Evaluation of a standardised radiographic technique of the equine hoof

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Summary

Radiography of the equine hoof is often used to obtain a diagnosis. Quantitative interpretation, especially for research purposes requires high quality and accuracy of radiographs. The purpose of this study was to describe and evaluate a radiographic technique for the lateromedial (LM) and the dorsopalmar (DP) view of the equine hoof. Ten radiographs for each view from one cadaver limb and from both front feet in a standing horse were taken in order to assess repeatability of the radiographic technique. The method requires easy to use adjustable and portable equipment and strictly defined external radio opaque markers on the hoof capsule. The digitalised radiographs were processed and analysed with the software package Metron PX™, measuring 13 parameters in the LM view and 10 parameters in the DP view, respectively. Results show that with few exceptions measurements of these parameters revealed a coefficient of variation that was smaller than 0.05. It was concluded that this easy to use standardised radiographic technique ensures excellent accuracy and repeatability for both the LM and DP view. Hence, this method provides an adequate tool for quantitative assessment of the equine hoof, inter- and intraindividually.

Keywords: equine hoof, radiography, standardised technique, metron PX™, evaluation

Evaluation einer standardisierten Röntgentechnik zur Untersuchung des Pferdehufes

Die Röntgenuntersuchung des Pferdehufes ist ein sehr wichtiges diagnostisches Hilfsmittel bei der orthopädischen Untersuchung. Für quantitative wissenschaftliche Untersuchungen sind eine gute Qualität der Röntgenbilder und eine standardisierbare Projektion unbedingt erforderlich. Das Ziel dieser Studie ist es, eine standardisierte Röntgentechnik für lateromediale (LM) und dorsopalmare (DP) Aufnahmen des Pferdehufes zu beschreiben und zu evaluieren. Um die Reproduzierbarkeit der Röntgentechnik zu untersuchen, wurden je 10 Aufnahmen von beiden Projektionsrichtungen eines Beines von einem geschlachteten Pferd und von beiden Vorderhufen eines stehenden Pferdes angefertigt. Die Röntgenbilder wurden mit Hilfe einer portablen Röntgenröhre, die auf einer speziellen Vorrichtung montiert war angefertigt. Auf der äusseren Hornkapsel wurden spezielle röntgendichte Marker befestigt. Die digitalisierten Röntgenbilder wurden mit dem Softwareprogramm Metron PX® verarbeitet und analysiert. Dabei wurden 13 Parameter auf der LM-Aufnahme und 10 Parameter auf der DP-Aufnahme ausgemessen. Abgesehen von wenigen Ausnahmen wiesen die gemessenen Parameter einen Varianzkoeffizienten kleiner als 0.05 auf. Diese standardisierte Röntgentechnik ist sehr genau, zeigt für die LM- und DP-Projektion eine gute Wiederholbarkeit und kann zur inter- und intraindividuellen quantitativen Untersuchung des Pferdehufes sehr gut verwendet werden.

Schlüsselwörter: Pferdehuf, Röntgenuntersuchung, standardisierte Technik, Metron PX®, Evaluation

Introduction

The foot is the most frequent radiographed region of the horse because many gait abnormalities result from problems in the hoof. There are several scientific studies dealing with measurements of hoof structures. Linford et al. (1993) evaluated the bone structures in relationship to the surrounding of horn and soft tissues in 41 thoroughbred horses. Cripps and Eustace (1999) investigated the normal position of the pedal bone with relevance to laminitis in different breeds. Other studies focused on the correct longitudinal and medio-lateral hoof balance (Butler *et al.*, 1993; Colles, 1983; Stashak, 1987). In a population of halfblood

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Table 1: Summary of the most frequently measured radiographic parameters on the LM view in scientific studies.

