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The Hemisphere Model - A new description of directions for head radiographs in the horse

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Summary

The Hemisphere Model is developed to specify directions of head radiographs very precisely even if different radiographic techniques are used. There is an imaginary globe around the head with two perpendicular sections. Two angles or geographic coordinates in these sections are sufficient to describe the direction of an x-ray beam. In this model the equator plane stays between the upper and lower jaw in the chewing surface. Thus, the upper jaw remains in the upper hemisphere and the lower jaw in the lower hemisphere. The 0° mark is rostral on the equator and is the description for a straight rostrocaudal radiographic direction. The first geographic coordinate describes the deviation from straight rostral in the horizontal equator level between 0° and 180°. The laterolateral direction has a 90° deviation from rostral and is given the coordinate 90° (no matter if the direction is right to left or left to right). The second geographic coordinate describes the angle of the x-ray beam towards the horizontal equator level. If the x-ray beam comes from dorsal, the numbers are positive between +1° and +90°. If the x-ray beam comes from ventral, the numbers are negative between -1° and -90°. In radiographs of the cheek teeth or structures of the head, the side with contact to the cassette is labeled right or left.

Keywords: head, horse, x-ray technique, teeth, imaging technique

Das Hemisphärenmodell – eine neue Bezeichnung der Projektionsrichtungen am Kopf des Pferdes in der Röntgendiagnostik

Mit dem Hemisphärenmodell wurde eine neue Bezeichnung der Strahlengänge am Kopf des Pferdes entwickelt, um die unterschiedlichen Aufnahmetechniken prägnant und eindeutig beschreiben zu können. Dazu sind nur zwei Koordinatenangaben notwendig, die sich bei einer gedachten Kugel auf zwei senkrecht aufeinander stehenden Ebenen befinden. Modellhaft werden Ober- und Unterkiefer als zwei getrennte Halbkugeln betrachtet, deren Äquatorebene zwischen den Ober- und Unterkieferzähnen eingeschoben ist. 0° befindet sich auf dem Äquator rostral und beschreibt den rostrokaudalen Strahlengang. Die Abweichung von rostral auf dem Äquator nach rechts oder links wird mit Gradzahlen von 1°-180° beschrieben. Diese Gradzahlen stellen die erste Koordinate dar. Der laterolaterale Strahlengang wird also stets mit 90° gekennzeichnet, unabhängig davon ob der Strahlengang in dextrosinistrale oder sinistrodextrale Richtungerfolgt. Die zweite Koordinate gibt den Winkel der Röntgenröhre zur Äquatorebene von dorsal (+1°bis +90°) oder von ventral (-1°bis -90°) an. Die abgebildete Kopfseite wird durch ein Seitenzeichen gekennzeichnet.

Schlüsselwörter: Kopf, Pferd, Röntgentechnik, Zähne, bildgebende Diagnostik

Introduction

In orthopedic radiographs there is an international uniform glossary specifying radiographic procedures. Head radiographs are often marked with an inconsistent nomenclature. The existing nomenclature is not easy to reproduce and specifying individual radiographic angles proves difficult. Dental radiographic procedures have been improved in the last few years. There are individual views of teeth, clinical crowns, reserve crowns and roots. With a focus on clinical lesions they necessitate the displacement of the transversal axis of the radiographic beam. This new situation requires a uniform nomenclature to describe these radiographic procedures very precisely and in a reproducible manner. (*Barakzai* und *Dixon* 2003, *Butler* et al. 2008, *Gibbs* 2003, *Barakzai* 2005, *Pease* 2007, *Keller* 2009, *Ros* 2010). The Hemisphere Model was developed to describe all possible radiographic procedures with a simple and reproducible nomenclature.

The Hemisphere Model

The head or rather the focused area of the head is placed in the center of an imaginary globe. The equatorial level of the globe is placed in the chewing surface between the upper and lower cheek teeth. Therefore, the upper jaw is positioned in the upper hemisphere and the lower jaw is placed in the lower hemisphere.

