3D photography is as accurate as digital planimetry tracing in determining burn wound area

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Abstract

Background: In the paediatric population careful attention needs to be made concerning techniques utilised for wound assessment to minimise discomfort and stress to the child.

Aim: To investigate whether 3D photography is a valid measure of burn wound area in children compared to the current clinical gold standard method of digital planimetry using VisitrakTM.

Method: Twenty-five children presenting to the Stuart Pegg Paediatric Burn Centre for burn dressing change following acute burn injury were included in the study. Burn wound area measurement was undertaken using both digital planimetry (VisitrakTM system) and 3D camera analysis. Inter-rater reliability of the 3D camera software was determined by three investigators independently assessing the burn wound area.

Results: A comparison of wound area was assessed using intraclass correlation co-efficients (ICC) which demonstrated excellent agreement 0.994 (CI 0.986, 0.997). Inter-rater reliability measured using ICC 0.989 (95% CI 0.979, 0.995) demonstrated excellent inter-rater reliability. Time taken to map the wound was significantly quicker using the camera at bedside compared to VisitrakTM 14.68 (7.00) s versus 36.84 (23.51) s (p < 0.001). In contrast, analysing wound area was significantly quicker using the VisitrakTM tablet compared to Dermapix® software for the 3D Images 31.36 (19.67) s versus 179.48 (56.86) s (p < 0.001).

Conclusion: This study demonstrates that images taken with the 3D LifeVizTM camera and assessed with Dermapix® software is a reliable method for wound area assessment in the acute paediatric burn setting.

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1. Introduction

Wound surface area measurements are a valid indicator of wound progress [1]. There are a number of methods utilised to measure wounds ranging from a simple ruler, which is quick and inexpensive but inaccurate when wounds are irregular [2], to complex computerised systems, which may be accurate but are costly and time consuming [3]. In order for a wound measurement technique to be useful in clinical practice and research it needs to be time and cost efficient, easy to use and minimise patient discomfort.

It has been well documented that burn wound care procedures are highly traumatic for children and as such...
the resultant stress interrupts the cascade of healing [4]. Therefore in the paediatric population careful attention needs to be made concerning techniques utilised for wound assessment to minimise discomfort and stress to the child.

Percentage of wound re-epithelialisation is an important outcome in determining treatment efficacy in acute burn injury. The most common wound measurement device used in burns is digital planimetry using the Visitrak™ wound measurement system (Smith & Nephew Medical Limited, Hull HU3 2BN, England). The entire burn area can be traced with additional tracings of non re-epithelialised areas to allow for calculation of percentage of re-epithelialisation [4]. Although widely used in the burns research arena the Visitrak™ system does have some limitations. Contact with the wound is required which may cause patient discomfort, increase the risk of infection and potentially cause wound bed damage. Tracing the wound requires the patient to stay still which can be difficult within the paediatric setting. Fogging of the film can occur which can make the wound border difficult to assess and as the film is quite shiny reflective light can also hinder accurate identification of wound border. Finally, the Visitrak™ film is quite stiff, making it difficult to conform to some body parts such as little fingers.

Wounds are three dimensional (3D). If wounds are on curved body surfaces or tapering limbs, two dimensional photography is unlikely to allow for accurate measurement [5]. Stereophotogrammetry involves the use of two or more cameras and the computer to reconstruct 3D images of wounds allowing calculation of wound area and volume. Recently, the 3D LifeViz™ system has been developed by Quantificare (Sophia Antipolis, France). The system is very easy to operate and comes with dedicated software for wound area and volume assessment (Dermapix®). The aim of this study was to investigate whether 3D photography is a valid measure of burn wound area in children compared to the current clinical gold standard method of Visitrak™.

2. Method

2.1. Participants

This study included children with acute burns presenting to the Stuart Pegg Paediatric Burn Centre, Brisbane. Exclusion criteria included non English speaking, cognitive impairment or current involvement with Department of Child Safety.

2.2. Ethics

This study received approval from the Children’s Health Services Queensland Human Research Ethics Committee (HREC/13/QRCH/28).

2.3. Recruitment

Treating physicians/nursing staff of all children meeting the inclusion/exclusion criteria determined eligibility for enrollment in the study. With parent/caregivers permission, an investigator aligned with the study discussed the study with the parents/caregivers and gained informed consent. In addition, if the child was over eight years of age, child assent was also sought.

2.4. Measurement techniques

All participants had their burn wounds measured by two techniques: Visitrak™ and 3D photography. Randomisation of treatment order was undertaken by the use of sealed, opaque, identical and serially numbered envelopes prepared by an independent party.

Both wound measurement techniques required two phases – actual wound measurement at bedside and analysis of wound area.

