# Wound metrology: strategies for achieving accuracy in wound measurement

KEY WORDS
- Measurement
- Metrology
- Wound

Wound measurement has long been recognised as a valuable tool for aiding clinical wound assessment and treatment decisions. Many reviews have analysed various available wound measurement methods (Plassmann et al, 1994; Fette, 2006; Shaw et al, 2007). However, there is no single, standardised wound measurement technique that is quantifiable, objective, reproducible, affordable and practical. As such there is justification for the need of a clear and effective clinical wound measurement protocol that can be applied across all wound care settings. Through an understanding of some fundamental concepts of metrology (the science of measurement), this paper explores ways in which clinicians can improve the accuracy of wound measurement in practice and suggests that a robust wound measurement methodology could be established through translation of standardised metrological techniques from the field of engineering into the field of wound care.

Wound care is by no means a modern topic. Many historical documents, such as the Smith Papyrus c. 1650 BC and clay tablets claimed to date back to 2200 BC, have all described ways in which to treat wounds including ablutions, topical preparations and various materials that could be used for dressings (Forrest, 1982; Shah, 2011). In some ways; for example many of the historically used pharmacological agents (honey, metals, plants and herb extracts), the way in which we treat wounds has not completely changed. This can also be said for wound measurement as, despite scientific and technological advances, the most commonly used method continues to apply a simple approach — the use of a ruler (Bryant and Nix, 2016).

Although simplistic methods are the most routinely applied, it is crucial to recognise the importance of good wound measurement as it can provide powerful information that can assist: clinical diagnosis, treatment choices and wound management regime decisions in addition to facilitating clear, quantitative assessment and documentation (Flanagan, 2003; Gethin, 2006; Cardinal et al, 2008). Wound measurement has also presented clinicians with scientific evidence that shows initial healing rates, calculated from baseline and continued wound measurements, can be used to predict healing outcomes in several types of wounds (Lavery et al, 2008; Chaby et al, 2013). Professionals in the field are now attempting to ensure that accurate measurement data is not only achieved, but also utilised effectively by clinicians through the introduction of additional evidence-based interpretative diagnostic aids (Milne, 2015).

Wound measurement methods can be organised into the following two groups:

- Manual methods/devices: estimation, rulers, Kundin gauge (Kundin, 1989), wound tracings/acetates (manual planimetric methods).
- Digital methods: digital planimetry, photogrammetry, deflectometry and interferometry with some specific devices being: Mavis (Plassmann and Jones, 1998), Eykona (Bowling et al, 2009), Silhouette (Kieser and Hammond, 2011) and the Visitrak wound measurement device (Sugama et al, 2007).

Although in the last two decades there has been an increase in the development of technologically advanced, non-contact, wound measurement devices that are capable of measuring wounds in an objective and more accurate manner, these appear

MICHELLE J MCHUGH
*Postgraduate Researcher, University of Huddersfield, Centre for Precision Technologies, Huddersfield*

not to have been widely adopted. Foltynski et al (2015) suggest that this passivity is attributable to the high associated costs and the length of time taken to gain measurements using these devices. Additionally; usability and the practicality of new method implementation, adaption and adoption within clinical practice is of due consideration. So; wound measurement remains, as previously stated by Salcido (2000), at a point where there is no current universal standardised approach that perfectly matches the specific requirements whilst facilitating accurate, comparable measurements between different wound care professionals and across all clinical settings.

This article aims to highlight how metrology and wound care professionals can work together to reduce current clinical measurement error levels and develop strong, evidence based wound metrology approaches.

## DISCUSSION: WOUND METROLOGY

### What is metrology?

Metrology; defined as the 'science of measurement and its application' (National Physical Laboratory, 2010; Joint Committee for Guides in Metrology, 2012), was born in ancient Egyptian times, through the introduction of the 'cubit,' a known measurement standard, determined as the measured length between the crease of the elbow through to the tip of the middle finger of the Pharaoh (Stout, 1998). The discipline of metrology has evolved greatly and now plays an enormous role in modern everyday life. In fact; all standardised measured components (e.g. weight, mileage, time) are guided by a field of scientific metrology: scales used to weigh food, recorded distances travelled, medicinal doses, right through to machined parts such as medical instrumentation and automotive components. These standardised measurements are achieved through the use of calibrated tools, designed and tested through the application of metrological concepts and processes. Thus; metrology underpins a system of standards that facilitate conformity and comparability of measurements across the world.