Parameter	Present study	Linford (1993)		Verschooten (1989)		Cripps (1999)	
	abbre-viation	abbre-viation	Mean ± SD	abbre-viation	Mean ± SD	abbre-viation	Mean ± SD
Hoof Angle (°)	HA	HFAX	48.20±2.60	β	51.00±3.30	S	50.52±5.03
Angle P3 to bottom (°)	P3A	DPAX	47.80±3.00			T	49.42±5.24
P3 to Ground (cm)	P3G	DPSHO	1.37±0.27	Dvt	2.10±0.67		
Hoof P3 Distance (cm)	HP3	STTD	1.46±0.10	Dk	1.92±0.23	WT	1.63±2.40
Hoof P3 Angle (°)		ROTA	–0.50±1.30			H	–0.86±2.37
Navicular Width (cm)	NW			h	2.27±0.25		
Length of P2 (cm)	LP2			H	4.34±0.37		
Founder Distance (mm)	PD					D	4.14±2.17

horses parameters measured on lateromedial radiographs of the equine foot were compared between sound horses and horses with navicular disease (Verschooten et al., 1989). In the reviewed studies about 40 different radiographic parameters concerning hoof structures were identified and measured on LM views. Table 1 summarises the most frequently applied parameters.

In all these studies, neither positioning of the foot for x-raying, nor the radiographic measurements were performed using a standardised technique. Recently, the radiographic technique was validated in cadaver limbs for the longitudinal balance of the front feet (Taccio et al., 2002). They postulated that measurements, particularly angles, seemed to be most affected by rotational divergence to the true LM view.

Trimming and shoeing remains an important issue in equine orthopedics. Currently, farriers, hooftrimmers and veterinarians use radiographs to evaluate the quality of the treatment or as a guideline for corrective shoeing in daily practice. However, for research purposes, a standardised and validated approach is absolutely essential for quantitative radiographic measurements on the equine hoof. This is also true for inter- and intraindividual comparison during radiographic follow-up studies, e.g. before and after trimming or corrective shoeing and evaluation of the course of laminitis. At present, several software packages exist for radiological measurements. For our study we used the Metron PX™ (Epona Tech; P.O. Box 361, Creston, CA 93432, USA). The exactness of the program itself was evaluated by other studies (Craig *et al.*, 2001; Vargas *et al.*, 2004). Vargas *et al.* (2004) utilized the same standardised technique described in this paper.

The goal of the present study was to establish specific guidelines for making radiographs that can be used for qualitative and especially for quantitative description of the shape and the dimension of hoof structures. With the exception of the study of Taccio et al. (2002) who concentrated on the longitudinal balance of the front feet, it is the first time that a detailed description and statistical evaluation of a standardised radiographic technique is performed, for lateromedial (LM) and dorsopalmar (DP) views. We hypothesized that the comparison of repeated radiographs of the same foot in a standing horse would show excellent accuracy and repeatability.

Materials and Methods

Radiographic method

The horse was positioned simultaneously with both forelimbs on a wooden block. The block was 8.5 cm thick, 33 cm long and 53 cm wide. The limbs had to be equally weighted and the third metacarpal bone had to be perpendicular to the surface of the block (Fig. 1). In the horizontal surface of the block two radiopaque markers with a length of exactly 5 cm were embedded in a lateromedial and dorsopalmar direction (Fig. 4). On the palmar and medial side there was a 2.5 cm deep and 1.6 cm broad groove for fixation of the film cassette (Fig. 1). The foot to be radiographed

