Tutorial Article

Nonconventional radiographic projections in the equine orthopaedic examination

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Introduction

The equine locomotor examination is classically composed of static and dynamic clinical examination (including diagnostic analgesia) and of complimentary examinations, principally medical imaging. Although alternative imaging techniques have been developed for use in horses in recent years, radiography remains an important step in the equine orthopaedic examination and standard radiographic projections for various joints have been determined.

The objective of this article is to regroup the less-commonly used, nonconventional, radiographic projections of the various equine joints, in order to review the specific anatomical structures that can be seen on each, then to explain the radiographic technique allowing the practitioner to obtain the view. The lesions that may be seen with each view are described and the use of these views is illustrated using clinical cases.

Radiographic nomenclature

In order to describe the various nonconventional radiographic projections, the standard radiographic nomenclature proposed by the American College of Veterinary Radiologists is used (Smallwood et al. 1985). Table 1 summarises the abbreviations used herein to describe radiographic projections. The terms cranial and caudal are applied when the projection is located proximal to the carpus or tarsus. Dorsal, palmar and plantar apply to anatomy located distal to this and are the correct veterinary terms, as opposed to the terms anterior and posterior (Smallwood et al. 1985).

A radiographic projection is described by initially naming the entrance point of the primary x-ray beam, followed by its exit point relative to the horse’s anatomy (e.g. dorso-palmar, D-Pa). The term ‘oblique’ (O) is added to the end of the projection name when the beam does not pass through the body parallel to one of the 3 major directional axes (lateral - medial, dorsal - ventral/palmar/plantar, cranial - caudal). Description of an oblique projection is a combination of the various directional terms in order to locate the beam axis relative to the horse (e.g. dorsoproximo-palmarodistal oblique, DPr-PaDiO). To specify the degree of obliquity, this angle is placed immediately before the axis with which it is associated (e.g. dorso10°proximo-palmarodistal oblique, D10Pr-PaDiO).

General considerations

Unnatural positioning (i.e. flexion) is required for some of the views described herein. This can be difficult in horses with joint pain, or in those with a limited range of motion. In some cases, loco-regional or intra-articular anaesthesia can relieve some of the discomfort associated with radiographic positioning.

As with all radiographic procedures, safety must be respected (i.e. wearing of lead aprons, thyroid protectors and dosimeters; minimising personnel and the number of projections; use of cassette holders). Radiation safety becomes particularly important for positions in which the limb and/or cassette must be held by hand. For these positions, it is essential to wear lead gloves, to maintain the gloved hands outside of the primary beam, maximise collimation and to minimise the number of people involved in taking the radiograph.

TABLE 1: List of abbreviations used to describe the nonconventional radiographic projections (based on Smallwood et al. 1985)

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<thead>
<tr>
<th>Abbreviation</th>
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The metacarpophalangeal joint

The metacarpophalangeal joint is a high motion joint, composed of the third metacarpal/metatarsal bone (Mc III), the proximal phalanx (P1) and the proximal sesamoid bones (PSBs). The conventional radiographic examination comprises 4 projections: dorso-palmar (D-Pa), latero-medial (L-M), dorso45°latero-palmaromedial oblique (D45L-PaMO) and dorso45°medio-palmarolateral oblique (D45M-PaLO). Although this section discusses the metacarpophalangeal joint, most of these views may also be performed in the metatarsophalangeal joint.

Specific areas of interest are the distal articular surface of Mc III, the proximal articular surface of P1 and particularly its dorsal and palmar processes, and finally the PSBs, which each include articular, axial and abaxial surfaces. Because each of these areas may be inadequately evaluated during a standard radiographic examination, several nonconventional radiographic projections have been developed.

