridement of infected wound, pressure sore, venous ulcer, and incision and drainage of abscess. Wound surface area was measured by linear, photographic, and transparency methods simultaneously on alternate days starting on the day of creation of wound.

Linear Method

In this study, maximum length and width of wound were taken by use of measuring tape and surface area was calculated by multiplying length and width of wound.

Transparency Method

In this study, two sterilized sheets of transparency (polyester film sheet, A4 size, 210 mm×297 mm, 100 μm in thickness) were directly placed over wound and the perimeter of wound was traced by using a permanent marker pen. The orientation of the wound and the position of the patient at the time of tracing were recorded. Care was taken to avoid movement of transparency and exertion of pressure over wound in order to avoid distortion. The upper sheet was used for surface area measurement and the lower sheet, which was in contact with wound, was disposed. Transparency with outline of wound by the permanent marker pen was taken for wound surface area measurement by use of the planimeter (Koizuni Sokk Manufacturing Ltd., Nagoakashi, Japan) and surface area was calculated in square centimeter by tracing outline of wound edge with the tip of the planimeter. The planimeter has an accuracy of ±0.2 % and a resolution of 0.1 cm^2.

Photographic Method

In this study, a digital camera was used. The distance of 1.5 ft was kept between the ulcer and the camera exactly at 90° above the center of wound. The resolution of the digital camera was approximately 4,10,000 pixels with a 16X zoom lens. Lighting conditions were optimized to reduce glare and shadow and image contrast was adjusted and then the photograph was taken. The captured digital images were transferred in the transfer image file format to retain maximum image quality with a frame grabber in the computer, using the AutoCAD 2004 software which is used for measurement of surface area. The actual procedure was after feeding the image to computer in autoCAD 2004 software the wound margines were deliniated by mouse and then the surface area of the wound was calculated by the software automatically. The computer software was used to finally calculate the surface area applying its command.

Result

Tables 1, 2 and 3 show the results observed after measuring of wound surface area by transparency, photographic, and linear methods.

Table 1 shows mean values and standard deviation of transparency and photographic methods. *P* value shows >0.05, and it shows that there is no significant difference between the transparency and photographic methods.

Table 2 shows mean values and standard deviation of transparency and linear methods. *P* value shows <0.05, and it shows that there is significant difference between transparency and linear methods.

Table 1 Comparison between transparency and photographic methods

Day	Mean of ransparency method (cm^2)	Mean of photographic method (cm^2)	Standard deviation	*P* value
1	47.40	51.78	36.70	0.59
3	46.69	50.92	36.65	0.60
5	45.81	50.19	36.49	0.59
7	45.04	49.62	36.42	0.57
9	41.66	49.35	34.74	0.32

Table 3 shows mean values and standard deviation of photographic and linear methods. *P* value shows <0.05, and it shows that there is significant difference between photographic and linear methods.

Discussion

To know whether there is any difference of measured values obtained by three methods and they are statistically significant, we calculated the *P* value. The *P* value of >0.05 by transparency and photographic methods on all the 5 days shows that there is no statistically significant difference, but during comparison of these two methods with simple methods, the *P* value of <0.05 shows that there is statistically significant difference. So, in the null hypothesis, the results indicated that the wound surface measurements obtained from photographic and transparency tracing did not differ significantly from each other as compared to each method to simple method.

Furthermore, measurement of these two methods did not differ at day 1, 3, 5, 7, and 9 follow-up periods and continued to yield equivalent measurements as ulcers became smaller.

Similar findings were reported by Griffin et al. [3]. In his study, he compared test–retest reliability of measurements obtained by the photographic method and those obtained by the transparency method and compared wound surface area (WSA) measurements obtained in square millimeter by these two methods. The magnitude of WSA measurements

Table 2 Comparison between transparency and linear methods

Day	Mean of transparency method (cm^2)	Mean of linear method (cm^2)	Standard deviation	*P* value
1	47.40	83.02	49.69	0.001
3	46.69	82.66	49.53	0.0009
5	45.81	82.43	49.50	0.0007
7	45.04	82.18	49.34	0.0006
9	41.66	81.66	48.74	0.0004

Table 3 Comparison between linear and photographic methods

Day	Mean of photographic method (cm^2)	Mean of linear method (cm^2)	Standard deviation	*P* value
1	51.78	83.02	49.81	0.0004
3	50.92	82.66	49.61	0.0039
5	50.19	82.43	49.58	0.0035
7	49.62	82.18	49.37	0.0033
9	49.35	81.66	48.86	0.0049

obtained by the photographic and transparency methods was compared in 22 ulcers measured on one occasion and in 16 ulcers measured at 5-day intervals for 20 days. Intraclass correlation coefficients (ICCs) were high (ICC=99) for each method, indicating reliability of measurements. The WSA measurements did not differ between photographic and transparency methods, either at one occasion or over a 20-day period.

But Thomas and Wysocki [11] in their study found that the photographic method related significantly smaller wound surface measurement than did the transparency method. Those investigators used a different system for generating tracing from slides, using a camera system.

The relative accuracy of the transparency and photographic methods could not be assessed because measurements of the "absolute" size of human skin ulcers in vivo were not feasible. Neither method provides a measurement of ulcer depth. A truly accurate ulcer measurement would entail quantification of skin defects in three dimensions.

Bulstrode et al. [1] described a stereo camera/computer system for obtaining such three-dimensional wound measurements and compared these stereogram metric measurements with measurements derived by transparency and photographic methods.

When measuring artificial ulcers of known area, accuracy and precision were significantly better with stereophotogrammetry than with either the transparency or the photographic method. In a study of chronic in vivo leg ulcers, accuracy and precision of transparency and photographic methods were similar, although both were inferior to stereophotogrammetry. The findings of Bulstrode et al. [1] indicate that photographic and transparency methods may lack accuracy. The results of our study, however, indicate that both methods can provide reliable measurements that can be used as indexes of healing rate for ulcers. Further research concerning sophisticated measurement techniques such as stereophotogrammetry is needed to assess the practicality and value of these measurements in patient care and clinical research environments.

An advantage of the photographic method was that measurement devices did not come in direct contact with the ulcer, a desirable feature when potential contamination and

tissue damage are of concern. In our study, no complication was encountered by using the transparency method, involving direct contact between transparency and wound.

Conclusion

Conclusion of this study is as follows:

1. Photographic and transparency methods, as described in this study, provided measurements of surface area of ulcers with equivalent results.
2. There was no statistically significant difference between transparency and photographic methods ($P>0.05$), but significant difference was found between these two methods and the linear method ($P<0.05$).

These methods are easily reproducible, but photographic and transparency methods are more accurate than the linear method. The uses of either method depend on the expertise a surgeon acquires, with a particular method.

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