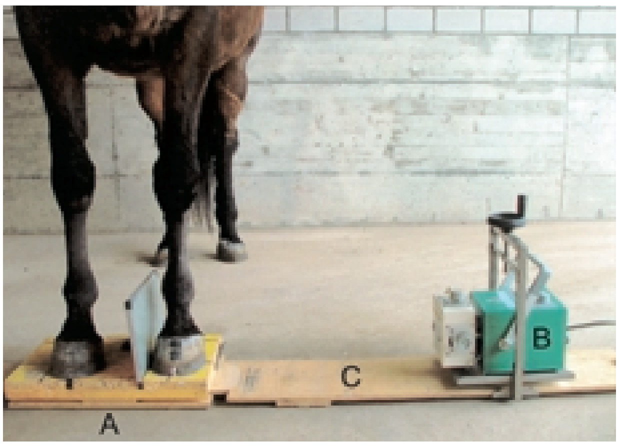

Figure 1: Technical equipment for standardised radiographic technique of the hoof. The horse stands with both forelimbs simultaneously on a wooden block (A). The portable x-ray unit (B) is positioned on a platform with adjustable level carried by a wooden board (C). A hinge in the block allows 90° range of motion to obtain radiographs in both lateromedial (LM) and dorsopalmar (DP) projections.

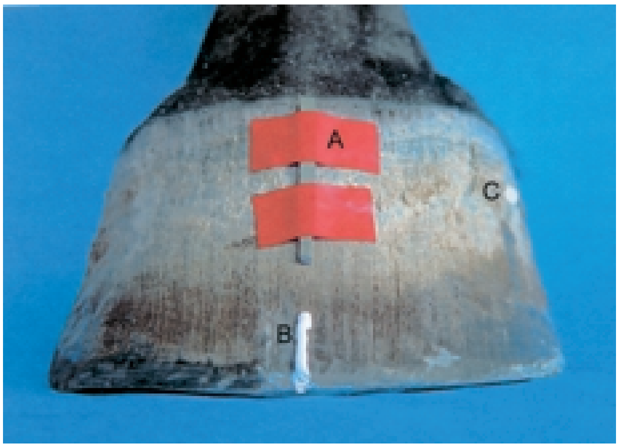

Figure 2: Location of radio opaque markers on the hoof wall. A 5 cm long and flexible band of lead (A) is positioned at the dorsal aspect of the hoof wall with its proximal end at the coronet bordering the hair line. The tip of the toe (B) and the point where the x-ray beam of the lateromedial projection is centred (C) are marked with barium paste.

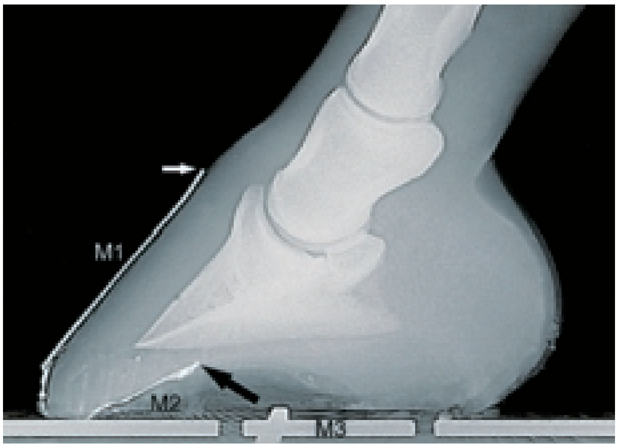

Figure 4: LM view of the left front hoof of a 15 year old warmblood mare. The proximal/distal position of the third phalanx relatvie to the hoof capsule can be discerned by placing a radio opaque marker (M1) on the dorsal hoof wall with the most proximal aspect at the coronet bordering the hair line (white arrow). The sole between the most distal point of the toe and the true apex of the frog (black arrow) is marked with barium paste (M2). The embedded marker (M3), a square iron rod with a length of 50 mm and width of 4 mm, both simplifies and guarantees accurante calibration for every radiograph.

was placed in a manner to assure that the cassette touches the hoof capsule on the medial side. On either side of the central wooden block a board of 130 cm length carried the portable x-ray unit (Vet-Ray®; Eikemeyer, Germany). The standing block and x-ray unit board were connected by a hinge, allowing 90° range of motion in order to take views in both LM and DP projections without need for alteration of the horse's position (Fig. 1). At the same time, this construction guaranteed a constant focus-film distance for each radiograph, 90 cm in the LM and 98 cm in the DP view, respectively. In addition, the level of the camera was adjustable for individual hoof anatomy. The exposure factors for the LM and the DP view were 58 kV, 8 mAs and 62 kV, 8 mAs, respectively.

