e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(11); 406-412

Original Research Article

An Evaluation of Accuracy of Wound Size Measurement from Digital Photography Compared to Clinical Assessment of Wounds on Living and Dead Bodies - A Prospective Study from A Tertiary Care Centre

Jomon Jacob[1], Varghese P.S.[2], Deepu T.[3], Seena Sebastian[4], Nisheed Aubid[5]

[1]Assistant Professor, Department of Forensic Medicine, Government Medical College, Kottayam, Kerala, India.

[2]Professor And Head, Department of Forensic Medicine, St. John's Medical College, Bangalore, Karnataka, India.

[3]Assistant Professor, Department of Forensic Medicine, Government Medical College, Kottayam, Kerala, India.

[4]Assistant Professor, Department of Chemistry, Assumption Autonomous College, Changanacherry, Kottayam, Kerala, India.

[5] Junior Resident, Department of Forensic Medicine, Government Medical College, Kottayam, Kerala, India.

Received: 16-08-2023 / Revised: 28-09-2023 / Accepted: 05-10-2023

Corresponding Author: Dr. Jomon Jacob

Conflict of interest: Nil

Abstract

Background: This study was conducted to validate the use of digital photographic wound assessment in the evaluation of the size of the wound when compared to clinical assessment and to study the factors influencing digital photographic wound measurement.

Methods: This was a cross-sectional study conducted for a period of 2 years among 107 wounds from trauma patients admitted to the ward or patients attending the OPD, emergency department, dressing room, or intensive care unit and dead bodies coming to the forensic medicine department of Tertiary care hospital. Patients who had bleeding disorders, connective tissue or skin disorders, or wounds on an unexposed part were excluded from the study.

Results: On comparison of length by manual and photographic methods, it was found that the photographic method is not as accurate as the manual method. While comparing the width using these methods, the same result was obtained. There was a significant change in the accuracy of length measurement according to the site of the body, but no significant change in the accuracy based on the type of wound. where there was a significant change in the accuracy of width measurement according to the type of wound.

Conclusion: When comparing the accuracy of wound length and width by photographic and manual methods, it is seen that accuracy depends on different factors like the margin of the wound, type of wound, camera angle, etc. If the wound is small with a clear margin and there is less chance of variation in camera angle based on the site of the wound, the photographic method is a better substitute for the manual or ruler method of wound size measurement.

Keywords: Wound Measurement, Photography, Ruler Method.

Introduction

Determining the cause of an injury and measuring the extent of an injury in both live and deceased people is a critical medico-legal problem in the field of criminal investigation. When certifying an injury, a physician must state the precise and particular wound size. [1-4] The size of the wounds and associated features give a clue as to the appropriate weapon causing the injury. Measuring the size of the wound is crucial for both effective wound care and record keeping, including for legal issues pertaining to medicine. Assessing and treating chronic wounds, as well as maintaining the medicolegal paperwork, depend heavily on measuring the extent of the wound. Conventional methods, such as ruler measures and transparency tracings, for measuring wound size often have low accuracy and reliability. Newer high-tech methods, while more reliable and accurate, are often expensive and difficult to use.

The estimation of wound size and subsequent communication or documentation is often

inaccurate [1] with high inter-observer variability. So a feasibility study of the agreement between clinical assessment and photographic assessment of wound size [2-4] is important. If wound size measurement from digital photography combined with wound measurement software like AWAMS [5] is valid, it is an alternative to direct clinical examination, alleviating access issues and conserving time.

This study was conducted to validate the use of digital photographic wound assessment in evaluating the size of wounds when compared to clinical assessment and to study the factors influencing digital photographic wound measurement.

Materials and Methods

This was a cross-sectional study conducted for a period of 2 years among 107 wounds from trauma patients admitted to the ward or patients attending the OPD, emergency department, dressing room, or intensive care unit and dead bodies coming to the forensic medicine department of Tertiary care hospital. Patients who had bleeding disorders, connective tissue or skin disorders, or wounds on an unexposed part were excluded from the study. The size of wounds from trauma patients and dead bodies was measured using two techniques: clinically using a ruler by a clinician and photography combined with AWAMS. The wounds were photographed with a Canon Power Shot A400 Digital Camera of 3.2 mega pixels, a lens of 5.9 (w) and 13.2 (T) mm (35mm film equivalent: 45 (w) and 100 (T) mm), f3.8, and a ruler included in the photographic frame to allow calibration. The images were then uploaded to a computer. The wound outline was defined from the photographic image, and the software AWAMS used to calculate the wound size.

