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Non-contact wound measurement in captive Asian elephants (*Elephas maximus*) using smartphone application

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Abstract
Skin wounds are one of the common problems in elephants as skin is the primary barrier of defense. Wound measurements are the key predictor of the progress of healing if taken from the day of initiation of treatment. Traditional measurement methods are mostly contact in nature which will cause disruption in healing, pain and discomfort. The advent of a smartphone capable of imaging and processing is a boon in healthcare systems across the world. A smartphone application dedicated for wound area measurement was used in captive Asian elephants in various-sized wounds non-invasively. The same smartphone and application was used throughout the study process by a single observer. The use of smartphone digital planimetry with a smartphone application was found to be useful as a non-contact wound measurement technique in captive Asian elephants.

Keywords: Captive Asian elephants, cutaneous wounds, smartphone, smartphone application, wound measurement, non-contact

1. Introduction
Elephants are special not only because of its large size and dexterous trunks but being the keystone species, their conservation matters most. As the skin is the primary barrier of defence, cutaneous wounds are regarded as one of the most common problems of captive elephants. Wound healing is a sequential process progressing through various stages and the normally will end up in healing and formation of scar. Wound measurements are the key predictor of the progress of healing if taken from the day of initiation of treatment. Traditional measurement methods are mostly contact in nature which will cause disruption in healing, pain and discomfort. The development of smartphone technology incorporating digital cameras and software applications is well performing in various fields. Smartphone-based planimetry applications are used in human medicine but rarely reported its use in captive Asian elephants. Other than ease of use, they provide options of storage, transmission and non-contact measurement.

2. Materials and Methods
As the part of the research work, this study was conducted in captive Asian elephants (*Elephas maximus*) with cutaneous wounds reported to Veterinary Hospitals of Kerala Veterinary and Animal Sciences University at Kokkalai and Mannuthy, and elephant camps within Kerala and outside over a period of three years from September 2019 to October 2022. The length, width, area and perimeter (circumference) of the selected wounds were recorded as a total of 111 measurements at different points in time by digital planimetry using a smartphone and smartphone application. The smartphone application 'imino' (Imito AG, Zurich, Switzerland) was downloaded from the Google Play store to an Android smartphone. For calibration, markers of 1.5 cm x 1.5 cm provided as PDF files by the developers of the application were used. The markers were printed onto a 220 GSM paper and cut them for single use and disposal of. All the observations were carried out by the same observer using a dedicated mobile phone and application for the study.

The routine updates of the smartphone application and mobile phone were done during the entire period of study. For taking measurements, the marker was placed near the wound (Figure-1). The application in use detected the marker and allowed user to capture the image and delineate (Figure-2) it with finger on screen (Dastjerdi *et al*., 2019 and Aarts *et al*., 2022) [4, 1]. Considering the margins marked, the application calculated the wound length, width, area and perimeter (Figure-3) and provided a PDF report.