**Table 1. Metrology vocabulary (National Physical Laboratory, 2010; Joint Committee for Guides in Metrology, 2012)**

| Metrology Terminology | Metrological Definitions |
|---|---|
| Accuracy | The closeness of agreement between the measured value gained through the use of a measuring device and the true measurement value. |
| Calibration | The comparison of the measuring device against a known standard for the identification of any detected errors. Errors may then be corrected for through adjustment. |
| Precision | Precision relates to a measure of the distribution of multiple values, e.g. obtained though repeated measurements. (i.e. If a set of values are in very close agreement, this indicates high precision.) N.B. This is different from accuracy which is a close agreement with the true value. |
| Repeatability | The concordance between measured values under controlled, unchanging situational conditions (e.g. the same time, location, assessor, technique). |
| Reproducibility | Is the closeness of agreement among measured values, where the measurement has been performed under a circumstantial variance (e.g. difference in time, location, assessor, technique). |
| Resolution | Is the lowest change/step in a measurement result that the measuring system is capable of detecting. For example; on a standard ruler the smallest unit you can measure to is normally a millimetre. |
| Tolerance | The maximal allowance (both positive and negative) between the measurement value and the ideal value. For example, if a highly accurate part was required for a machine there may only be a very small tolerance limit as anything above the tolerance limit may cause problems within the system. |
| Traceability | The ability to link a measurement to either an international or national measurement standard through a chain of calibrations with reference standards that have known levels of uncertainties. |
| Uncertainty | A quantified value that relates to the summation of estimated errors and thus indicates the level of distrust in the measurement result. |

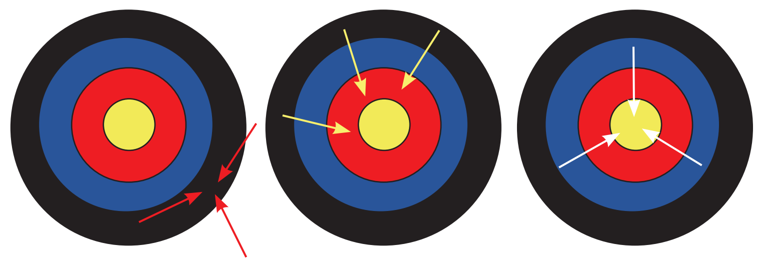



**Figure 1. Accuracy and precision (National Physical Laboratory, 2010)**

## Fundamental metrological concepts and terminology

To facilitate clear communication of information, unambiguous definitions for terminologies must be established in all branches of science. This includes the medical field and the discipline of wound care where differences in the use of vocabulary can have an impact on clinical relevance. An example of this has been previously highlighted by Hermans (2010) who approached the differences between 'old' and 'new' nomenclature in regards to wounds and ulcers. Furthermore, the need for clarity, consistency and conformity with metrology terminology in relation to medical measurement systems has recently been recognised (Kessler et al, 2015). Thus, an understanding of metrological terms that apply to wound measurement is fundamental for clinical wound measurement comparability and communication.

## Problems that exist with wound measurement methods

The most commonly used wound measurement methods often only provide rudimentary estimates at best and thus can be low in accuracy (Plassmann et al, 1994; Fette, 2006). Furthermore; the highly subjective methods that are regularly applied in clinical practice can introduce varying levels of errors that contribute to measurements with inherent high levels of uncertainty, poor precision and thus low accuracy. These introduced errors can occur through problems such as: confusion between accuracy and precision (*Figure 1*), repeatability issues (e.g. patient movement between measurements), reproducibility issues (differences in time, location, assessor, technique), measurement factors (measurement process/procedure, e.g. chosen method, calculations and equipment), environmental factors such as temperature and human/individual error factors (e.g. difference in perspective and choice of measuring points).

