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Comparison of a new laser beam wound camera and a digital photoplanimetry-based method for wound measurement in horses

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ABSTRACT

The aim of this study was to compare the accuracy, precision, inter- and intra-operator reliability of a new laser beam (LB) wound camera and a digital photoplanimetry-based (DPB) method for measuring the dimensions of equine wounds. Forty-one wounds were created on equine cadavers. The area, circumference, maximum depth and volume of each wound were measured four times with both techniques by two operators. A silicone cast was made of each wound and served as the reference standard to measure the wound dimensions.

The DPB method had a higher accuracy and precision in determining the wound volume compared with the LB camera, which had a higher accuracy in determining the wound area and maximum depth and better precision in determining the area and circumference. The LB camera also had a significantly higher overall inter-operator reliability for measuring the wound area, circumference and volume. In contrast, the DPB method had poor intra-operator reliability for the wound circumference. The LB camera was more user-friendly than the DPB method.

The LB wound camera is recommended as the better objective method to assess the dimensions of wounds in horses, despite its poorer performance for the measurement of wound volume. However, if the wound measurements are performed by one operator on cadavers or animals under general anaesthesia, the DPB method is a less expensive and valid alternative.

Introduction

Traumatic wounds are very common in horses and are often left to heal by second intention because of massive tissue loss, heavy bacterial contamination, or high skin tension (Wilmink et al., 2002; Theoret, 2008a). Second intention wound healing is often delayed due to infection, chronic inflammation, the presence of foreign bodies or impaired blood supply, so the choice of topical treatment is very important and should be based on careful monitoring of wound healing. Besides a subjective evaluation of the degree of inflammation and the quality and quantity of the granulation tissue, an objective and correct measurement of the wound dimensions (area and depth) is essential to follow the progress of wound healing through contraction and epithelisation. Objective monitoring allows for more rapid intervention and adaptation of the treatment plan when the wound deteriorates (Sibbald et al., 2006; Theoret, 2008b; Wilmink, 2008). Furthermore, objective evaluation of wound dimensions can facilitate clear communication to the horse owner about the progress of healing, and can aid high quality research designed to investigate wound healing.

Granulation tissue formation plays a crucial role in equine wound healing in the horse (Theoret, 2008a) but its formation cannot be monitored by area and circumference measurements only, especially in the early stages. During this early period, granulation tissue starts to form at the base of the wound, but the wound surface area remains unchanged (Little et al., 2009), so depth and volume measurements are essential to monitor progress. Area measurement of wounds is difficult when the skin surface is curved, or if the digital camera is not perpendicular to the wound surface (Treuillet et al., 2009). Therefore, it is important in measuring wounds to use a three dimensional technique, such as structured light or stereophotogrammetry (which can compensate for the skin curvature).

Measuring wound dimensions in horses is more challenging than measuring wounds in humans and the biggest problem is immobilisation of the animal during the procedure. A measurement technique that requires contact with the wound is often difficult to perform accurately and is likely to be time-consuming, especially when the wound is painful. Moreover, contact with the wound

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increases the risk of contamination and so a fast non-contact technique is preferable. The digital photoplanimetry (DP) technique, commonly used in equine studies to evaluate wound dimensions (Berry and Sullins, 2003; Monteiro et al., 2009; Tóth et al., 2011; Azari et al., 2012; Bischofberger et al., 2013), meets the non-contact requirement, but cannot measure either the depth or volume of a wound. Moreover, the accuracy or precision of the technique is unknown, reflecting a dearth of published information on wound measurement techniques in veterinary medicine. Only one study has been published on the feasibility and intra-operator variability of stereophotogrammetry (Labens and Blikslager, 2013), and to our knowledge, research investigating the accuracy and precision of other wound measurement techniques has not been published.

The aim of the present study was to compare two wound measurement techniques in horses. DP was chosen as the first technique, since it is frequently used in equine studies to assess wound dimensions (Berry and Sullins, 2003; Monteiro et al., 2009; Tóth et al., 2011; Azari et al., 2012; Bischofberger et al., 2013). The technique was supplemented with a manual measurement of the maximum wound depth, thus allowing the wound volume to be calculated using the validated Kundin formula (Kundin, 1989; Langemo et al., 1998, 2001, 2001). For the second technique, a new laser beam (LB) wound camera (SilhouetteStar, ARANZ Medical) was chosen. The accuracy, precision, inter- and intra-operator reliability of the two techniques for the measurement of equine wounds were assessed. Silicone wound casts served as the reference standard to measure wound dimensions.

