Radiographic examination of the equine thoracolumbar spine

Radiographic examination of the thoracolumbar spine in horses can be challenging. However, with careful positioning of the horse and radiographic equipment, diagnostic views of the dorsal spinous processes can be obtained even with most portable machines. When evaluating radiographs, knowledge about the normal anatomy and common radiographic findings is key. However, not all horses with clinical signs of back pain will have radiographic abnormalities, and radiographic findings do not necessarily indicate pain as these abnormalities can be also found in clinically sound horses. Therefore, a clinical examination should always be the gold standard and clinical signs should be localised and confirmed before treatment.

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The most common indication for obtaining radiographs of the equine thoracolumbar spine is 'back pain'. This is commonly a result of impingement of the dorsal spinous processes, or less commonly because of osteoarthritis of the facet joints. Horses are commonly presented because of poor performance, bucking or altered gait, with most horses having a chronic history – in rare occasions, some are presented with acute signs after trauma.

Clinical signs of back pain besides pain on palpation include reduced flexion and extension of the spine, stiffness and alteration of gait (Denoix and Dyson, 2011). Distinguishing between primary back pain and secondary back pain, the latter as a consequence of lameness, might not always be straightforward and a thorough clinical examination should be performed before diagnostic imaging is considered. Therefore, a full lameness examination is advised to localise the cause of any clinical signs.

Radiographs of the thoracolumbar spine might also be taken as part of the radiographic examination during pre-purchase examinations. However, due to the limited scientific evidence of correlations between radiographic findings and clinical signs, the Federation of European Equine Veterinary Associations does not recommend this (Federation of European Equine Veterinary Associations, 2018). Furthermore, the German Equine Veterinary Association has recently removed the radiographic examination of the thoracolumbar spine from their radiographic guidelines during pre-purchase examination (German Equine Veterinary Association, 2018). Intra- and inter-observer agreements vary for different parameters and the wide variety of scoring systems should be kept in mind when evaluating radiographs, especially in sound horses (Looijen et al, 2022).

How to acquire radiographs of the thoracolumbar spine

As for all radiographic examinations, positioning and preparation is key. The horse should stand squarely on all four legs to avoid rotation of the spine. Furthermore, the head and neck position should be standardised (with the head at the level of the shoulder joint to help comparison between different examinations), as a low head and neck position will cause increased distances between the dorsal spinous processes, and a high position will lead to decreased distances (Berner et al, 2012). A head stand will help to standardise the head and neck position, and might also be helpful in reducing swaying of the horse and associated movement artefacts. Because of the relatively long exposure times needed, the patient should move as little as possible – further restraining methods, such as sedation with romifidine or detomidine, should be considered. Furthermore, obtaining radiographs at the end of expiration might further avoid movement because there is less thoracic movement at this time (Denoix and Dyson, 2011).

The x-ray beam is only perpendicular in the centre and diverts at the periphery. As the collimation is relatively wide in thoracolumbar radiographs, to include as many dorsal spinous processes as possi-

ble on large cassettes, this divergence will lead to geometric distortion resulting in a decreased observed distances between the dorsal spinous processes at the corner of the image (Djernæs et al, 2017). Therefore, if reduced distances between dorsal spinous processes are seen at the periphery of the image, obtaining another radiograph centred on the area in question can be considered. However, distortion of the images can also be a result of misaligned radiographic equipment, so care should be taken to position the cassette and the x-ray machine perpendicular to each other. This is easily achievable when using ceiling mounted equipment that have a linked x-ray camera and plate, but with portable equipment this can be quite challenging. As the plate is positioned on one side of the horse and the generator on the other side, determining their orthogonal positioning is more challenging than in more distal areas, especially because the majority of the plate might not be visible from the side of the generator. An easy way to overcome this problem is to use external references, for example drainage channels or joints on the floor. These can be used for orientation – the horse and the plate should be positioned parallel to these, whilst the generator should be orientated perpendicular.

As with radiographic examinations of other areas, care should be taken to ensure the area of interest is clean to avoid artefacts. Particularly during winter, when horses are presented with longer coats, air trapped between the hairs can lead to linear artefacts on the image. Wet fur due to sweating can also cause similar artefacts.

Because of the size of the thoracolumbar spine, several views are necessary for full visualisation of the entire spine. The use of radiopaque markers on the dorsal aspect of the back will help show overlap between the images. These markers should be positioned such that at least two markers are visible per image. Furthermore, markers are helpful to localise specific areas if treatment is indicated as a result of diagnostic x-rays. If this is the case, the position of the markers can be more permanently marked after the radiographic examination by clipping the area or using, for example, correction fluid.