Figure 3: Location of radio opaque markers on the sole and the bulbs of the hoof. The line between the true apex of the frog and the most dorsal part of the toe (A) is marked with barium. The most palmar points of the quarters (B) and the palmar contour of the heel bulbs (C) are marked similarly.

For the LM view, the horizontal x-ray beam was centred 2 centimetres below and at the midlevel of the coronary band, between the bulbs of the heel and the proximo-dorsal aspect of the hoof wall. This point was marked with barium paste (Fig. 2).

After moving the board with the x-ray unit 90° for the DP images, the horizontal x-ray beam was centred on the median dorsal hoof wall without changing the level of the x-ray beam.

For the LM view, the dorsal hoof wall was marked with a flexible 5 cm long band of lead. The upper rim of the lead-band was placed at the coronet bordering the hair line (Fig. 2 and 4). The distal part of the dorsal hoof wall and the line between the true apex of the frog and the most dorsal part of the toe were marked with barium paste (Fig. 3 and 4). To mark the medial and lateral hoof wall in the DP view, equal pieces of lead were used. They were both placed parallel to the horn tubules and the proximal end at the coronary band at the broadest part of the hoof. All markers were placed by the same person, in both studies, the main and cadaver study, respectively.

Experimental method

In the cadaver study, a distal right forelimb of a euthanized 12 year old warmblood mare was fixed on the block. Prior, the hoof was prepared with the markers

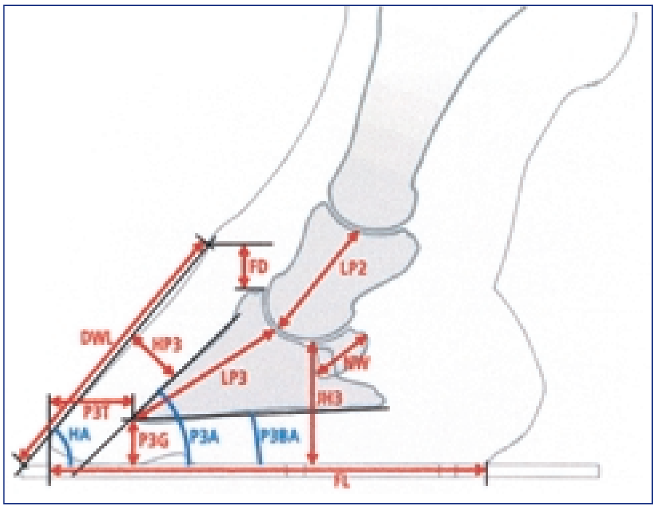

Figure 5: Schematic view of a LM radiography indicating the 13 measured parameters.
Distances: LP2 = Length of P2 (Distance between the middle of P2/P3 joint and the middle of P1/P2 joint) (cm); LP3 = Length of P3 (shortest distance from the point of P3 to the surface of P2/P3 joint) (cm); NW = Navicular Width (cm); DWL = Dorsal Wall Length (cm); HP3 = Hoof/P3 Distance (in the distal third of P3) (cm); FD = Founder Distance (cm); FL = Foot Length (cm); P3T = P3 to Toe (cm); P3G = P3 to Ground (cm); JH3 = P2/P3 Joint Hight (shortest distance between ground and P2/P3 joint surface) (cm).