One of the most complicated subjectivity challenges to overcome in wound measurement may be concerning the difficulties associated with the clear definition of the wound edge which currently is at the discretion of the assessor when using basic non-digitalised methods. Moreover, the individual and highly variable nature of the human body, combined with hard to replicate measurement scenarios due to varying clinical visits and appointments, deems the idea of reproducibility immensely complex. The combination of these measurement accuracy impacting factors can result in largely non-comparable data values deeming the usefulness of the measurements gravely limited.

## How can metrology concepts be applied to achieve more accurate wound measurement?

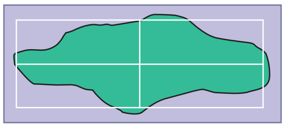
A key step towards achieving wound measurements with greater accuracy, is an appreciation of some basic metrology concepts which provide insight along with an understanding of the factors that can introduce errors and thus create uncertainty in the measurements gained. The following is a brief overview of some common error factors that can impact clinical wound measurement procedures and data:

### Uncertainty of measurement or measurement error

No measurement is perfect as all measurements are susceptible to error. All quantitative measurements comprise of a) The numerical value and b) the estimated associated uncertainty value, this is imperative for establishing whether the measurements are fit for purpose and comparable with other readings (Farrance and Frenkel, 2012). Thus, it is important to consider the potential level of uncertainty of measurement incurred through wound measurement methods.

**Area estimation:**

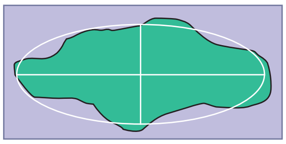
**Rectangular approximation method**



A= l x w

Overestimates true area 44%

**Elliptical area**



A= l x w x $\pi$/4

Overestimates true area 13%

Figure 2. Area Estimation Errors (Schultz et al, 2005)

**Estimation error**

Some measurements methods can only ever provide approximations. This may be through the equipment (e.g. low resolution) or through calculation/s applied. For example, as shown in *Figure 2*, by using a simpler, rectangular mathematical approach to wound area over an elliptical approach, a comparatively much larger estimation error can be introduced to the result (Schultz et al, 2005). In addition to recognising that these calculation methods typically overestimate wound area, it is important to realise that values calculated using differing methods between assessors would not be comparable with each other due to the differing levels of estimation error and this would serve to introduce further uncertainty.

**Subjectivity**

Wound measurement methods are often highly subjective. Furthermore, the involvement of multiple assessors in the care of a single patient can often introduce measurement uncertainty through problems surrounding the concepts of repeatability and reproducibility. When using the most common wound measurement method (the ruler), it is the assessor that decides at which points to take the measurements. Different clinicians may use different approaches to choosing these points, greatest length and perpendicular width or a clock-face approach where the 12–6 and 9–3 linear axes may be selected, and despite the chosen approach the odds of two assessors picking the exact same points is extremely low. One longstanding problem as previously stated by Plassmann et al, is the issue of defining the wound edge that in ruler, tracing and photographic methods is dependent upon the subjective perception of the assessor.

**Personal Perception**

It is known that the eye can perceive objects of the same size (for example the two red circles and the lines in *Figure 3*) differently, particularly if the surroundings differ (Doherty et al, 2008). Interestingly, studies have shown that size perception can differ with distance and age (Gori et al, 2012), culture (Doherty et al, 2008) and gender (Peterson et al, 2014). It is thus reasonable to infer that individuals may perceive wound size differently and especially if perception of where the wound edge lies differs.

**Parallax**

As defined by the Oxford English Dictionary (2005), Parallax is the 'Difference or change in the apparent position or direction of an object as seen from two different points' (*Figure 4*). In wound measurement this error can result from measurements being taken from an angle, to avoid this the measurement assessment device (e.g. ruler or camera) needs to be perpendicular to the surface of the wound. Although it may be clear that parallax errors could be introduced during non-contact wound measurement using a ruler, it is important to note that these errors can also occur through digital methods, particularly if the wound is on a limb and is circumambient (Santamaria et al, 2002).