Flexed latero-medial view

The flexed latero-medial (flexed L-M) view is similar to the standard L-M view. In addition, when the joint is flexed, P1 moves palmarly, and the distal aspect of the sagittal ridge of Mc III is revealed. The PSBs move proximally, revealing their base and their dorsal articular surface. During exposure, the limb must be manually supported, in order to maintain flexion of the fetlock. An alternative is to rest the flexed limb on a wooden block; however, a lesser degree of flexion will be achieved. The beam remains horizontal and centred on the metacarpophalangeal articulation as for a standard L-M view (Morgan et al. 1991) (Fig 1).
The flexed L-M view particularly highlights the distal aspect of the sagittal ridge. Osteochondrosis lesions may be seen at this level (Yovich et al. 1985) (Fig 2). In 1162 horses (Kane et al. 2003), the flexed L-M view was carried out systematically instead of the L-M. A flatness or a radiolucent zone of the sagittal ridge was observed in 27.2% of these (Kane et al. 2003).

The flexed L-M projection is also useful for basilar fractures of the PSBs and may detect lesions not seen on other radiographic views (Bertone 2002). Basilar proximal sesamoid bone fractures are predominantly a forelimb injury of Thoroughbred racehorses (Parente et al. 1993) with the probability of return to racing being inversely proportional to length and height of the fractured fragment (Southwood and McIlwraith 2000). Although basilar PSB fragments are visible with conventional oblique radiographs, they are often superimposed on the palmar/plantar aspect of the Mc III condyle (Morgan et al. 1991) and the articular involvement may be difficult to assess.

Articular degeneration of the metacarpophalangeal joint, particularly at the palmar aspect of Mc III, just proximal to the sagittal ridge, may also be more visible with the flexed L-M view (Butler et al. 2000).

Dorsodisto-palmaroproximal oblique (DDi-PaPrO-125) view

The distal articular surface of Mc III involves a 180° radius and thus is inadequately evaluated on only one projection. The
dorsodisto-palmaroproximal oblique (DDi-PaPrO-125) view (Hornof and O’Brien 1980) allows evaluation of the palmar aspect of the Mc/Mt III condyles. The DDi-PaPrO-125 projection is performed with the limb in forward extension, which allows the primary x-ray beam to remain relatively parallel to the ground, centred on the fetlock joint (Morgan et al. 1991) (Fig 3). The limb is extended such that the angle between the beam and Mc III is 125°. The cassette remains perpendicular to the beam (Hornof and O’Brien 1980). Approximately one third to one quarter of the PSBs will be projected distal to the joint space. The observed width of the joint space is approximately twice as large as on the D-Pa view (Hornof and O’Brien 1980).

The DDi-PaPrO-125 view allows for evaluation of ulcerative lesions of the palmarodistal aspect of Mc III (palmar metacarpal fragmentation, formerly known as traumatic osteochondrosis), most commonly seen in Thoroughbred racehorses. It allows confirmation of lesions suspected with L-M or flexed L-M projections, and determination of their extent as well as their depth (Hornof and O’Brien 1980).

With sagittal condylar fractures, this projection has 2 uses, both of which have an important impact on prognosis. Firstly, it helps to detect the presence of comminution on the palmar articular condylar surface (Hornof and O’Brien 1980). Moreover, this view allows detection of concurrent palmar erosive lesions that may be present with condylar fractures (Rick et al. 1983). These complications may lead to severe osteoarthritis and are associated with a poor prognosis for return to racing (Rick et al. 1983). Hornof and O’Brien (1980) suggested incorporating the DDi-PaPrO-125 view into all radiographic examinations for suspected Mc III condylar fractures.

**Flexed dorsoproximal-plantaroproximal oblique (D35Di-PaPrO) view**

An alternative to the dorsodisto-palmaroproximal oblique (DDi-PaPrO-125) view is the flexed dorsoproximal-distal-palmaroproximal oblique (D35Di-PaPrO) view, which allows evaluation of the central aspect of the metacarpal condyles (Pilsworth et al. 1988). The D35Di-PaPrO projection is performed with the fetlock manually flexed and Mc III remaining vertical (Fig 4). The beam is directed from distal to proximal with a 35° angle; alternatively, the beam can remain horizontal to evaluate more dorsal portion of the condyle. In addition, this view can also be useful in the evaluation of the PSBs as it superimposes them equally on the distal metacarpus. It may permit the detection of radiolucent zones, which may not be apparent on the conventional D-Pa view (Butler et al. 2000).