Angles: HA = Hoof Angle (°); P3A = P3 Angle (°); P3BA = P3/Bottom Angle (angle between margo solearis of P3 and the bottom), (°)

and the radiopaque paste as described earlier. A set of 10 radiographs for both views (LM and DP) were taken by regularly changing the positioning of the x-ray unit from DP to LM. In the main study both front feet of a 15 years old sound warmblood mare were radiographed sequentially. The front feet of the horse were positioned on the wooden block. A set of radiographs consisting of a LM and a DP view of both front feet were taken. Then the horse was walked down and repositioned on the block again. Also the markers on the hoof were removed and repositioned for each set. This procedure was repeated ten times, producing a total of 40 radiographs (10 radiographs for each view).

Measurements

All radiographs were digitalised with a scanner FUJI-FILM FCR AC – 3CS™ (FUJI-FILM; 8152 Glattbrugg, Switzerland) and imported into the software program Metron PX™. Following the instructions of the program, parameters that are included in the software Metron PX™ were measured by the same experienced person; 13 for the LM view (Fig. 5), 10 for the DP view (Fig. 6).

For statistical analysis the software Statview® SAS statistical software was used. Descriptive statistics included calculation of the mean, standard deviation (SD) and range. Accuracy and repeatability for the different parameters were considered excellent when the coefficient of variation (cv) was smaller than 0.05 (Hüsler and Zimmermann, 1996).

Results

The cv for all parameters (LM and DP view) are presented in Tables 2 and 3. In the LM view 13 parameters were evaluated, 10 distances and 3 angles (Tab. 2). Most of the parameters revealed a cv < 0.05. In the standing horse the Navicular Width (NW), Founder Distance (FD) and P3/Bottom Angle (P3BA) had cv ≥ 0.05. P3BA in the cadaver study showed also increased cv (Tab. 2). With exception of NW and FD accuracy and repeatability of the parameters were not different between cadaver study and the standing horse. In the DP view 10 parameters were evaluated, 8 distances and 2 angles (Tab. 3). Both tests show similar values for cv. Only the Medial Wall Angle (MWA) in the standing horse revealed a cv ≥ 0.05 (Tab. 3).

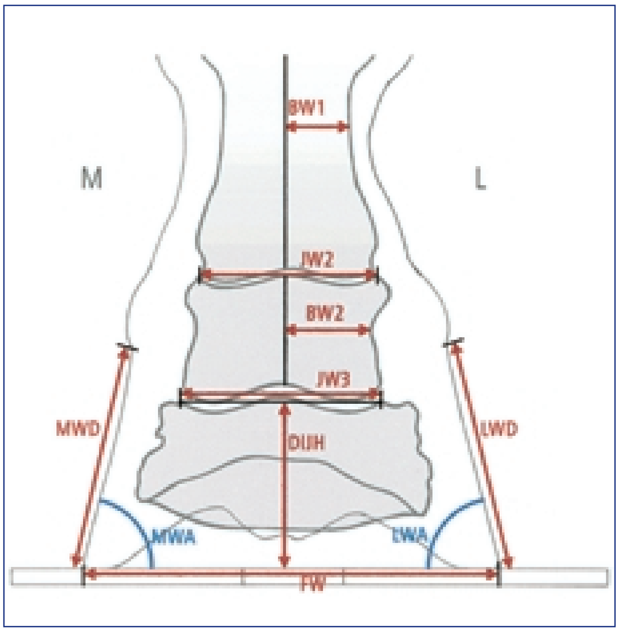

Figure 6: Schematic view of a DP radiography indicating the 10 measured parameters.
Distances: FW = Foot Width (cm); MWD = Medial Wall Distance (cm); LWD = Lateral Wall Distance (cm); BW1 = Half Bone Width of P1 (at the region of minimal extension) (cm); BW2 = Half Bone Width of P2 (at the region of minimal extension) (cm); JW2 = P1/P2 Joint Width (cm); JW3 = P2/P3 Joint Width (cm); DIJH = P2/P3 Joint Hight (vertical distance from a line through the most medial and lateral aspect of the P2/P3 joint to ground) (cm).

Angles: MWA = Medial Wall Angle (°); LWA = Lateral Wall Angle (°)

Table 2: Coefficient of variation (cv) of the parameters in the LM view in a standing horse and in a cadaver limb.