An x-ray beam with straight rostrocaudal direction in the equatorial level is named 0°, 0° projection. The position of the x-ray machine for a 0°, 0° projection is the starting point for the subsequent movements of the x-ray machine. Every movement is clearly described by means of two coordinates as shown in figures 1-3.

The first coordinates indicates the deviation from 0° (rostral) to the right or the left side in the equatorial level. The first coordinate 90° specifies a straight laterolateral beam without a differentiation between the direction left to right or right to left. The first coordinate 180° labels a straight caudorostral direction in the equatorial plane.

The second coordinate describes the movement of the x-ray machine along the longitude of the imaginary globe. It indicates the angle of the beam towards the equatorial level. If the movement along the longitude is 90° upwards, the pro-

jection is straight dorsoventrale, indicated by the coordinate +90°. A movement in the opposite direction, i.e. 90° downwards, specifies a straight ventrodorsal view which is indicated by the coordinate -90°.

To separate the teeth, or rather the roots and reserve crowns of the right and left side in a radiograph, oblique projections between 0° and 90° are used. All projections parallel to the equator level are given the second coordinate 0°. If the x-ray beam has a dorsoventral direction, the second coordinate is positive. In a ventrodorsal direction the second coordinate is negative. (Tab 1). The second coordinate gives us the angle of the x-ray beam towards the horizontal level (equator level) from dorsal (+1 to +90°) or from ventral (-1 to -90°).

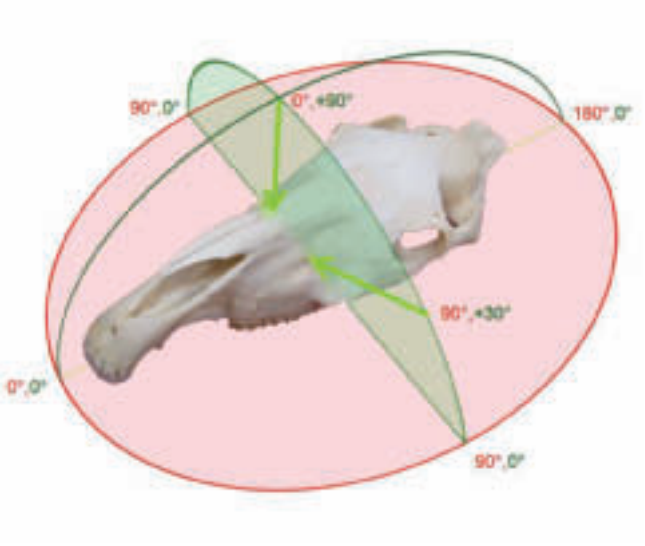

Fig. 1 Exemplary illustration of x-ray beams of the upper jaw of a horse. The equatorial level is depicted red (equator). The first coordinate in the system states the position of the x-ray machine in the equatorial level along the equator. A straight rostral position is referred to as 0°, a lateral position as 90°. The second coordinate states a longitudinal position (green line). On the upper hemisphere this coordinate is positive (dorso-ventral beam) and on the lower hemisphere the second coordinate is negative (ventro-dorsal beam). For demonstration purposes there are two beams illustrated in the model: 90°, +30° (movement of the x-ray machine is 90° sideways on the equator and 30° upwards on the longitude) and 0°, +90° (0° = no movement on the equator, 90° upward movement on the longitude) shows a straight dorso-ventral x-ray beam.
Modellhafte Darstellung der Strahlengänge am Oberkiefer des Pferdes. Die Äquatorebene der Hemisphären ist rot dargestellt. Die erste Koordinate wird auf der Äquatorebene eingestellt, beginnend mit 0° von rostral. Seitlich beträgt sie 90°. Die zweite Koordinate wird auf den grünen Halbkugeln gewählt und erhält mit dorsoventralem Strahlengang ein positives, mit ventrodorsalem ein negatives Vorzeichen. Eingezeichnet sind 90°, +30° (zuerst seitlich 90° auf Äquatorebene und anschließend 30° von oben), sowie 0°, +90° (0° = keine Bewegung auf dem Äquator, 90° nach oben) gibt einen dorsoventralen Strahlengang an.