The D35Di-PaPrO view has the advantage of displacing the PSBs from the articular space, but the palmar aspect of P1 becomes superimposed with Mc III (Pilsworth et al. 1988). This projection highlights essentially the same structures and the same lesions as the dorsodisto-palmaroproximal oblique (DDi-PaPrO-125) view.

**Flexed dorsoproximal-dorsodistal view**

The flexed dorsoproximo-dorsodistal (flexed DPr-DDi) view evaluates the dorsodistal articular surface of Mc III, including the sagittal ridge. The radiograph is performed with the fetlock manually flexed and Mc III perpendicular to the ground. The beam is centred on the joint with a 45–70° angle from horizontal and the cassette is placed distally to the joint and parallel to the ground (McCall and Kneller 1989) (Fig 5). Sufficient flexion of the joint is necessary in order to avoid dorsal superimposition of P1 on Mc III. In some cases, the flexed DPr-DDi is painful and can be difficult to obtain adequately.

The flexed DPr-DDi view can show articular involvement of lesions on the dorsal aspect of the sagittal ridge or distal metacarpal condyle. In addition, sagittal ridge osteochondrosis lesions can be further evaluated using this view.

**Oblique views of the palmar aspect of the metacarpophalangeal joint**

The dorsoproximo-distal-lateral-palmarodistomedial oblique (D30Pr70L-PaDiMO) view and the dorsoproximo-distal-lateral-palmarodistomedial oblique (D45Pr45L-PaDiMO) view are described here (Fig 6). The plantar terminology will be sometimes employed in this section, as these projections are generally used to detect lesions more commonly found in the pelvic limbs (Fortier et al. 1995; Kane et al. 2003). DPrL-PaDiMO views highlight the proximal articular margin of the lateral plantar process of P1 while projecting the lateral PSB distal to the medial PSB (Butler et al. 2000). These projections are particularly useful to determine the exact localisation of axial proximoplantar fragments of P1 and the ‘fragment bed’ on the plantar process of P1 (Dick 1988; Ross et al. 1991) (Fig 7). Axial fragments of the proximoplantar aspect of P1 are most frequently seen medially in Standardbreds (Fortier et al. 1995) and may be present in 11.8% (Sandgren 1988) to 28.8% of individuals in this breed (Grøndal 1992). Axial proximoplantar fragments of P1 are also found in other breeds, such as Thoroughbred yearlings with an incidence of 4.1% (Kane et al. 2003). The D45Pr45L-PaDiMO view additionally allows very good visualisation of the
palmar area of the metacarpal condyle (Butler et al. 2000) and is complementary to the flexed L-M since it allows further evaluation of subchondral stress-related lesions on the palmar aspect of the metacarpal condyle (Ross 1998).

**Latero45°proximo-mediodial oblique (L45Pr-MDiO) view**

The latero45°proximo-mediodial oblique (L45Pr-MDiO) view allows evaluation of abaxial surface of the PSBs. The radiography is carried out on the weightbearing horse, with the beam directed 45° distally (Palmer 1982). The medial sesamoid bone will be projected proximally relative to the lateral sesamoid bone (Fig 8). If disease is suspected within the lateral sesamoid bone, this bone should be placed against the cassette and the view should be made in a M45Pr-LDiO direction.

Although abaxial fracture can be diagnosed with D-Pa, L-M and D45L-PaMO views, the (non)articular nature of the fractured fragment will be shown by the L45Pr-MDiO view (Palmer 1982) (Fig 9). This articular implication is very important: an intra-articular fragment can be removed by arthroscopy, whereas extra-articular fracture is preferentially treated conservatively (Palmer 1989; Southwood et al. 1998).