Another challenge of radiographing the thoracolumbar spine is the variety of its thickness, with only small amounts of soft tissues and bones at its dorsal aspect but a rapid increase in thickness further ventrally due to the musculature. Hence, lower exposures are necessary for the dorsal aspect and higher exposures for the ventral aspect. Obtaining two radiographs with different settings might help provide optimal visualisation of the different structures, but it will increase number of views. Therefore, a wedge-shaped aluminium filter used in front of the generator can help to adjust the exposures and enable the clinician to obtain one view of the spine with the same settings. The wider aspect of the filter should overlay the dorsal aspect of the spine, so the filter decreases the exposure at this level. The exposure will be decreased to a lesser extent further ventrally, where the filter becomes thinner – the ventral half of the beam is not filtered at all. However, if abnormalities are seen in the obtained views, sometimes using smaller collimation and reducing scatter to show more detail might be helpful to evaluate these findings more precisely.

Laterolateral views (*Figure 1*) can be obtained with portable equipment, whereas oblique radiographs with relative high exposures might not be achievable with these systems. For laterolateral radiographs of the dorsal spinous processes, the central x-ray beam should be centred roughly at the dorsoventral mid-level of the dorsal spinous processes, approximately 10 cm ventral to the skin surface. To obtain optimal radiographs of the vertebral bodies, centring should be more ventral – around 20 cm ventral to the skin surface.

Oblique radiographs have to be obtained from both sides; 'right ventral – left dorsal oblique' and 'left ventral – right dorsal oblique' views to highlight the left and right facet joints respectively. The x-ray beam should be angled 20 degrees from ventral and its centre should be 20 cm ventral to the skin surface (Butler et al, 2017). It is advised to manually measure this distance as it is often underestimated as a result of the curvature of the horse's back. Because of the presence of the lung, good quality radiographs of the facet joints up to the 16th thoracic vertebra can be obtained with high-output generators. However, even with this equipment, further caudal views can be quite challenging to obtain. Additionally, the lack of contrast due to increased amount of soft tissue might lead to views with only limited detail and diagnostic values.

Radiographic anatomy and findings

The equine thoracolumbar spine consists of 18 thoracic vertebrae and six lumbar vertebrae, meaning that multiple overlapping views are necessary for full evaluation. The pathognomonic anatomic

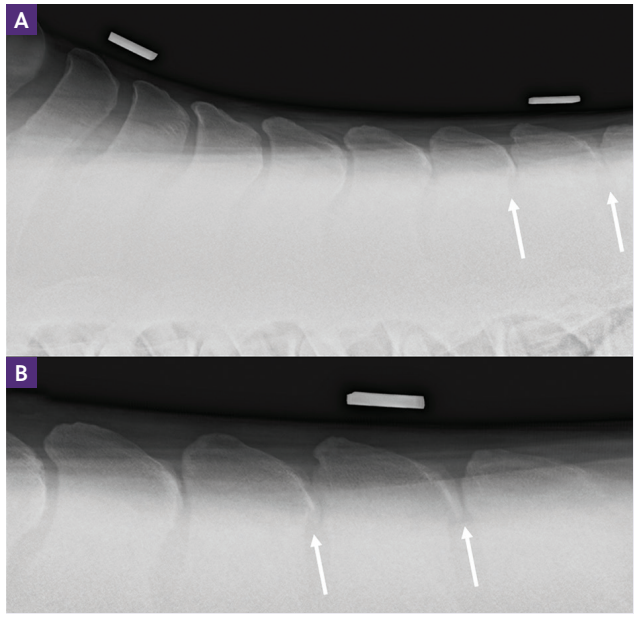

Figure 1. Laterolateral radiographs thoracolumbar spine of the same horse. A) Radiograph before cleaning showing multiple linear areas through the dorsal aspects of the spinous processes caused by wet hair. The distances between the 15th and 16th as well as the 16th and 17th spinous processes are decreased (indicated by the arrows). However, there is lack of detail in this area. B) Radiograph obtained after cleaning and centred on the 15th to 16th spinous processes with closer collimation. The previous artefacts have massively decreased. The distance between the 16th and 17th spinous processes is now wider due to different centring and the margin of the spinous processes show more detailed due to closer collimation (indicated by the arrows).