Discussion

The beam paths at the head of a horse can generally be depicted as lateral, ventrodorsal and tangential, or rather slanted exposures. The description of slanted exposure techniques proves more difficult because here relationships to well-known structures are missing in the perception of the performing radiologist. Often a stipulated orthoradial can only be understood by considering a corresponding depiction.

In German-speaking areas the labelling of beam paths goes back to *Zeller* et al. (1975) and Keller (2009). However, only

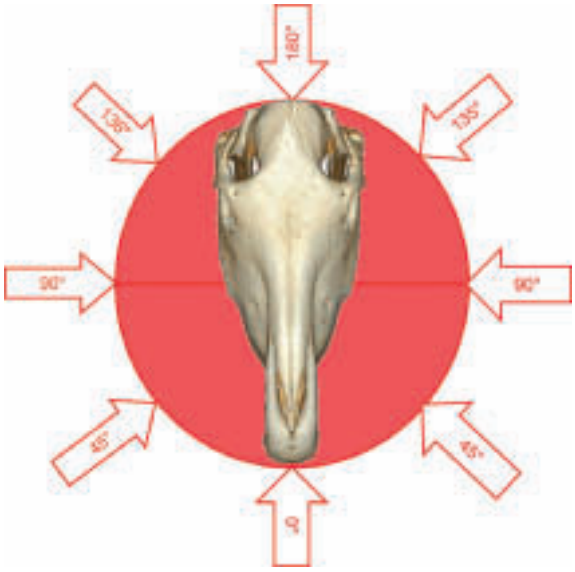

Fig. 2 Angles on the equator, it states the first direction of primary x-ray beam on the equatorial level.
Gradangaben auf dem Äquator, zuerst wird die Richtung des Zentralstrahles auf der Äquatorebene ausgerichtet.

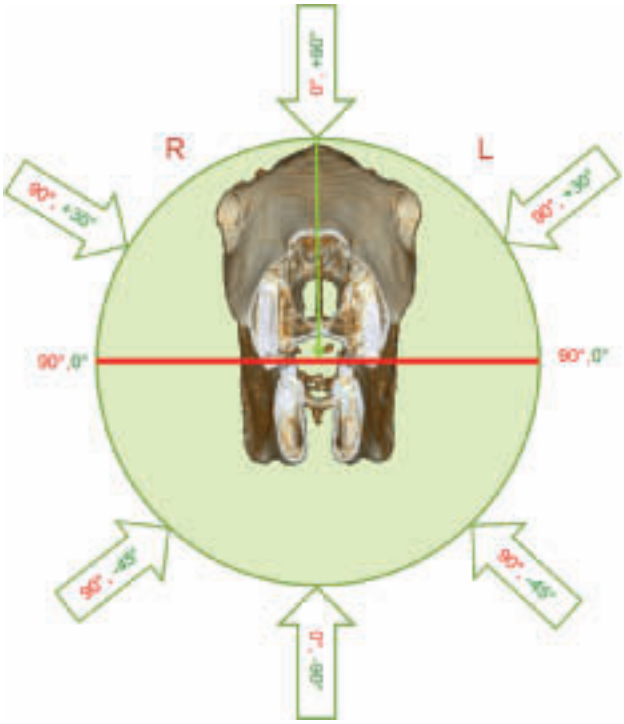

Fig. 3 Angles of the second level, it states the second direction of primary x-ray beam. The equatorial level is red. It's advisible to choose the direct short approach dorsally (0°, +90°).
Gradangaben auf der zweiten Ebene. Die Äquatorebene ist rot eingezeichnet. Es wird empfohlen, den direkten kürzesten Weg nach dorsal zu wählen (0°, +90°).