2.4.1. Visitrak™ method

Visitrak™ wound measurement system involves mapping the wound onto a tracing grid sheet, which is then retracted onto the Visitrak™ digital pad which automatically calculates the area calculations. Visitrak™ is a valid tool for wound measurement that has been shown to have excellent intra and inter-operator reliability [6].

2.4.2. Photographic method

The 3D LifeViz™ camera is held above the wound. Dual beam pointers are lined up visually which ensures that each image is taken at a distance of 60 cm. The image is directly transferred to a laptop. Dermapix® software can then be utilised to trace the wound and area is automatically calculated.

2.5. Outcome measures

The following measures were taken for each participant using both wound measurement devices.

1. Wound area – measured in cm².
2. Preferred technique – following wound measurement using both techniques, patients and caregivers were asked which wound assessment they preferred.
3. Preferred technique – following wound measurement using both techniques, investigators were asked which wound assessment they preferred.
   a. For Visitrak™ tracing versus image capture using the 3D camera (at patient bedside).
   b. Wound measurement (mapping the area on the Visitrak™ grid versus calculating wound area using the 3D image with the use of Dermapix®).
4. Ease of use – investigators were asked to rate the ease of using each measurement device at the bedside using a 5 point Likert scale where 1 = extremely easy, 2 = very easy, 3 = somewhat easy, 4 = not very easy and 5 = not at all easy.
5. Time taken for wound tracing at the bedside and post processing (analysis) was measured via stopwatch.
6. Pain was measured at three time points – before the first measurement technique, between measurement techniques and following the second measurement technique. Caregivers were asked to report their children’s level of pain using a 0–10 visual analogue scale (VAS) [7]. The Faces, Legs, Activity, Cry and Consolability scale (FLACC) [8] was used by nursing staff to determine the distress of the child. If the
child was over three years of age they also completed a self report of pain using the Revised Faces scale (FACES) [9], a 0–10 pictorial scale validated in children three years and over.

2.6. Inter-rater reliability

Images were loaded onto the Dermapix software. All assessors worked within the paediatric burns outpatient setting and were experienced in assessing burn wounds. All three assessors independently measured the wounds and were blinded to the other assessor’s results. Two of the patients had two distinct burn wounds, each wound was assessed by each rater individually to give a total of 27 wounds for inclusion in inter-rater reliability.

2.7. Statistics

2.7.1. Sample size

Twenty five children were recruited to the study. This sample size was adequate to determine inter-rater reliability as described by Doros and Lew in 2010 [10].

2.7.2. Data analysis

Data were entered into SPSS (SPSS, Chicago, 21.0) and Graph Pad Prism 6 (Graph Pad Software, La Jolla, CA). Demographics such as age, gender and mechanism of injury was described and data presented as mean and standard deviation (sd) or median and interquartile range (IQR) as appropriate. The agreement in wound area measurement between the two measurement techniques was assessed using an intraclass correlation coefficient (ICC) and via the Bland–Altman method [11]. This allows visual inspection of the relationship between the two wound area measurements by producing a scatterplot of the two tests with 95% limits of agreement (LOA). Standard error of measurement (SEM) was calculated using the equation

\[ SEM = \frac{sd}{\sqrt{1 - rxx}} \]

where sd is standard deviation of the difference between the scores and rxx is the reliability coefficient [12]. Repeated measures Student’s t-test was utilised to compare both measurement techniques with respect to the time taken at bedside and the wound area analysis time. Preferred technique was determined using contingency tables (Chi square or Fisher’s exact test as appropriate). Contingency tables were also used to determine if there was a difference between groups with respect to pain during the measurement procedure. Data was tested for order effect. Inter-rater reliability was determined using intraclass correlation (model ICC 2.1) with 95% confidence interval. The coefficient was calculated in a 2-way analysis of variance (ANOVA) based on absolute agreement. Statistical significance was set at \( p < 0.05 \).

3. Results

Twenty-five patients presenting to the burns outpatient department for acute burn care management participated in the study (10 males, 15 females), median age 3 years, 7 months (IQR 1 year, 2 months–9 years, 1 month). Thirteen children presented with scald injuries and 12 with contact burns.

For all cases (100% of the time) nurses rated the camera as a 1 or 2 for ease of use whereas the Visitrak™ system only received a rating of 1 or 2 in 44% of the cases (Fig. 1).

Fig. 1 – Ease of use at bedside of measurement techniques. Likert scale whereby 1 = extremely easy, 2 = very easy, 3 = somewhat easy, 4 = not very easy, 5 = not at all easy. There was no significant difference in pain rating between measurement instruments with low pain scores recorded during both measurement techniques.

The preferred technique at bedside was the camera 24/25 (parents), 24/25 (investigators). However, the Visitrak™ was the preferred technique of the investigators for analysis of wound area.