AWAMS–SAM software module was developed to provide the market with advanced tools and options in detailed wound measurement and surface area mapping. It is the most comprehensive wound tracking and area measurement system available today. [5]

Results

107 samples were collected and studied. On comparison of length by manual and photographic methods, the p' value obtained was 0.537, which denotes that there is no statistically significant difference between the two methods. It may be because of several factors, like the length of the wound, its wide range, the site of the wound, the type of the wound, the angulation in photography, etc.

On comparison of the width of the wound by the manual and photographic methods, the p' value obtained was 1.00, which again denotes that there is no statistically significant difference between the two methods. The reasons could be the curve of the sites, camera angle, type of wound, etc.

When the accuracy of the length of wounds by manual method and photographic method (Table 1, 2) was studied based on various sites, the p' value obtained was 0.002 by both methods, which means variation in length based on sites is significant. It can be attributed to variations in the curvature of different sites. Also, when the width of wounds was measured by manual and photographic methods based on various sites (Table 3, 4) was studied the p' values obtained were 0.009 and 0.004, respectively, which denotes that the change is significant. It can also be explained by changes in the curvature of various sites.

When the type of wound was studied with length by manual and photographic methods, the results obtained were p' values of 0.446 and 0.427, respectively. Thus, there was no significant change based on type of wound when length was measured either by manual method or by photographic method.

While studying the width of the wound by the manual and photographic methods based on the type of wound, the p' values obtained were 0.062 and 0.074, respectively, which means the change in width based on the type of wound is insignificant.

Thus, there was no difference between the groups with respect to measurements of either length or breadth. With respect to the site of injury, both methods showed a difference. However, there was no difference in either method with respect to the type of injury.

From the results, it is clear that if the factors are favourable, photographic wound assessment is an acceptable alternative to the regular ruler or manual method. That is, if the site to be photographed is flat or less curved, the type of wound has regular margins, less camera angle variation, etc. So when these can be satisfied, results are comparable with any of the photographic methods like the WMD, stereotype camera, or MAVIS, as mentioned earlier

Table 1: Accuracy of Length of Wounds by Manual Method over Various Sites

Variable	Category	Mean	SD	P-Value
Length Manual	Upper limb	4.48	2.93	0.002
	Lower limb	7.86	5.84	
	Head and neck	4.70	2.43	
	Trunk	3.98	2.41	

Table 2: Accuracy of Length of Wounds by Photographic Method over Various Sites

Variable	Category	Mean	SD	P-Value
Length Photo	Upper Limb	4.15	2.71	0.002
	Lower Limb	7.42	5.70	
	Head and Neck	4.40	2.08	
	Trunk	3.59	2.58	

Table 3: Accuracy of Width of Wounds by Manual Method over Various Sites

Variable	Category	Mean	SD	P-Value
Width Manual	Upper Limb	2.12	1.99	0.009
	Lower Limb	3.41	2.47	
	Head and Neck	2.05	2.00	
	Trunk	1.18	0.64	

Table 4: Accuracy of Width of Wounds by Photographic Method over Various Sites

Variable	Category	Mean	SD	P-Value
Width Photo	Upper Limb	1.69	1.51	0.004
	Lower Limb	2.88	1.86	
	Head and Neck	1.84	1.67	
	Trunk	1.20	0.38	

Discussion

Wounds or mechanical injuries are terms for harm to the body from physical violence. The legal definition of a wound is a breach of the full thickness of the skin (or lining of the lip). This excludes abrasions, bruises, internal injuries, and fractures. The measurement of the wound gives an idea of the object causing it and tells whether it is grievous or not. There are different methods to measure the size of wounds other than a ruler or direct method, like digital photography assisted with different software like Image J, AWAMS, etc.

Measuring the size of the wound is crucial for both effective wound care and recordkeeping, including for legal issues pertaining to medicine.

Different Methods of Measurement of Wounds

A digital photograph-based measuring technique and a ruler are frequently employed in clinical forensic medicine. Nevertheless, there are significant drawbacks to both approaches that may reduce their accuracy. It has been demonstrated that the ruler approach overestimates the extent of wounds, whereas the digital method may underestimate those regions. [5,6]

Conventional wound-size measurement techniques, such as transparency tracings and ruler measurements, frequently have poor precision and dependability. Modern high-tech techniques are more accurate and dependable, yet they can be costly and challenging to apply. The goal of the research done by Michelle et al. [7] was to create a WMD (Wound Measuring Device) that was battery-operated, hand-held, dependable, low-cost, non-contact, and easy to use. There are several tools and techniques available for measuring wounds. However, for the approach to be effective in standard clinical practice, it must be accurate, sensitive, impartial, easy to use for all operators, and save time and money.

The estimation of wound size and subsequent communication or documentation is often inaccurate [1] with high inter-observer variability. So a feasibility study of the agreement between clinical assessment and photographic assessment of wound size [2-4] is important. If wound size measurement from digital photography combined with wound measurement software like AWAMS [5] is valid, it is an alternative to direct clinical examination, alleviating access issues and conserving time.