**Comparability**

All factors that have the potential to introduce errors within the wound measurement should also be considered when assessing measurement comparability. For example, wound area values calculated using different approaches (e.g. rectangular and elliptical), despite giving the same parameter would be not suitable for comparison due to the different levels of uncertainty within the

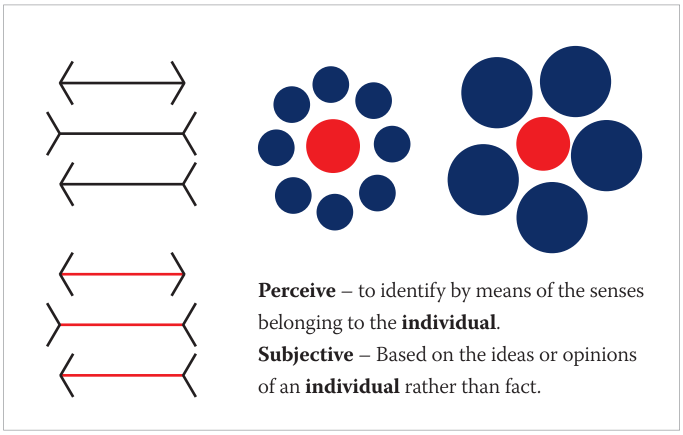
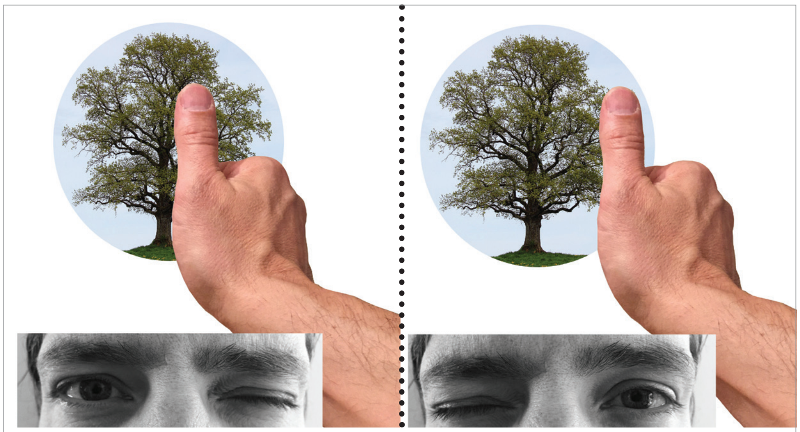



**Figure 3. Size perception**



Notice the sideways 'shift' with respect to background when transferring sight from one eye to the other.

**Figure 4. Parallax**

calculation. Wound measurement values achieved through the use of different methods and/or assessors may not be suitable for comparison due to highly variable levels of accuracy and precision within and between systems.

Other important considerations from a wound metrology view point include calibration, traceability and tolerance. These concepts concern the equipment and processes applied. Calibration (as defined in *Table 1*), involves the comparison of the measuring device with a known standard and the calibration process is linked to traceability whereby the measurement of uncertainty is known in all reference standards used to calibrate. These factors are important for the understanding of measurement uncertainty and the accuracy of the gained measurement. Tolerance conversely is of significance when considering the level of accuracy required from the measurement to afford informative data and thus the clinician must decide if the chosen method will give results that meet the specific requirements needed to afford meaningful data fit for the intended purpose.

## CONCLUSION

'Good' wound measurement data can provide wound care professionals with a valuable predictive wound healing tool, aid clinical management and facilitate clear wound progression documentation. There are many wound measurement methods available, however, during wound measurement collection processes a multitude of errors may be introduced that can impact and limit the accuracy and usefulness of the data. The more simplistic and commonly applied clinical methods are particularly susceptible to this. Armed with an awareness of some fundamental metrological concepts and considerations, wound care professionals could improve wound measurement results by implementing measurement procedures that reduce identified errors that can be easily introduced during common practice procedures.

Technologically advanced wound measurement devices, capable of providing objective measurements with greater accuracy, are currently inaccessible to most. To facilitate good measurement practice, and useful data collection, across a range of wound care settings there is the need for a standardised approach that can present accurate wound measurements within a suitable tolerance limit. The rationale for further research surrounding the translation of metrology into the field of wound care is evident and further evidenced through the recognition of the importance of metrology within medical disciplines (Kessler et al, 2015). Moreover, metrology is applicable to all good measurements and thus all clinical measurement practices underpinned with sound metrology principles would provide beneficial outcomes to all. WUK

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