Tab. 1 Common radiographic projections of the horse's head with different nomenclature / *Vergleichende Bezeichnungen häufiger Aufnahmerichtungen am Kopf des Pferdes im Röntgenbild*

Focus of radiograph	Nomenclature according to *Keller*	Nomenclature in English literature	Hemisphere Model
upper cheek teeth, reserve crowns and roots	tangential dorso-lateral-sinsiter towards ventro-lateral-dexter (315°) or dorso-lateral-dexter- towards ventro-lateral-sinister (45°)	laterodorsal-lateroventral oblique 30°	90°/+30°
lower cheek teeth, reserve crowns and roots	tangential ventro-lateral-dexter towards dorso-lateral-sinister (135 °) or ventro-lateral sinister towards dorso-lateral dexter (225°)	lateroventral-laterodorsal oblique 45°	90°/-45°
sinuses, teeth	lateral 90° or 270°	lateral	90°/0°
upper incisors intraoral	dorsoventral 180°	dorsoventral oblique, dorsal 45°	0°/+45
lower incisors intraoral	ventrodorsal 180°	ventrodorsal, oblique, 45°	0°/-45°
sinuses, septum, conchae	dorsoventral 0°	dorsoventral	0°/ +90°
sinuses, septum, conchae	ventrodorsal 180°	ventrodorsal	0°/ -90°

one spatial allocation is predefined, a needed second level is missing. Additionally, the person performing the examination is often overwhelmed by a specification of 270° in the lateral projection from the left side or the tooth roots with 315° tangential dorsolateralsinister towards ventrolateraldexter. While angle specifications between 0° and 90° are easily understood by most operators, labelings over 100° put much greater demands on spatial sense.

In English-speaking areas, for example, labelings such as L D-RVO (left dorsal – right ventral oblique) or RD-LVO (right dorsal-left ventral oblique) have been enforced for depicting the roots of the molars in the upper jaw (*Smallwood* et al. 1985, *Pease* 2007, *Butler* et al. 2008).Simultaneously, an abbreviated labelling of the beam path is used: ventrolateral-lateral (*Barakzai* and *Dixon* 2003). The Hemisphere Model is now successful in clearly defining this exposure technique with the labelling 90°/+30°.

Additionally, other angles have to be implemented depending on the horse's age or rather the depiction of a particular tooth due to the course of the dental arcade. This applies not only to the molars but also to the incisors. In present specialist literature there are no specifications at all regarding incisor exposures and above all age-dependent depiction of them on an x-ray. With the Hemisphere Model not only can molar exposures be characterized together, but also incisor ones. This publication does not cover all precise adjustments for specialised teeth exposures, as for example the aligning of slanted exposures of the molars to the dental arcade shape. For this, further literature is recommended (*Ros* 2010, *Gibbs* 2003, *Butler* et al. 2008).

Just as the dental arcade, the chewing surface of the molars takes its course in differing angles. Therefore, the imaginary slice of the equator level is very schematically chosen, and actually describes a surface which proceeds parallel to the hard palate and takes its course through the chewing surface of the premolar teeth.

The use of two levels perpendicular to one another is also described in human medicine (*Düker* 2006). *Smallwood* et al. (1985) have already worked with these levels in veterinary medicine. These authors referred to the area which we labelled as equator level as dorsal level, and the vertical level as transversal level, as is common in the three-dimensional cross-sectional technique. However, these details have not yet been processed to a complex model.

That no left or right marker reference is undertaken is seen as a disadvantage of the Hemisphere Model. For this reason the labelling of the x-ray with a marker indication is particularly important. When developing the x-ray, this is not so decisive, since the veterinarian knows the diseased side from the clinical examination. It is assumed that the cassette is positioned on the diseased side and if possible at a right angle to the central beam or rather the angle bisector is chosen (*Keller* 2009).

Furthermore, it must be observed that no specifications are given on the precise point of aim of the central beam, only its direction. If a particular tooth, or tooth section, sinuses or jawbone shifts in the central beam this has to be individually adjusted. The technique of tooth imaging with the so-called Open Mouth Technique (*Barakzai* 2005) or intraoral exposures (*Barakzai* and *Dixon* 2003) are carried out, as is commonly the case, and also characterized by degree specifications.

The advantage of the Hemisphere Model is the implementation of a uniform nomenclature for all horse teeth. Additionally, the direction of the central beam can be defined for all structures at the head in various x-ray projections with only two coordinates. The Hemisphere Model provides a simple and concise description of x-ray exposures of the horse's head.

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