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BRIEF COMMUNICATION: Measurement of sole thickness and distance to distal phalanx using a portable ultrasound machine

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INTRODUCTION

Using a high specification ultrasound machine, with the ultrasound transducer applied to the sole surface, Kofler *et al.* (1999) were able to estimate sole and soft tissue thickness in claws from bovine cadavers. These ultrasound estimates were significantly correlated with measurements, made using mechanical callipers, of the same parameters in claws after sectioning. Moreover, Kofler *et al.* (1999) demonstrated that it was possible to image the internal structures of the bovine claw in the live animal and also reported the use of a portable ultrasound. They did however state that the images were of lower quality, due to the poorer resolution of the transducer, and were more difficult to obtain. In contrast, van Amstel *et al.* (2003, 2004a, 2004b) were able to visualise the sole and corium using a portable ultrasound, but did not assess the accuracy of the measurements in cadaver claws. As a consequence, this paper aims to assess bovine claws collected from cattle post mortem, to measure claw sole thickness and distance to distal phalanx using a portable ultrasound machine and to compare these with measurement collected using electronic callipers following sectioning of the frozen claws, such that changes in sole thickness could be assessed in future longitudinal studies with lactating dairy heifers.

MATERIALS AND METHODS

The distal limbs were collected from 24 dairy cows, eight had died within the previous 24 hours of conditions unrelated to lameness, three were culled dairy cattle euthanased on-farm and the remainder were collected from a local abattoir. The age, breed and cause of death of each animal were recorded. On removal, each limb was identified using an elastic band of a specified colour. After collection, the limbs were washed and a latex glove placed over the sawn end of the limb to prevent moisture loss. All four limbs from each cow were placed in an individual plastic bag, sealed with a cable tie, and stored at 3 to 5°C, prior to ultrasound assessment. All ultrasound measurements were completed within 72 hours post mortem.

Ultrasound assessment of claws

The ultrasound machine used for this study was a Mindray DP 6600 (Mindray, Szechuan, China). Prior to examination the solar surface of each claw was lightly pared. The transducer was protected by a vinyl glove containing acoustic coupling gel prior to use and additional gel was then applied to the claw surface to aid coupling between the claw surface and transducer. The transducer was placed along a line perpendicular to and bisecting the line from the abaxial groove to the axial border, which was also perpendicular to, and bisecting, the line from the end of the axial white line to the abaxial border (modified from Räber *et al*., 2004). The ultrasound measurements were taken at two sites; the tip of the distal phalanx (Site 1) and 25 mm towards the heel (Site 2). All measurements were completed with the probe set at a frequency of 5 MHz. Two measurements were taken at each site; the distance to the distal phalanx from the external sole surface (DP) and the distance from the external sole surface to the internal sole surface (STh).The internal sole surface was visualised as a thin hyperechoic line of a continuous or interrupted nature above an anechoic region (Figure 1).

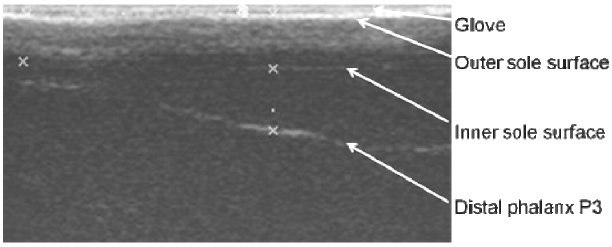
Calliper measurement of distance to distal phalanx and sole thickness

The limbs were frozen at –20°C, directly following ultrasonography, for at least 24 hours before being sectioned. The frozen claws were sectioned sagittally along the line where the transducer was placed, using a band saw. DP and STh were measured using electronic callipers at Sites 1 and 2.

Statistical analysis

Pearson's correlation was used to assess the relationship within all the parameters measured using the electronic callipers, and within the four ultrasound measurements, and to evaluate the association between the measurements obtained using ultrasound and measurements obtained using electronic callipers. All statistical analysis was completed using SPSS 16, (SPSS Inc., Chicago, Illinois, USA).

FIGURE 1: Image obtained with a 5MHz linear probe. The uppermost white line represents the glove protecting the probe; below this is the outer surface of the sole. The lowest white line is the palmar/plantar surface of the distal phalanx. The white line above this is the inner surface of the sole. All distances were measured from the outer sole surface. Grey crosses denote cursor positions for measurements taken.



RESULTS

An image could not be obtained from four of the 96 claws assessed. All four of these cases involved the same individual animal. The sole thickness could not be measured in a further two claws at Site 1 and five claws at Site 2 where there no internal sole surface visible or the line was obscured by a lesion artefact. Correlations between the estimates for sole thickness and the distance to the distal phalanx obtained using ultrasound and measured on the sectioned hoof, are presented in Table 1.