Ruler (Clinical Assessment)

Using a ruler to measure the wound area is the most straightforward way (clinical evaluation). The result is the largest breadth times the biggest length perpendicularly. This method is simple to use, fast, and affordable. [1] However, research has demonstrated that this kind of computation overestimates wound area by 10% to 44%, with accuracy declining as wound size rises. [2]

When the wound is uneven, manual tracing can provide a more precise area estimation by covering the wound with a transparent film and using a permanent marker to trace the contour. There are several ways to determine area from the trace. The number of squares in a known area may be counted by placing the trace on a metric grid. This is quick and simple, but when determining the partial squares value, errors occur. Despite being a widely used technique, it has a few disadvantages, which are:

1. It is a subjective method and is limited by inter-observer variability. Determining the greatest wound dimensions can vary from one examiner to another, especially if the wound is irregular. [8,9]

2. There is little doubt that movement and subject position changes have an impact on the method's reproducibility.
3. It overestimates or underestimates the wound area. Assessing the measurement of a wound area by multiplying its length and width assumes that the wound shape is rectangular or square. It overestimates the actual area of the wound by up to 10%-44% or more.[8] Greater overestimation arises when the injuries are larger and more irregularly shaped. [10]
4. Another method (the elliptical formula) for measuring a wound is length x breadth x 0.785; nevertheless, the outcomes derived from using this formula are still unreliable. For tiny wounds, it is correct; nevertheless, it underestimates bigger or irregular wounds. Foltynski et al. [11] state that measuring the areas of irregularly shaped wounds using the elliptical approach (length x breadth (perpendicular to each other) x 3.1416/4) can overestimate the areas by up to 33% and should not be used in domains where the wound areas are a crucial measurement. There are no permanent records. If the wound has healed or a corpse is not available, the measurements cannot be reassessed for a second opinion.
5. Because it involves contact, there is a chance of infection. [12]

Photography

The wound area may be computed by photography. A digital snapshot is used to trace the wound's boundaries. By taking a picture of a ruler or other precise scale next to the wound, the user may calibrate the programme so that it can determine distance. Photography has the benefit of not requiring contact with wounds. [2] It offers a lasting record of the look as well as the size of the wound. When employing photography, camera angle, illumination, and picture quality are all important factors to take into account. [2] An underestimate of the wound area by up to 10% may result from variations in the camera angle. When tracing circumferential wounds or wounds on curved body surfaces, an apparent wound size difference may also arise since a 2D picture is depicting a 3D structure. Research has still shown excellent intra- and inter-operator dependability in spite of these challenges.

The wound area may be computed by photography. Using a mouse or digital pen on a digital tablet, the borders of the wound are traced from a digital image. To enable the programme to assess distance, the user can picture a precise scale, such as a ruler, close to the wound and calibrate the software. Photography has the benefit of not requiring contact with the wound. It offers a lasting record of both the size and appearance of the wound. Determining the borders of a wound is subjective, much like with other types of wound tracing, and can be difficult if the margins are blurry or poorly defined. In order to accurately identify epithelial development near wound edges, high-resolution photos are necessary. When employing photography, lighting, camera angle, and picture quality are all critical factors to take into account.

The identical wound tracing procedure is used in digital planimetry, but the contour is retraced onto a digital tablet so that the area may be calculated. This offers the benefit of calculating wound circumference quickly, precisely, and objectively. Digital planimetry systems such as the Visitrak system (Smith & Nephew Wound Management, Largo, Florida) were created in response to the demand for a simple, quick, and dependable tool for clinical application. Compared to other digital planimetry systems, Visitrak has demonstrated great intra- and interoperator reliability, high validity, and a correlation co-efficient of 0.99. This method has a number of drawbacks, such as making it difficult to identify the edges of the wound, obscuring vision due to fogging beneath the film, changing the outline of the wound when pressure is applied, and requiring the film to remain in contact with the wound for an extended period of time, which increases the risk of contamination, damage to the wound bed, and discomfort and pain for the patient. [13]

Digital photography in general has become a common recording technique these days. It is superior to film photography in many ways. The primary benefits are the enhanced image quality and the computer software's ability to make adjustments to the photos. [14,15] Digital photos can also be used to match patterned skin damage to a suspected causative instrument, obtain second views, and serve as an electronic source of wound measurements (wound dimensions or areas).

