Should radiographs of the thoracolumbar spine remain part of the pre-purchase examination?

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Abstract

The inclusion of thoracolumbar radiographs in a pre-purchase examination (PPE) is a topic of current and intense debate, subsequent to a statement from the Federation of European Equine Veterinary Associations (FEEVA) advocating the exclusion of spinous process radiography from the PPE. This review will consider the reasons behind the addition of such radiographs into PPEs, the limitations of radiography in ambulatory practice and therefore the diagnostic limitations to the practitioner, the diagnostic benefit of a complete radiographic examination, and discussion of common and less-frequent thoracolumbar pathologies. We will focus on laterolateral radiographs of the spinous processes as these are most commonly acquired during the PPE. The lack of consistent and repeatable grading systems highlights the subjective nature and variability in assessing this region radiographically. Coupled with the sparse evidence of correlation between clinical symptoms and radiographic abnormalities of the thoracolumbar spine leads us to conclude that taking radiographs of the back during PPEs should not be performed unless the clinical examination indicates otherwise.

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Keywords**:** equine, back, thoracolumbar spine, spinous processes, pre-purchase examination, radiographs.

Summary

The inclusion of thoracolumbar radiographs in a pre-purchase examination (PPE) is a topic of current and intense debate, subsequent to a statement from the Federation of European Equine Veterinary Associations (FEEVA) advocating the exclusion of spinous process radiography from the PPE. This review will consider the reasons behind the addition of such radiographs into PPEs, the limitations of radiography in ambulatory practice and therefore the diagnostic limitations to the practitioner, the diagnostic benefit of a complete radiographic examination, and discussion of common and less-frequent thoracolumbar pathologies. We will focus on laterolateral radiographs of the spinous processes as these are most commonly acquired during the PPE. The lack of consistent and repeatable grading systems highlights the subjective nature and variability in assessing this region radiographically. Coupled with the sparse evidence of correlation between clinical symptoms and radiographic abnormalities of the thoracolumbar spine leads us to conclude that taking radiographs of the back during PPEs should not be performed unless the clinical examination indicates otherwise.

Main text

Introduction

Ongoing discussion exists on the necessity of a radiographic examination of the equine thoracolumbar spine during the pre-purchase examination (PPE). In 2018, the Federation of European Equine Veterinary Associations (FEEVA) stated that they do not recommend radiography of spinous processes (SP) of the thoracolumbar spine as part of the PPE (*FEEVA Position Statement of Pre-Purchase Radiography on Dorsal*

Spinous Processes , 2018). However, other federations such as the British Equine Veterinary Association (BEVA), American Association of Equine Practitioners (AAEP) and others have not followed up on this statement. The German Equine Veterinary Association (DVG) decided not to include the thoracolumbar spine in their 2018 PPE guidelines, and this will likely remain in 2023 (Röntgen-Leitfaden (2018) - Leitfaden Fur Die Röntgenologische Beurteilung Bei Der Kaufuntersuchung Des Pferdes, 2018). Still, the fact remains that radiography of the thoracolumbar spine is a common occurrence during PPEs.

Radiographs of the SP are often included in the PPE due to a request by the client, the purchasing party. Reasons for purchasers to request these radiographs are numerous and may involve ridden or clinical queries, the "just to exclude" reason or for re-sale purposes. Often, decision making is done upon exclusion; if the horse does not show any radiographic abnormalities of the thoracolumbar spine, this is a positive outcome, if the horse does show abnormalities then many factors are involved in the final decision. Another facet of the process are the insurance companies. Most companies do not request radiographs for their policies; however, some require radiographs for horses worth over £10,001.