Parameter	cv	
	Standing horse	Cadaver limb
LP2 = Length of P2 (cm)	+	+
LP3 = Length of P3 (cm)	+	+
NW = Navicular Width (cm)	–	+
DWL = Dorsal Wall Length (cm)	+	+
HP3 = Hoof/P3 Distance (cm)	+	+
FD = Founder Distance (cm)	–	+
FL = Foot Length (cm)	+	+
P3T = P3 to toe (cm)	+	+
P3G = P3 to Ground (cm)	+	+
JH3 = P2/P3 Joint High (cm)	+	+
HA = Hoof Angle (°)	+	+
P3A = P3 Angle (°)	+	+
P3BA = P3 Bottom Angle (°)		

+ = cv < 0.05
– = cv ≥ 0.05

Table 3: Coefficient of variation (cv) of the parameters in the DP view in a standing horse and in a cadaver limb.

Parameter	cv	
	Standing horse	Cadaver limb
FW = Food Width (cm)	+	+
MWD = Medial Wall Distance (cm)	+	+
LWD = Lateral Wall Distance (cm)	+	+
BW1 = Half Bone Width of P1 (cm)	+	+
BW2 = Half Bone Width of P2 (cm)	+	+
JW2 = P1/P2 Joint Width (cm)	+	+
JW3 = P2/P3 Joint Width (cm)	+	+
DIJH = P2/P3 Joint Hight (cm)	+	+
MWA = Medial Wall Angle (°)	–	+
LWA = Lateral Wall Angle (°)	+	+

+ = cv < 0.05
– = cv ≥ 0.05

Discussion

The quantitative evaluation of x-ray images demands both excellent quality and a standardised procedure. This is especially true when measurements shall be compared between and within individuals. We established a new method that includes an easy to handle equipment and technique, as well as the placement of external radiopaque markers for calibration. Horses are placed on the block simultaneously with both limbs equally weighted and the metacarpal bones in a perpendicular position. This is necessary to assess the axis of the phalanges. The foot to be radiographed is positioned in a manner that allows the cassette to touch the hoof wall and the x-ray beam in the LM view to be parallel to a virtual line between both heel bulbs. Another possibility to achieve a good position of the hoof is using a block with a V-shaped groove on the top surface (Colles, 1983). Page (2001) proposed a block 6.35 cm thick, 24.78 cm long and 22.24 cm wide. We used a larger one that allowed a flexible connection with a wooden board carrying the x-ray unit. On this block the horse can be positioned with both limbs on the same level and equally weighted.

In each radiograph of the hoof magnification occurs due to the fact that the area of interest is mostly not in direct contact with the film cassette. Page and Hagen (2002) mentioned that the magnification effect resulted in less than 0.075 cm overestimation of their measurements. For calculating the magnification factor it would be necessary to know the focus-object distance that unfortunately was not provided in their report.

Reference markers greatly enhance the accuracy and reproducibility when the radiograph is used for quantitative assessments. As a matter of fact, all existing software applications for hoof measurement use a calibration system requiring a defined marker. An embedded marker centred below the standing hoof as used in our method both simplifies and guarantees accurate calibration for each radiograph. As a further benefit, the surface of the block is indicated by the marker on the radiograph. We used square iron rods with a length of 50 mm and width of 4 mm. Page (2001) used twopenny-nails separated by 5.08 cm to ensure exact measurements.