**Palmaroproximal-palmarodistal view**

Although the PaPr-PaDiO view is not well described in the literature, this view allows evaluation of the palmar, axial and abaxial aspects of the PSBs. The foot is placed on the ground as far caudally as possible, in order to extend the fetlock. The cassette is placed on the ground, under the foot. The beam is palmar to the limb and as vertical as possible (Morgan et al. 1991). In some cases, the necessary foot position is painful, thus limiting radiographic quality. If fetlock extension is insufficient, the PSBs will be superimposed on the heels of the horse (Fig 10). Also, it is advisable to remove the shoe before radiography in order to avoid superimposition with PSBs.

The practical use of this projection is not well described. It could be used to detect axial fractures in the intersesamoidean region (Hogan 1997), or to further characterise other types of PSB fractures (Fig 11). In addition, osteolytic lesions of the axial aspect of the PSBs can be evaluated.

**Flexed latero medial view**

The flexed latero-medial (flexed L-M) view allows good evaluation of the *tuber calcaneus*, the proximoplantar aspect of the trochlea of the talus, as well as caudodal aspect of the tibia (Butler et al. 2000). Indeed, these structures are superimposed on conventional L-M view. Radiography is performed with the tarsus flexed and the limb manually supported (Fig 12). The angle between the tibia and Mt III must be approximately 50°. The beam is centred on the tarsus, and abduction of the limb is avoided (Butler et al. 2000).

The flexed L-M projection is particularly useful to highlight fragmentation or fracture involving the proximoplantar surface of the medial trochlear ridge of the talus (Sullins and Stashak 1983; Specht and Moran 1990). This type of fracture is generally traumatic (Tulleners and Reid 1981a; Specht and Moran 1990), and occurs when the limb is flexed (Foerner 1992). Osteochondrosis of the proximal articular margin of the medial trochlear ridge of the talus can also be demonstrated (Simpson and Lumsden 2001). Other types of palmar tibiotalar fragmentation can also be seen (Fig 13).

**Flexed caudoproximal-caudodistal view of the tarsus**

The flexed caudoproximal-caudodistal view of the tarsus (flexed CdPr-CdDi), allows good evaluation of the *tuber calcanei, sustentaculum tali*, tarsal groove, medial trochlear ridge and talocalcaneal joint (Farrow et al. 1976; Butler et al. 2000). This view is also called a flexed dorso-plantar view of the calcaneus (Farrow et al. 1976). Radiography is carried out with the tarsus flexed and the limb manually supported, Mt III horizontal being horizontal (Fig 14). The cassette must be along the plantar aspect of the calcaneus. The beam is caudal to the tibia and directed as vertically as possible (Butler et al. 2000). The necessary flexion for this view can be painful for the horse. A flexed plantar-dorsal view of the calcaneus has also been described by Jones (1976).

The flexed CdPr-CdDi view is commonly used to evaluate and exactly localise osteitis (generally infectious) of the calcaneus and osteomyelitis of the *sustentaculum tali* (Tulleners and Reid 1981b; Mattoon and O’Brien 1988; MacDonald et al. 1989; Hand et al. 2001) (Fig 15). These observable lesions on the calcaneus and the *sustentaculum tali* are frequently traumatic (MacDonald et al. 1989). In 24 horses with osteolytic lesions of the calcaneus, the flexed D-Pl view was essential to diagnosis in 7 cases (29%), and helped to confirm and define size and extent (lateral and medial) of the lesions in the 17 other cases (Mattoon and O’Brien 1988). It is also recommended to perform the flexed D-Pl view for any case of calcaneal bursitis or gastrocnemius tendonitis in order to exclude underlying calcaneal osteitis (Bassage et al. 2000).