Clinical examination

Abnormalities on clinical examination involving the thoracolumbar spine may be another reason for performing radiographs during the PPE. There are a considerable number of clinically significant osseous and soft tissue related primary back problems but one cannot always distinguish those with back pain as a secondary consequence from orthopaedic conditions (Henson, F. M.D.Kidd, 2009). A systematic protocol for the clinical part of the PPE is therefore an important feature. Guidance notes on the 5 stage vetting of a horse are written by the BEVA, in association with the RCVS, preluding a structured approach to this (RCVS & BEVA, 2018). Unfortunately, clinical symptoms are often vague and encompass a multitude of variable combinations. Symptoms are; back pain, abnormal spinal conformation, muscle wastage, abnormal reaction on palpation and manipulation, back stiffness, unwillingness to go forwards, poor performance, lameness, bucking, pain or resentment on saddling and/or girth tightening and other gait abnormalities such as an abnormal canter, disunited gait, poor hindlimb impulsion, ''bunny-hopping" and difficulty to transfer from one gait to another (Henson, F. M.D.Kidd, 2009). The cause of back pain can be very challenging to discover and often requires a combination of clinical examination and diagnostic aids such as regional blocks and diagnostic imaging. The former diagnostic aid not being a regular part in the PPE. In the majority of cases, a diagnosis can only be made by elimination of other conditions which may cause back pain and a thorough work-up is needed before the final diagnosis can be made.

Radiography

Radiography of the equine thoracolumbar spine in horses is a common diagnostic procedure. Portable machines are likely sufficient for the thoracic spinous processes; however, a high-output stationary generator is often required for the vertebral bodies, articular process joints and the lumbar spine (Manso-Diaz et al., 2018). These anatomical regions often require higher exposure settings; the subsequent effect of increased scatter radiation must be controlled by use of an appropriate grid (Butler, Janet A. et al., 2017). A lead sheet may be placed behind the detector plate to prevent backscatter (Butler, Janet A. et al., 2017). A standard radiographic examination of the thoracolumbar spine of an adult horse involves a series of multiple overlapping laterolateral (LL) views (Figure 1) of the SP and, if possible, the vertebral bodies (Manso-Diaz et al., 2018). The latter sometimes needs to be performed separately due to differences in laterolateral thickness of the horse more dorsally compared to ventrally, and additionally this allows tighter collimation. If taken in one view, this may result in exposure failures on either anatomical structure; quite often seen as overexposure of the spinous processes. Additional oblique projections (L20V-RDO and R20V-LDO, respectively left 20 degrees ventral to right dorsal oblique and right 20 degrees ventral to left dorsal oblique) (Figure 2) can be acquired to separate the left and right articular process joints (Manso-Diaz et al., 2018). When acquiring radiographs of the thoracolumbar spine it is helpful to add dorsal radiopaque markers (Figure 3), which will enable the identification of specific vertebrae and SP in relation to the horse, ensuring each view overlaps slightly and therefore all SP are included (Manso-Diaz et al., 2018).

Radiographic quality is an important feature when obtaining radiographs of the thoracolumbar spine. Successful interpretation will result from a radiograph that shows exactly what is necessary for diagnosis and this depends on multiple factors (Cervantes, 2016). Accessing the quality of radiographs is subjective, however, the main important physical features are judgement of contrast, sharpness and quantum noise (Dhiego Donizethe Ferreira & Israel de Souza, 2021; Kjelle & Chilanga, 2022). There is a distinguishable difference between radiographs taken with a high-output stationary system in comparison to those taken with a low-output portable machine of which the image examiner should be aware of during interpretation. The main difference between these are the limitations in radiographic technique based on exposure limits. The large mass of the thoracolumbar spine requires a generator output of 75-120kV and 100-250mAs (Butler, Janet A. et al., 2017). However, more recently other resources describe less exposure is needed, varying from 65-90kV and 20-40mAs (Manso-Diaz et al., 2018). This is likely due the advent to digital radiography and the improvement in flat panel detector technology being able to register signal difference over a very wide range of exposures, having a 'wide dynamic range'. In addition, exposures may differ due to the major differences in the horse's size and conformation and may be hard to predict. As previously stated, when taking radiographs in ambulatory practice, diagnostic radiographs of anatomical locations other than the SP are difficult to obtain, and conditions such as spondylosis of the vertebral bodies or severe osteoarthritis of the articular process joints cannot be easily diagnosed.