Location of the central beam for LM views of the hoof is not consistent in literature. Taccio et al. (2002) centred perpendicular to the real sagital plane of P3, the main axis of the x-ray beam at the top of the palmar border of the articular surface on phalanges and 1 cm below the coronary band on hooves. In the method described by Page (2001), the x-ray beam was aimed about 2.54 cm below the coronary band, 5.08 cm–7.62 cm dorsal to the heel bulbs. According to Butler et al. (1993) maximum information about the hoof will be obtained if the x–ray beam centred on the navicular bone – the beam should be positioned approximately 1 cm below the coronary band, and midway between the most dorsal and most palmar aspects of the foot. In our study the central beam was marked with a barium dot on the hoof capsule. In this manner we could demonstrate that by centering 2 centimetres below and at the midlevel of the coronary band, between the bulbs of the heel and the proximodorsal aspect of the hoof wall, the central beam went through the navicular bone. In contrast to the above mentioned methods Linford et al. (1993) centred in the middle of the hoof capsule, 3 cm proximal to the bearing surface and Cripps and Eustace (1999) used a 71 mm thick wooden block with the x-ray beam 98 mm above the ground. In the latter study, this resulted in a position of the beam at the centre of the distal phalanx. The disadvantage of these two methods is that the x-ray beam is localised in relationship to the ground and not to a defined point on the hoof capsule. For the central beam, a defined location in relationship to an invariable anatomical structure of the hoof is essential if repeated measurements are taken during changes of the outer foot structures i.e. before and after trimming. Hence, our equipment involves an adjustable beam level.

If measurements of the thickness of the wall and sole, or hoof angles and "founder distances" as described by Cripps and Eustace (1999) are intended, markers that are fixed on the horn capsule are necessary. The positioning and various materials of the radio-opaque markers are described by Turner (1992), Page (2001) and Redden (2003). They placed e.g. a thumb tack into the true apex of the frog. The true apex was defined as the location where the frog blends with the sole (Page, 2001; Page and Hagen, 2002; Turner, 1992). In our experience flexible piece of lead or barium paste served better than stiff markers for visualizing on the LM view the dorsal contour of the hoof wall or the sole between the most distal aspect of the toe and the true apex of the frog.

The proximal/distal position of the third phalanx relative to the hoof capsule can be discerned by placing a radio-opaque marker on the dorsal hoof wall with the most proximal aspect of the marker at the coronet bordering the hairline (Page, 2001; Page and Hagen, 2002). This is in line with our methodology. Another method describes a fixed straight stiff wire marker with the beginning at the point at which the wall horn begins to yield moderate digital pressure (Cripps and Eustace, 1999; Page and Hagen, 2002). In our experience this technique depends on very individual points of view. To mark the medial and lateral contour of the hoof we position the markers parallel to the horntubules at the widest localisation of the hoof. Page (2001) proposes that the medial/lateral extension of the hoof can be measured radiographically by placing two radiopaque markers on the hoof wall. The ungual cartilage is palpated where it turns and progresses distally to the coronary band. A wire is placed at this location, parallel to the tubules, with the most proximal aspect on the coronet bordering the hairline.

Cripps and Eustace (1999) used a fixed 20 mA 80 kV x-ray generator with variable exposure time. Page (2001) used 64 kV, 0.06 seconds and a focal/film distance of 71.12 cm from the tape measure location to the cassette. Both used rare earth screens. In our study lower kV and lower mAs were applied because a digital radiography system was used. The exposure factor also depends of the focus-film distance. We prefer 90 cm for the LM view and 98 cm for the DP view. Colles (1983) describes use of a grid or an 18 cm air gap between the foot and the film may be used. Both prevent scattered radiation, which significantly reduces the quality of radiographs. The quality of the radiographs produced with our portable equipment was equal to those produced in immobile installations (Fig. 4). The software package Metron PX™ was validated by Vargas et al. (2004). These authors demonstrated that the measurements of the radiographs with the program Metron PX™ have good reproducibility and accuracy.