features of thoracic vertebrae are the presence of ribs that attach at the cranial aspect of their vertebral body, whereas lumbar vertebrae have large transverse processes (Liebich and Koenig, 2020). However – especially with portable machines – obtaining radiographs of the entire vertebra, including the ribs, might not be possible and knowing which location the alterations are shown might be challenging. However, there are multiple anatomical features that can be used to number the dorsal spinous processes. Separate centres of ossification are present in the dorsal spinous processes of the second to seventh, and sometimes eighth, thoracic vertebrae, with the separate centre of ossification of the spinous process of the third thoracic vertebrae being triangular in shape. The dorsal spinous process of the sixth thoracic vertebrae is usually the tallest, and in most horses the dorsal spinous process of the 15th thoracic vertebrae is the anticlinal one and perpendicular to the floor. The dorsal spinous processes of more cranial vertebrae angle their dorsal aspect caudally, and the dorsal spinous processes of more caudal vertebrae are angled in the opposite direction. The diaphragm usually crosses the vertebral bodies of the 16th and/or 17th thoracic vertebrae (Butler et al, 2017). Obtaining good quality radiographs of the lumbar vertebrae might be challenging due to the increased amount of soft tissues. In this area, higher exposures are necessary and even with these, contrast can be suboptimal.

It should be kept in mind that most of the anatomical reference points are found in the more cranial area of the thoracic spine, whereas clinically significant abnormalities are more commonly found in the mid to caudal area. Therefore, the first radiograph obtained in clinical cases is around T9 to T15, where the more cranial anatomical reference points are not available. However, precise numbering of the dorsal spinous processes might be less clinically relevant – some horses have a different number of vertebrae, and medicating the correct location rather than the number indicated of the dorsal spinous processes is more important. Using markers during acquisition and using theses as references for precise medication of the interspinous spaces is, in the author's opinion, much more important. To help facilitate more exact treatment, medication can also be considered under radiographic guidance with views obtained after needle positioning.

Abnormalities seen on radiographs include:

- Decreased distance between the dorsal spinous processes
- No space between the dorsal spinous processes
- In more severe cases, overlap of the dorsal spinous processes.

Adjacent spinous processes should be carefully evaluated for presence of increased opacities, commonly seen as linear areas at their cranio- and caudo-dorsal aspects (*Figure 2*). More advanced remodelling might be seen in some horses, with the presence of heterogeneous areas (which consist of a mixture of areas of increased and decreased opacities) leading to a mottled appearance of the dorsal spinous process. In some horses, osseous, cyst-like lesions might be present. Other abnormalities caused by the adjacent soft tissue structures include elongation of the craniodorsal aspect of the dorsal spinous process, resulting in a beak shaped appearance. This is because of enthesophyte formation at the attachment of the supraspinous ligament. In some horses, mineral opacities might be visible at the dorsal aspect of the dorsal spinous process, caused by either separation of the periosteum because of strain or mineralisation of the ligament. Enthesophyte formations at the attachment of interspinous ligament are seen as irregular outlines of the cranial and caudal margins of the dorsal spinous process caused by new bone formation. These are often seen in the more cranial dorsal spinous

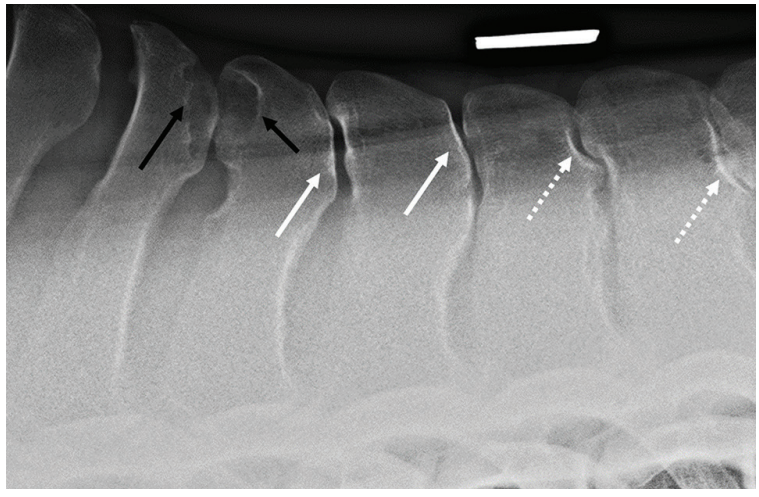

Figure 2. Laterolateral radiograph of the thoracolumbar spine a 5-year-old Thoroughbred showing moderate to marked changes. The margins of the spinous processes show moderate to marked remodelling and decreased distance (white solid arrows) and overlap of the spinous processes (white dashed arrows). In some spinous processes, radiolucent, cyst-like lesions are visible (black arrows).