Wounds varied in size from 0.3 cm² to 143.8 cm². A comparison of wound area was assessed using ICC (2.1) which demonstrated excellent agreement 0.994 (CI 0.986, 0.997) (Fig. 2). In addition, agreement between the two measurement techniques was visually inspected using Bland Altman plots comparing the mean wound area to the average area of the two methods. The plot (Fig. 3) demonstrates a bias of 2.65 (LOA –5.77, 11.07) cm² with a SEM of 0.33 cm². The plot demonstrates heteroscedasticity with larger wounds exhibiting greater variability between the two techniques.

Time taken to map the wound was significantly quicker using the camera at bedside compared to Visitrak™ 14.68 (sd 7.00) s versus 36.84 (sd 23.51) s (\( p < 0.001 \)). In contrast, analysing wound area was significantly quicker using the Visitrak™ tablet compared to Dermapix® software for the 3D images 31.36 (sd 19.67) s versus 179.48 (sd 56.86) s (\( p < 0.001 \)).

Table 1 demonstrates the individual measurements from each of the raters. Inter-rater reliability measured using ICC (2.1) was 0.989 (95% CI 0.979–0.995) demonstrating excellent inter-rater reliability.

Fig. 2 – Scatterplot showing paired data using both measurement techniques (Visitrak™ and 3D camera).
Advantages of photography over Visitrak™ are that no contact with the wound is required, the image provides a record of wound appearance not just area and importantly, capturing the image only takes a few seconds at the bedside. A recent study by Chang et al. [1] demonstrated that 2D photography combined with Imagej software [14] was an accurate alternative to Visitrak™ for measuring wound area. The wound was photographed with a ruler in the photograph to allow for calibration. The images were uploaded to a computer and opened with Imagej. The wound outline was defined from the photograph using a digital pad and the Imagej software calculated wound area. However, this study was conducted on surgically created porcine wounds of a regular shape on a relatively flat surface located on body areas easy to photograph. Animals were anaesthetised during measurement.

The results of this study demonstrate that both wound measurement techniques can be used within the paediatric burn setting. Ease of use (simplicity and speed) is important from the investigators perspective as demonstrated by the preferred choice being the camera at the bedside and the Visitrak™ for analysis. From a parent perspective the camera was the preferred technique as no contact with the wound was required.

This study demonstrates the reliability of 3D LifeViz™ as an alternative to Visitrak for measuring wound area as demonstrated by the excellent ICCs comparing the two techniques and the strong inter-rater reliability. The photographic method has the advantage of not requiring contact with the wound bed, thereby decreasing the risk of contamination and damage to new epithelium. This non-contact technique is highly desirable within the paediatric setting as any contact with the wound has the potential to cause pain and anxiety in children.

The usefulness of wound area assessment relies upon accurate identification of wound margin. As the wounds were acute burn injuries, fogging of the Visitrak™ film frequently occurred making exact identification of the wound margin difficult. In addition tracings of wounds with the Visitrak™ film often lacked fine wound edge detail as tracings were performed rapidly due to patient’s inability to remain still. This was particularly evident in larger wounds. In contrast the Dermapix software, whilst taking longer to analyse wound area, allowed for images taken by the 3D camera to be enlarged allowing for close examination and identification of the wound margin. The high quality image taken with the camera allows for comparison of wound appearance between patient visits. In addition, the 3D camera has the capacity to measure volume and has been shown to be a reliable and valid method of scar assessment, thus a valuable outcome measure throughout the burn continuum of care [13].

This study investigated a compliant group of patients as the investigators wanted to ensure both the wound measurement techniques would be tolerated by the child. The median age of children in this study was over 3 years of age. Clinically wound assessment using Visitrak™ is often difficult to achieve in very young children as it requires contact with the burn area and requires the child to stay still. Thus wound assessment using a non-contact quick device would be practical in the younger population. This requires further investigation.

4. Discussion

Calculation of wound area is frequently utilised in the clinical and research setting to monitor progress and determine efficacy of treatment [13]. It has been well documented that burn wound care procedures are highly traumatic for children. Therefore in the paediatric population assessment of wound area needs to be valid and reliable whilst minimising discomfort to the child.

### Table 1 - Individual burn wound area measurements using Dermapix® software.

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Measurements in cm².
Circumferential and burns over very curved areas still remain a challenge. Whilst the Visitrak™ film can potentially be wrapped around curved areas, the stiff film makes it very difficult to achieve on small fingers and toes. The 3D camera has the technology to enable overlaying photographs and stitching images together using anatomical landmarks, however this is technically difficult and thus would be utilised more as a research tool than in the clinical setting.

5. Conclusion

This study demonstrates that images taken with the 3D LifeViz™ camera and assessed with Dermapix® software is a reliable method for wound area assessment in the acute paediatric burn setting.

Conflict of interest statement

Nil.

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