For the majority of the parameters in the LM and DP view the statistic evaluations of the repeated radiographic measurements in both tests show cv < 0.05. In the LM view, the indistinct bony conformation of the palmar end of the distal border of P3 (sharp edges are more easily recognised) explains the increased values of cv. A hoof with unclear real sagital plane of P3 is not easily to position regularly in the same manner. This is corresponding to the postulation of Taccio et al. (2002) who mentioned the measurements (particularly angles) seemed to be most affected by rotational divergence to the true LM view. In the DP view, most of the cv of the medial and lateral wall angle are increased comparing with the measured distances. In the DP view it is very difficult to position the radiographic beam exactly parallel to the real sagital plane of P3, because a guideline like the alignment of the two bulbs for the LM view is missing. In this case certain rotational divergences are inevitable. In addition a lot of hoofs showed deformed medial and lateral hoof walls. In this case, it is difficult to approximate the real angle on the radiographs.

The conclusion of the statistical evaluation in the standing horse is that the measurements of the repeated radiographs after new positioning of the horse shows excellent accuracy and repeatability for both views. That is emphasized by comparing the cv in the standing horse and the cadaver study which show very similar values. The postulated hypothesis at the beginning could be absolutely confirmed. The described method could be used with security for research purposes especially when quantitative inter- and intraindividual evaluation are performed.

Acknowledgements

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Evaluation d'une technique radiologique standardisée pour l'examen du sabot du cheval

L'examen radiologique du sabot du cheval est un examen complémentaire très important lors de l'évaluation orthopédique. Une bonne qualité des radiographies et une projection standardisée sont absolument nécessaires pour un examen quantitatif scientifique. Le but de cette étude est de décrire et d'évaluer une technique radiographique standardisée pour les prises de vue latéro-médiales (LM) et dorso-palmaires (DP) du sabot du cheval. Afin d'évaluer la reproductibilité de la technique radiographique, on a réalisé 10 prises de vue dans chacune des projections sur un membre de cheval abattu ainsi que sur les deux antérieurs d'un cheval debout. Les clichés ont été réalisés avec un appareil portable monté sur un statif spécial. Des marquers radio-opaques ont été fixés sur la paroi du sabot. Les clichés radiographiques digitalisés ont été traités et analysés au moyen du programme Metron PX®. 13 paramètres ont été mesurés sur la vue LM et 10 paramètres sur la vue DP. Mis à part quelques rares exceptions, les paramètres mesurés présentaient un coefficient de variation plus petit que 0,05. La technique radiologique standardisée est très exacte, montre pour les projections LM et DP une bonne productibilité et peut être très bien appliquée pour des examens quantitatifs du pied du cheval tant de façon inter-individuelle qu'intra-individuelle.

Valutazione di una tecnica di radiografica standard per l'esame dello zoccolo del cavallo

L'analisi radiologica dello zoccolo del cavallo è un metodo diagnostico importantissimo per l'esame ortopedico. Per ottenere delle analisi quantitative scientifiche sono assolutamente necessarie una buona qualità delle immagini radiologiche e delle proiezione standardizzabili. Scopo dello studio è di descrivere e valutare una tecnica radiologica standardizzata per una radiografia dello zoccolo del cavallo lateromediale (LM) e dorsopalmare (DP). Per analizzare la riproducibilità della tecnica radiologica, sono state eseguite 10 radiografie per ognuna di entrambe le direzioni di proiezione di una gamba di un cavallo abbattuto e di entrambi gli zoccoli anteriori di un cavallo in piedi. Le radiografie sono state eseguite con l'aiuto di un tubo radiogeno, che è stato montato su di un dispositivo particolare. Sulla capsula cornea esterna sono stati fissati speciali marcatori della densità radiologica. Le immagini radiologiche digitali sono state analizzate e elaborate con il programma Metron PX®. Misurati sono stati 13 parametri della registrazione LM et 10 di quella DP. A prescindere da poche eccezioni i valori misurati presentano un coefficiente della varianza inferiore a 0,05. Questa tecnica radiografica standardizzata è molto precisa, mostra per le proiezioni LM e DP una buona riproducibilità e può essere utilizzate ottimamente negli esami quantitativi inter e intra individuali dello zoccolo del cavallo.

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