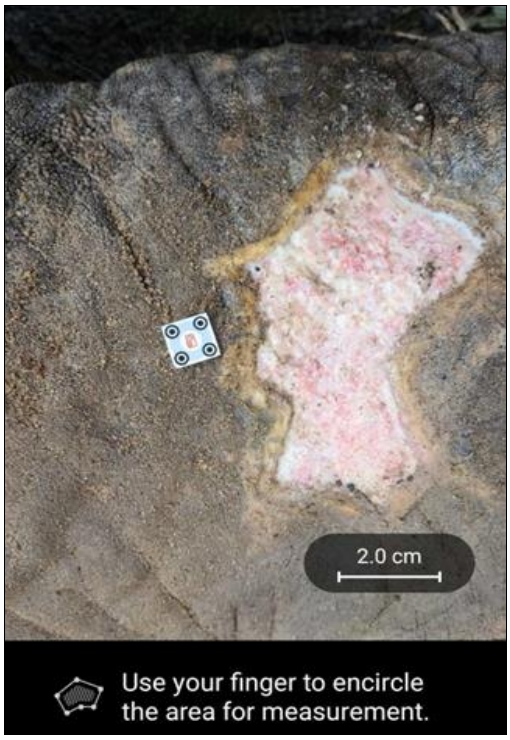

Fig 1: Marker placed near the wound

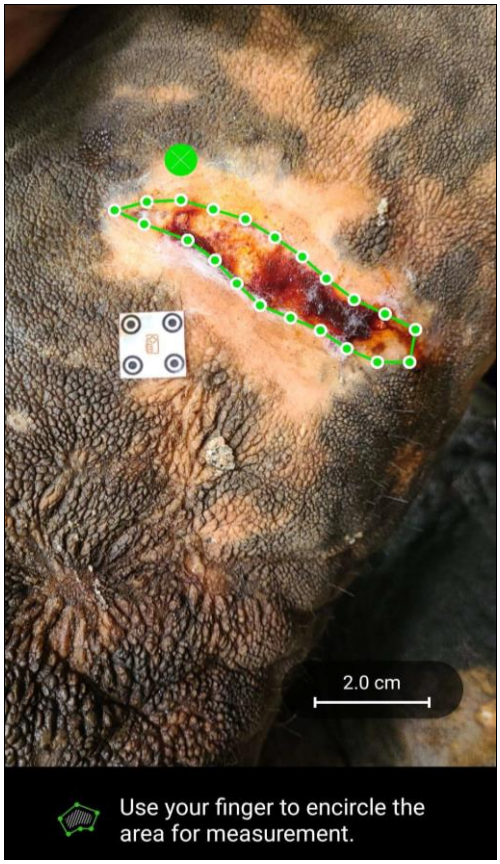

Fig 2: wound margins marked by finger seen as green dotted lines

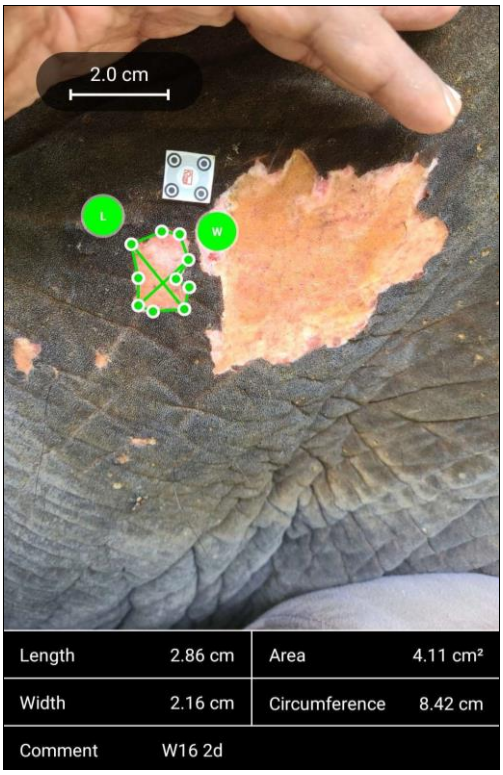

Fig 3: Measurements calculated by application seen on the result screen

3. Results and Discussion

Being the primary barrier of a large surface area, elephant skin is more prone to injuries. The wound measurement data showed a wide variation of measurements. By this smartphone application, we detected lengths as small as 0.64 cm and as large as 33.94 cm. The smallest width recorded was 0.23 cm and the biggest was 17.28 cm. The smallest area calculated by the smartphone application was 0.09 cm2 and the biggest was 313.75 cm^2. The perimeter detected was as low as 1.39 cm to as big as 103.14 cm (Table-1). So, it was evident that the 'imino' smartphone application was able to detect smaller measurements as small as 0.23 cm. Even though this study was conducted in elephants, this result clearly indicates that the same application can be used in wound measurements in small animals and hence will be best suited in wound studies using laboratory animals like mice, rats etc. Van Poucke *et al*. (2010) [19] opined that, before a tool can be applied in clinical practice, a validation process that assesses the reliability and repeatability of its use by different healthcare professionals should be performed. In this study, method used was planimetry which means measurement of the surface area and the periphery of a plane figure by tracing its boundaries (Ahn and Salcido, 2008) [2]. Smartphone use is spreading worldwide, and applications for treating various health ailments are becoming more popular. With a straightforward and useful tool, mobile applications enable chronological and iconographic follow-up of wounds like pressure ulcers (Koepp *et al*., 2020) [7]. Being a non-contact method, the objective evaluation and measurement techniques performed using this method from the day of first observation helped to assess the progress of healing by recording the reduction of active wound margins during healing. Measuring the wound area on the day zero of observation was found to be the best practice for the accurate healing assessment (Dowsett and Newton, 2009) [5]. Melhuish *et al*. (1994) [11] reported contact wound techniques carried the risk of contamination and wound disturbance which could be

avoided in the present study by effective use of remote measuring technique.

Table 1: Lowest, highest and average values of measurements

No.	Item	Lowest	Highest	Average
1.	Length (cm)	0.64	33.94	8.45
2.	Width (cm)	0.23	17.28	4.23
3.	Area(cm^2)	0.09	313.75	34.61
4.	Perimeter (cm)	1.39	103.14	21.83

In the present study, only one observer collected the data. The results revealed that sticking on to one single observer and a strict protocol in this study, for the visual appraisal of wound conditions was found to be effective. Similar observations were also made by Schiffmann *et al.* (2020) [14]. The usefulness of wound area assessment relies upon accurate identification of wound margin (Shaw and Bell, 2011; Stockton *et al*., 2014) [16, 17] and subjectivity can lead to inaccuracy (Plassmann and Jones, 1998) [13]. This method was found to be more accurate in clinical practice (Treuillet *et al*., 2009) [18] and had a definite advantage over the manual methods of wound measurements in species like elephants. The method adopted in the present study was found to be time and cost-efficient, easy to use and with minimal patient discomfort in clinical practice especially in elephants for accurate assessment of the wound (Stockton *et al*., 2014) [17] where there are limitations of invasive interaction. This also provided procedures with reduced cost, less dependence on technology, and without the risk of infection and provided a portable, user-friendly point-of-care biomedical imaging device through user-centred customized hardware and software interfaces for long-term monitoring (Huynh (2019) [6], Liu *et al*. (2019) [9], Majumder and Deen (2019) [10], Pafitanis *et al*. (2019) [12], Shamloul *et al*. (2019) [15] and Alves *et al*. (2022) [3].

4. Conclusion

The advent of a smartphone capable of imaging and processing is a boon in healthcare systems across the world. The use of smartphone digital planimetry with a smartphone application was found to be useful as a non-contact wound measurement technique in captive Asian elephants. The ease of use, simplicity, speed of data generation, ability to store and transmit etc. are the advantages of this method. Even though the present study is performed in elephants, due to the ability to detect very small measurements, this smartphone application can be used in studies using small laboratory animals also and is hence recommended.

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