All four calliper measurements were highly correlated with the coefficient ranging from 0.71 to 0.92 (P <0.001). The correlation coefficient between the four ultrasound measurements was lower and ranged from 0.25 to 0.64. All coefficient s were highly significant (P <0.001) except for the relationship between STh2 and the two DP measures which were significant (P = 0.018 for both relationships).

The comparison of the ultrasound and electronic calliper measurements showed that the correlation was higher for estimates of DP than STh, and for measurements made at Site 1 than at Site 2. The correlations between the calliper and ultrasound measurements of the distance to the distal phalanx (DP1 and DP2) were both >0.85 (P <0.001), whereas for STh1 the correlation coefficient was 0.513 (P <0.001). The correlation for STh2 was not significant (r = 0.103, P = 0.340). At both measurement sites, there was a higher correlation between the ultrasound estimate of DP and the calliper STh than there was between ultrasound DP and the ultrasound estimate of STh. At Site 1, the correlation between ultrasound DP1 and calliper STh1 was r = 0.77 compared with r = 0.513 for the two STh measurements. At Site 2 the relationships were r = 0.72 and r = 0.103, respectively.

DISCUSSION

In this study similar images of the internal structures of the claw were obtained as those reported in the studies by Kofler *et al.* (1999) and Van Amstel *et al* (2003, 2004a, 2004b). There was only one individual animal for which no image of the internal structures could be obtained. This animal was found to have a greater than average STh and DP when the claws were sectioned. A failure to obtain ultrasound measurements from individual animals with soles ≥10mm thick was reported by Kofler *et al.* (1999). These authors related imaging failure to attenuation of the ultrasound waves. Hard or dry sole horn is also

TABLE 1: Pearson correlation coefficients for estimates of sole thickness (STh) and distance to distal phalanx (DP) measured using ultrasound in the intact claw and using electronic callipers after sectioning of the frozen claw on a band saw. Measurements were made at the tip of the distal phalanx (1) and 25 mm along the solar surface of the claw towards the heel (2). Coefficients shown in bold = P<0.01, coefficients shown in bold italics= P<0.05. Numbers of claws measured by ultrasound (in brackets) were STh1 (90), DP1 (92), STh2 (887), DP2 (92). Numbers of claws measured by calliper after sectioning with band saw were 96 for all measurements.

Technique		Ultrasound			Calliper			
	Measurement	DP1	Th2	DP2	STh1	DP1	STh2	DP2
Ultrasound	STh1	**0.64**	**0.46**	**0.42**	**0.51**	**0.60**	**0.35**	**0.37**
	DP1		***0.25***	**0.64**	**0.77**	**0.85**	**0.605**	**0.60**
	STh2			***0.25***	0.17	***0.24***	0.10	0.21
	DP2				**0.61**	**0.64**	**0.72**	**0.85**
Calliper	STh1					**0.92**	**0.81**	**0.71**
	DP1						**0.77**	**0.75**
	STh2							**0.90**

reported to interfere with imaging Kofler *et al.* (1999) and van Amstel *et al.* (2003, 2004a). While Kofler *et al.* (1999) successfully imaged the internal sole surface, as a thin hyper echoic line, in 86% (86/100) of the claws; they reported that the line was either interrupted or incomplete in only 9% (8/86) of the claws. This interruption was a more frequent finding of 14% (13/90) in this study.

In this study minimal claw preparation was undertaken, prior to obtaining ultrasound images, so as to not alter sole thickness or cause greater sole thinning. Despite this, good surface contact was achieved, most likely due to the relatively smooth and non-flaky nature of the sole horn. This was increased by the placement of the transducer probe into a glove filled with acoustic ultrasound gel, which moulded to the contour of the sole.

The present study used two measurements along a repeatable line, parallel to the long axis of the claw. This line was employed to allow collection of histological specimens for light microscopy from standard sites (Räber *et al.,* 2004). This proved to be a practical method for probe application and landmark recognition.

The results in this study agree with those reported by Kofler *et al.* (1999) in that correlations obtained for the distance to distal phalanx between ultrasound and calliper measurements were high for all sites measured. However, this study resulted in moderate correlations between sole thickness at Site 1 and no significant correlation at Site 2. Kofler *at al.* (1999) reported high correlations levels for these sites. Thus, it was concluded that, applying the methods used in this study, a Mindray DP 6600 portable ultrasound could be used to accurately estimate DP, however it was not considered sufficiently accurate for the direct estimation of STh.

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