In forensic medicine, some kinds of photography have been employed to record ambiguous injuries that are not apparent to the unaided eye or in regular digital camera photos. Digital data may be collected to determine the area of the wound as well as its linear dimensions (length and breadth). AWAMS, the Pictzar Digital Planimetry Programme Software, the VeV MD system, and Image-J software are some of the programmes used for this. [16]

While digital photography is a widely used technique for documenting wounds, it is susceptible to several conditions, including illumination and distance. The proximity effect makes 3D objects look out of focus at very close ranges. Another important consideration that is

difficult to manage during photography is the lighting. Technical faults, noise, and distortions can also be present in digital images. Evans et al. [17] have classified these distortions into four categories: three forms of scale distortions and one angular distortion.

Image mistakes are easily created, even by the most skilled and qualified practitioner, according to Evans et al. [17] This is because there are no guarantees in photography because it is a highly variable art form that needs careful attention. Additionally, photographers may unintentionally introduce their own mistakes into the images.

Drawbacks with the Digital Approach.

There are a number of significant drawbacks that affect the accuracy of this measuring method. These include:

1. The area was calculated using a subjective delineation of the wound boundary that required human intervention. A scale, blood, or an accompanying injury may obscure the wound's border.
2. The wound area may be underestimated or overestimated. The picture needs to be taken at the proper angle in order to determine the precise location, size, and form of the wound. A slight change in angle can have an influence on the photograph view, resulting in an underestimation of the wound area by up to 10%–34.8%. The greater the change in the angle, the greater the measurement error. In reality, acquiring the image from the exact recommended angle is unlikely to be achieved because the camera is hand-held and the injuries could be anywhere on the body. Foltynski et al.[11]
3. Injuries are reduced to the 2D level when three-dimensional injuries are captured in two-dimensional photos. Therefore, the depth and volume of the injuries cannot be obtained digitally and have to be collected manually. [18]
4. The measuring technique for plain photographs is biased when the wounds are situated on curved surfaces because it ignores the body's natural surface curvature.
5. Another cause of error for this measuring technique is circumferential wounds. Multiple photos are needed to fully capture these wounds. The measurements won't be correct even if the wound is completely caught since the optical methods ignore the body's natural surface curvature.
6. Researchers believe that the digital measurement method is contactless, so there is no risk of infection.. Nonetheless, when the scale is positioned near the injury, there is a direct touch component. [19]

Lastly, since human judgement is always involved in the measuring process, no measurement technique is totally objective. There is simply the best guess; there is no absolute measurement. [20]

Therefore, the purpose of this study was to determine if a widely accessible, low-cost, quick, and simple photographic method may replace Visitrak as an accurate means of measuring wound area when a non-wound-contact approach is preferred. This is not accurate enough and should not be applied to huge, irregular, or cavitous wounds.[19] Using the formula for the area of an ellipse instead of a rectangle or a formula for a shape like the wound can both increase accuracy. [21]

The reliability of measurements made with a software-based technique employing digital photos and a manual transparency tracing method was compared by Thawer et al. [21] This evaluation was based on excisional wounds in laboratory rats and chronic lower extremity wounds in humans. When assessing the minor animal wounds, the computerised procedure had a much higher inter-rater reliability ($r = 0.99$) than the manual tracing method ($r = 0.77$). The bigger human wounds showed inconsistent inter-rater reliability among approaches, all of which exceeded 0.91. For the wounds on humans and animals, the intra-rater reliability for both the manual and computerised approaches was higher than 0.98.

Bulstrode et al. study [22] used plaster cast ulcer models and ten real leg ulcers from patients in a clinical setting to compare stereophotogrammetry to direct tracing and straightforward photography. The measurement accuracy of the ulcer models using stereophotogrammetry was >99%, with a precision of < 2% between the measured and real surface areas. Lower accuracy and precision are obtained from simple photography and tracing: the mean error for basic photography was 11.4% with a precision of 21.0%, while the mean error for direct tracing was 11.7% with an 18.2% precision.

Stereophotogrammetry was also 10 times more exact in the clinical situation, according to Bulstrode et al.'s findings. [22] The 95% confidence intervals for the accuracy of direct tracing, basic photography, and stereophotogrammetry were expressed as percentages of the mean surface area values during testing using actual ulcers. Whereas the precision for direct tracing was 37.8% and for basic photography it was 28.6%, the mean 95% confidence interval for SPG was 3.36%.

In the present study, we could conclude that if the factors are favourable, photographic wound

assessment is an acceptable alternative to the regular ruler or manual method. That is, if the site to be photographed is flat or less curved, the type of wound has regular margins, less camera angle variation, etc. So when these can be satisfied, results are comparable with any of the photographic methods, such as the AWAMS.

Conclusion

In the present study, the photographic method was found to be less accurate in measuring the length and width of the wounds as compared to the manual method since the photographic method depends on several factors like camera angle, site of the wound, and type of wound. Further research focused on the reduction of irregularities would make photographic wound measurement a better alternative to measuring wound size, as it is less time-consuming with no direct contact with the wound.

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