Materials and methods

Forty-one wounds were created on equine cadavers collected from the Pathology Department of the Faculty of Veterinary Medicine, Ghent University. The cadavers originated from horses euthanased for reasons other than the conduct of this study and informed consent was obtained from the owners of the horses used. If the horses were euthanased more than 2 h before creating the wounds, their cadavers were stored in a refrigerator at 4 °C until the start of the experiment. After clipping, wounds were created with a scalpel on either the neck, or the thorax, or the limbs proximal to the carpus or tarsus, by removing the skin and a piece of the underlying muscle depending on the desired depth of the wound. The wounds were created 1–48 h after euthanasia and varied in surface, depth, shape and size to resemble real-life clinical cases.

For each wound, the surface area, circumference, maximum depth and volume were measured. All wounds were measured with the DP-based (DPB) method first, followed by the LB camera by two different operators to determine inter-operator reliability; one operator had experience with wound management, whereas the other did not. Each wound was measured four times with each technique to assess the intra-operator reliability. After performing the wound measurements, silicone casts were made of the wounds to serve as the reference standard. During the experiment, the cadavers were not moved so that distortion of the soft tissues that could lead to a change in the wound dimensions was avoided.

Digital photoplanimetry-based method

The wounds were photographed with a digital camera held perpendicular to the wound surface. A ruler positioned next to the wound served as a metric scale (Fig. 1). To measure the maximum depth, a cotton-tipped swab was positioned in the deepest part of the wound and was pinched between thumb and index finger at the level of the surrounding skin. The swab was then removed from the wound while remaining pinched between thumb and index finger, before the distance from the cotton tip to the top of the fingers was measured with a ruler. The pictures were analysed with an open source Java-based program to calculate the surface area and the circumference of the wound.[1]

The volume of the wound was calculated using the Kundin formula:

$$\text{Volume} = \text{Area} \times \text{maximum depth} \times 0.327$$

Fig. 1. Picture obtained perpendicular to the wound surface with a metric scale marker included for analysis within the ImageJ[1] program for the digital photoplanimetry-based method.

Laser beam wound camera

First, the LB camera (SilhouetteStar, ARANZ Medical) was connected to a laptop containing the appropriate software (SilhouetteConnect, ARANZ Medical). The camera was held perpendicular to the wound surface as described in the manufacturer's instructions. Ideally, the three laser lines projected by the camera on the wound surface crossed in a star shape, with the ends of the lines lying on the adjacent skin and the central focus point of the star at or near to the centre of the wound (Fig. 2). The operators ensured that at least a part of one of the laser lines always ran over the deepest part of the wound. After taking a picture, the circumference, maximum depth and volume of the wound were calculated using the accompanying software.

The software used the three laser lines projected on the wound surface as a 'scaffold' to build a mathematical model of the wound (Fig. 3a). A mathematical surface was drawn over the laser lines as shown in Fig. 3b, onto which the software added the wound boundaries as traced by the operator (Fig. 3c). For concave wounds (as was the case for all the wounds in our study), the software stretched a virtual cap over the mathematical wound concavity, which represented a reconstruction of the former intact skin and served as a digital reference to calculate the maximum depth and volume of the wound (Figs 3d and 4).

Silicone wound casts

Silicone wound casts were used as the reference standard to measure wound dimensions. The wound casts were made after the measurements with the DPB method and the LB camera were completed, since removing the casts could change the wound dimensions. For all casts, body double 'fast set' silicone (FormX) was used, because silicone does not shrink and provides highly detailed reproductions. The wounds were first covered with transparent plastic to prevent the silicone from extending above the level of the surrounding skin. Next, the silicone was injected beneath the plastic foil into the wounds with aid of a dispensing gun to minimise spillage and to obtain an optimal mix of the silicone components. The casts were removed from the wound bed after 5–15 min, when the silicone was set.

To measure the area and circumference of a cast, it was photographed with a digital camera held perpendicular to its surface. A ruler positioned next to the cast served as a metric scale (Fig. 5). ImageJ[1] was used to calculate the area and circumference of the cast surface. To calculate the maximum depth of a cast, it was photographed with a digital camera held perpendicular to the side of the cast (Fig. 6). A ruler held next to the cast served as a metric scale. The pictures were also analysed with ImageJ[1] to calculate the maximum depth of the wound cast. To measure the volume of a wound cast, the cast was weighed and the mass was divided by the specific gravity of the silicone (1.17 g/cm^3). All cast dimensions measurements were repeated four times by the same operator. The values of the cast dimensions represented the true wound dimensions.

Data processing

Since the true wound dimensions were measured, the relative bias (RB) of the DPB method and the LB camera could be calculated for each wound (Langemo et al., 1998, 2001). The RB is a measure of the accuracy of a technique. In this study, the average value of wound dimensions across operators and repeated measurements was used to calculate RB. The following equation was used to calculate RB for the two techniques (Langemo et al., 2001):

[1] See: Rasband, W.S., ImageJ, U. S. National Institutes of Health, http://imagej.nih.gov/ij/ (accessed 9 December 2014).