A systematic review of the performance of instruments designed to measure the dimensions of pressure ulcers

O’Meara SM, Bland JM, Dumville JC, Cullum NA

CRD summary
This review found that, although there were reliable methods for measuring surface area, there was a paucity of evidence on the performance of instruments designed to measure other dimensions of pressure ulcers. The authors’ conclusions about the paucity of high quality studies and the performance of instruments to measure pressure ulcer surface area are likely to be reliable.

Authors’ objectives
To review the performance of wound measurement instruments in the measurement of pressure ulcers.

Searching
Eight databases (including EMBASE, MEDLINE and The Cochrane Library) were searched up to August 2010; search terms were reported. Websites for the United Kingdom National Institute for Health Research Health Technology Assessment Methodology Panel were also searched. Databases of theses, relevant book chapters, and bibliographies of reviews and included studies were checked for additional studies. Citation searches were also performed. Experts and manufacturers in the field were contacted for further studies. There were no restrictions for language or publication type.

Study selection
Eligible for inclusion were studies of any design that evaluated methods of estimating the diameter, depth, surface area or volume of pressure ulcers in any care setting. Eligible studies were required to provide data on at least one of: intra-rater or inter-rater reliability of at least one method of wound measurement, agreement between two methods of wound measurement, comparison of at least one method of wound measurement against a defined reference standard, or a comparison of the feasibility of at least two methods of wound measurement. Evaluations of tools were excluded as these typically focus on the performance of the tool, not individual components such as wound measurement.

Included patients were recruited from spinal rehabilitation centres, long term care centres, geriatric clinics, where reported. The assessors included nurses, physicians and physiotherapists. The wound measurement tools used were rulers, transparency tracings, and digital or computerised planimetry. Wound volume was measured by fluid injection, alginate moulds and stereophotogrammetry. The number of assessors (where reported) ranged from one to six. The numbers of times measurement estimates were repeated ranged from zero to nine.

One reviewer performed the study selection; a second reviewer checked the selection independently, and any disagreements were resolved by discussion. When study eligibility could not be determined, authors were contacted to provide additional information.

Assessment of study quality
Methodological quality was assessed using an adaptation of a quality assessment checklist for diagnostic studies into two checklists. Quality criteria assessed were items on patient spectrum and selection, assessor selection, time period between wound measurement, numbers of participants receiving the measurements, execution of the measurement tool, likelihood of bias, the statistical methods used, and study withdrawals. One checklist was used for reliability studies; another checklist was used for validity assessments.

One reviewer assessed methodological quality and a second reviewer independently checked the assessment. Any disagreements were resolved by discussion.

Data extraction
Data were extracted from each study on the number of repetitions and frequency of measurement for the reliability studies, and validity for the accuracy studies. Other statistical analysis, including percentage variation, correlation
coefficient and statistical significance were also extracted. Study authors were contacted for additional data if necessary.

One reviewer extracted the data and a second reviewer checked the data. Any disagreements were resolved by discussion.

Methods of synthesis
The results were summarised using a narrative synthesis because of the variation in design, patient and assessor characteristics, measurement instruments and methods of analysis. The results were grouped by type of pressure ulcer measurement (diameter, depth, surface area, volume) and type of assessment (reliability, validity, feasibility) because of the variation in design, patient and assessor characteristics, measurement instruments and methods of analysis.

Results of the review
Twelve studies (range 622 to 639 ulcers) were included in the review. Where reported, sample sizes of patients in the studies ranged from four to 30 patients. One study evaluated measurement of 373 ulcers; the numbers of ulcers measured in the remaining studies ranged from four to 37 ulcers. Four of eight studies evaluating reliability and five of seven studies evaluating validity were judged to be of high or unknown risk of bias for at least half the items on the checklist.

Reliability of pressure wound measurement: Reliability for ulcer diameter measurements were mixed for inter-rater reliability (two studies). One study used a tape measure and found intra-rater variation from 2.1% to 11%. The second study measured depth using a probe and found inter-rater variation of 48%. Seven studies assessed reliability for surface area measurements. For surface area measurements there was satisfactory inter-rater reliability for transparency tracing combined with whole plus partial square count (CC=0.99, one study) and stereophotogrammetry combined with computerised image analysis (CC=0.99, one study). There was satisfactory intra-reliability for grid tracings from photographs combined with whole plus partial square count (CC=0.99, one study), slide photography with computerised planimetry (CC=0.999, one study), direct contact transparency tracing with computerised planimetry (CC=0.999, one study), and three layer sterile tracing grid combined with a portable digital pad (CC=0.99, one study).

Methodological problems precluded analyses of some studies evaluating transparency tracing methods and photography (three studies). Three studies assessed ulcer volume measurement reliability. Two studies used solutions to fill the ulcer cavity. One reported variations of 19% (inter-rater) and 6% (intra-rater) using sterile saline gel. The second study found no significant differences between two assessors using sterile fluid. A third study found high inter-rater correlation (CC=0.99) when using stereophotogrammetry with computerised image analysis.

Accuracy of ulcer wound measurements: One study found central wound depth measured with a probe was not valid compared with the reference standard, although the authors noted that the reference standard may contain unrealistic assumptions. One study (373 ulcers) compared four methods of surface area measurement with the reference standard. All methods used direct tracing of the wound boundary onto a transparent grid. The reference standard involved transparency tracing and digital planimetry. Two methods (whole plus partial square count, whole plus residual square count squares) were reported as accurate (both 1% variation from reference standard). One study assessing pressure ulcer volume found high correlation (CC=0.96) between nuclear magnetic resonance spectroscopy of alginate moulds and water displacement of moulds (the reference standard).

Agreement between pressure wound measurements: Two studies assessed agreement for measurements of surface area. One study found statistically significant differences between photography combined with digital planimetry, transparency tracing combined with digital planimetry and the Kundin device with a mathematical adjustment for estimating surface area. One study found agreement between photographic tracing and direct acetate tracing (both combined with digitising tablets and computerised planimetry). One study estimating ulcer volume found a high correlation (CC=0.89) between weight of alginate mould and volume calculated from a formula using direct wound dimensions.

Feasibility: One study found the median time taken to use a portable digital pad was shorter than using a scanned photograph (54 seconds compared with 126 seconds, p<0.001).

Authors’ conclusions
Although there were reliable methods for measuring the surface areas of pressure ulcers (including grid tracings from
photographs with whole plus partial square counts, portable digital pads and stereophotogrammetry combined with computerised image analyses), definitive conclusions could not be drawn about the instruments used to measure wound depth, diameter or volume, as most of the studies had methodological problems.

**CRD commentary**
The review addressed a clear question and criteria for the inclusion of studies were specified. Multiple databases were searched including attempts to identify unpublished studies. Steps were taken by the reviewers to minimise errors and bias at each stage of the review process.

The methodological quality of the included studies was assessed; most of the studies were found to be of poor quality and/or used inappropriate statistical methods. The authors’ decision to summarise the results in a narrative review appeared justified because of the heterogeneity in the included populations, instruments and outcomes.

The authors’ conclusions about the paucity of high quality studies and the performance of instruments to measure the surface areas of ulcers are likely to be reliable.

**Implications of the review for practice and research**

**Practice:** The authors did not state any implications for practice.

**Research:** The authors stated that further research was required to evaluate methods of wound measurement used in clinical practice. They also stated that future studies should include assessments of feasibility, particularly for patient comfort, acceptance, ease of use, time and cost. Methodological and statistical flaws highlighted in this research have the potential to inform future research agendas.

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