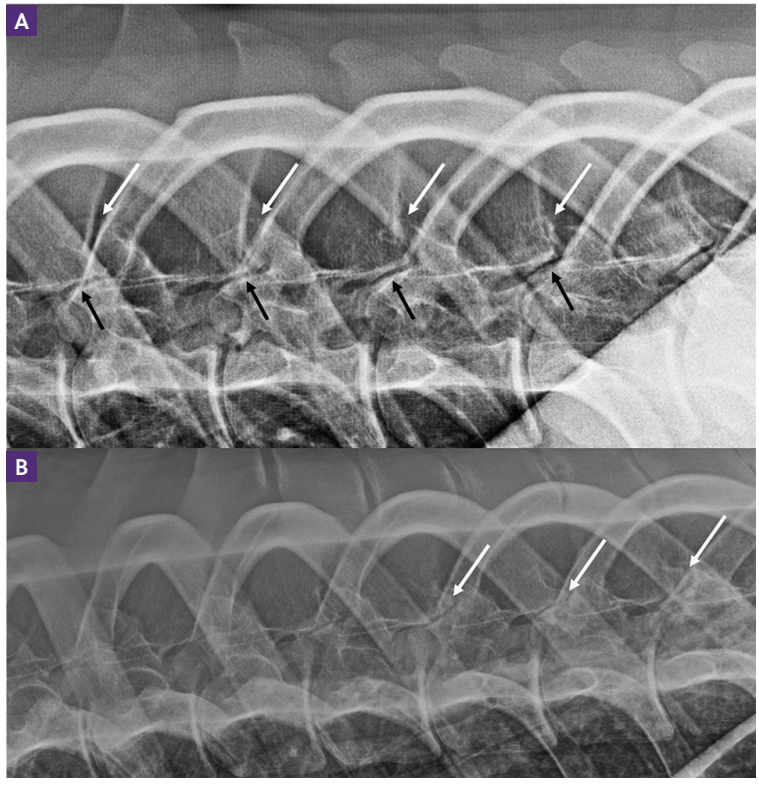

Figure 3. Oblique radiographs of the thoracolumbar spine for visualisation of the facet joints. A) normal appearance of the facet joint (black arrows). Note the dorsal adjacent and partial overlapping mammillary processes (white arrows). B) moderate remodelling of the caudal facet joints is visible (white arrows), with decreased joint spaces and remodelling of the articular surfaces.

KEY POINTS

- A thorough clinical examination should be performed before a radiographic examination of the thoracolumbar spine is considered.
- Optimal positioning of the horse and radiographic equipment is necessary for diagnostic views.
- Positioning of the equipment and horse will alter the appearance of the spine.
- There is a wide variety of radiographic findings and correlation between these findings and clinical signs is not always possible.

processes at the withers, and their clinical significance at this location is uncertain. However, it cannot be stated enough that the correlation between clinical signs and radiographic abnormalities can be quite poor (Ranner et al, 2002; Erichsen et al, 2004). A major reason for this is that the changes seen on radiographs are often chronic and therefore might be historical than causing present clinical signs. Therefore, the clinical examination is key in order to truly evaluate the significance of radiographic findings. Furthermore, judging the significance of abnormalities found during pre-purchase examination is rather challenging and prediction of developing future clinical signs caused by the radiographic findings is nearly impossible (Holmer et al, 2007).

The facet joints can be evaluated on the oblique radiographs but, similar to the dorsal spinous processes, a wide variation of abnormalities exist and prediction of their clinical significance is challenging (*Figure 3*) (Cousty et al, 2010). As with other joints, careful evaluation of the width of the joint space as well as its articular margins for presence of abnormal densities and osteophyte formation should be performed (Girodroux et al, 2009). However, because of their different angulation and distance from the central x-ray beam, the width of the joint space might not be similar in all joints on the same radiograph. Furthermore, superimposition with the ribs and the mammillary process should not be confused for increased density or enlarged articular process.

Less common abnormalities seen on radiographs include spondylosis or congenital defects such as abnormal shaped vertebrae and malalignment between the vertebrae. Acute onset of clinical signs of back pain can be caused by fractures – these are rare in general but are most commonly seen in the withers as a result of a fall.

Conclusions

Obtaining radiographs of the thoracolumbar spine is challenging, but with careful positions and preparation obtaining good quality radiographs is possible. Furthermore, the clinical significance of radiographic findings needs to be evaluated on a case-by-case basis due to the limited evidence of the correlation between clinical signs and radiographic findings. EQ

Conflict of interest

The author declares that there are no conflicts of interest.

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