The flexed CdPr-CdDi view is also important in calcaneal fractures (Tulleners and Reid 1981a; Honnas et al. 1988; Mattoon and O’Brien 1988); it gives information on the exact localisation of the fragment (Tulleners and Reid 1981a) and on the possibility and extent of articular involvement (Mattoon et al. 1990; Moran 1990), and occurs when the limb is flexed (Foerner 1992). Osteochondrosis of the proximal articular margin of the medial trochlear ridge of the talus can also be demonstrated (Simpson and Lumsden 2001). Other types of palmar tibiotalar fragmentation can also be seen (Fig 13).
and O’Brien 1988) (Fig 15). This view, in conjunction with the flexed L-M view, helps in diagnosis of proximoplantar medial trochlear ridge fractures (Specht and Moran 1990).

The stifle

The stifle is composed of the femur, tibia and patella, and includes 3 joints: the femoropatellar joint, and medial and lateral femorotibial joints. Conventional radiographic examination comprises 3 projections: latero-medial (L-M), caudo60°latero-craniomedial oblique (Ca60L-CrMO) and caudo-cranial (Ca-Cr).

**Flexed cranioproximal-craniodistal view**

The flexed cranioproximo-craniodistal view (flexed CrPr-CrDi) allows good evaluation of the base of the patella, its articular...
surface as well as the femoral trochlear ridges (Butler et al. 2000). Radiography is performed with the limb manually supported and the stifle moderately flexed (Fig 16). The cassette is placed horizontally and distally to the stifle and proximal tibia. The beam is located cranially to the stifle and must be as vertical as possible; nevertheless, a 10° angle in the latero-medial plane is sometimes necessary to avoid the abdominal wall (Butler et al. 2000).

Fig 12: Radiographic positioning for the flexed L-M view of the tarsus. The normal radiographic appearance of this projection is shown to the right.

Fig 13: Standard L-M and flexed L-M views showing fragmentation involving the plantar aspect of the talus (arrows). The flexed L-M view allowed the tibia to be excluded as a possible origin for the fragment.

Fig 14: Radiographic positioning for the flexed CdPr-CdDi view of the tarsus. The normal radiographic appearance of this projection is shown to the right.

The flexed CrPr-CrDi projection is essential for diagnosis of sagittal fracture of medial aspect of the patella (Dick and Nemeth 1983; Dyson et al. 1992), which is, in spite of a low prevalence, the most common patellar fracture (Walmsley 2003) (Fig 17). The flexed CrPr-CrDi projection allows precise identification of the fracture site and configuration (Dyson et al. 1992). This view is recommended in any horse with history of trauma and lameness attributable to the patellar region (Hance and Bramlage 1996).

Fig 15: Flexed CdPr-CdDi views of the tarsus showing focal well-defined osteolysis associated with osteomyelitis of the tuber calcaneus (A), a sagittal articular fracture of the calcaneus (B), and osteolysis and irregular new bone formation associated with osteitis of the sustentaculum tali (C).

Fig 16: Radiographic positioning for the flexed CrPr-CrDi view of the stifle. The normal radiographic appearance of this projection is shown to the right.
Fig 17: Flexed CrPr-CrDi views of the stifle in the same horse. A comminuted, articular fracture of the medial aspect of the patella is present in A, and complete healing of this fracture can be seen in B.

Conclusion

Many of the pathologies highlighted by the projections described in this article are uncommon or rare. Because of this, and for reasons of radiation safety, these views need not be incorporated into the standard radiographic examination. However in several situations, use of these projections should be considered. When anatomical localisation of lameness can be clearly determined, no abnormalities are seen on conventional radiographic projections, nonconventional views of the affected area may provide a diagnosis. Nonconventional projections can also serve to confirm a lesion suspected on conventional views. Finally, nonconventional projections should be used systematically on certain lesions to obtain complementary information (location, extent, articular involvement, fragmentation, commination, etc.) that will allow a better determination of prognosis and appropriate course of treatment.

References

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