Regardless of the system and machine used, there are several other elements described which may also contribute to the difficulty of image interpretation of the SP (Looijen et al., 2022a). The impossibility for orthogonal views, scatter radiation and magnification due to increased film-patient distance may result in variable quality of radiographs (Looijen et al., 2022a). Measuring the interspinous spaces of the equine thoracolumbar spine on computed tomographic images in comparison to radiographs resulted in inconsistencies in those measurements, most likely due to geometric distortion because of x-ray beam angulation (Djernæs et al., 2017). Moreover, differences in head and neck positioning resulted in inconsistent measurements of the interspinous space with lower positions leading to increasing interspinous distances (Berner et al., 2012). A consistent and neutral head position is imperative when taking radiographs of the thoracolumbar spine. We recommend using a head stand, or something to act as a head stand, set at the height of the horses' shoulders to provide a neutral head and neck position.

Image interpretation

For optimal interpretation of radiographs of the equine thoracolumbar spine, good anatomical knowledge is required (Figure 1). We do need to be aware of anatomical variations seen in SP but also, we should be aware of other possible radiographic abnormalities associated with abnormal clinical findings within the remainder of the spine. Other anatomical structures to be aware of are the articular processes, the vertebral bodies, the ribs, the transverse processes and/or surrounding soft tissues. In addition, we need to consider overlying structures such as the epaxial and hypaxial musculature, the scapula and ileum which are superimposed over important structures of the thoracolumbar spine and may contribute to image distortion. The nuchal ligament and its continuation as the supraspinous ligament, as well as the interspinous ligaments are also important to assess. These ligaments, in combination with the spinal musculature, offer core stability and contribute to a clinically healthy back (Townsend et al., 1986).

When assessing radiographs of the thoracolumbar spine it is important, as with any image interpretation, to maintain consistency. To facilitate detection of abnormal findings it is advised to orientate them in a standard manner for viewing, for example; laterolateral views should be assessed with the cranial aspect of the animal to the interpreter's left (Thrall, 2018). In addition, always make sure you look at a radiograph in the same way, starting from the outside of the anatomy working inwards as per anatomical structure or from cranial to caudal and/or dorsal to ventral. Image interpretation should be done remotely and not in the field with day light blurring your image interpretation. Make sure you choose a quiet isolated place without distraction (Thrall, 2018). Nowadays DICOM images can easily be transferred to such places and they allow, on the contrary to JPEG files, the reader to manipulate the orientation, size, blackness and contrast (Thrall, 2018).

Radiographic abnormalities

Very common radiographic abnormalities associated with the thoracolumbar spine are those associated with the SP. They can show a huge variability in their size, shape and margin but also in radiopacity and interspinous space width (Figures 4 and 5) (Looijen et al., 2022a; M. Zimmerman et al., 2012). The main location of narrow interspinous spaces is the caudal saddle region and the cranial lumbar spine (T14–L2), which is reported consistently in the literature (Butler, Janet A. et al., 2017; Haussler et al., 1999; Henson, F. M.D.Kidd, 2009; Jeffcott, 1979, 1980; Townsend et al., 1986). How these changes arise and/or develop remains unclear. As does the question of what the true incidence of pain arising from abnormal SP is (Henson, F.M.D., Kidd, 2009). The anatomical abnormality itself is however, extremely common (Henson, F.M.D., Kidd, 2009). Unfortunately, little is known about its congenital and developmental features. One study revealed that in foals at a young age, barely any radiographic changes were found within the thoracolumbar spine(Sinding & Berg, 2010). Which conflicts with Pressanto et al. 2023, who stated that the absence of difference in occurrence of radiographic findings of the SP between yearlings and older horses supported a developmental rather than acquired aetiology (Pressanto et al., 2023).

Post-mortem research revealed that horses with overriding SP were found in 86% and 92% of the cases, unrelated to their clinical presentation (Haussler et al., 1999; Townsend et al., 1986). Radiographic incidence of abnormalities was found in 34% of normal horses and 33% in horses with a history of thoracolumbar pain (Jeffcott, 1979, 1980). Histopathology of the interspinous ligament in horses with impingement revealed altered collagen fibre alignment and ligamentous layers. They also found evidence of a significant increase in the number of nerves located within the ligament suggesting a possible explanation for thoracolumbar pain (Ehrle et al., 2019). Unfortunately, the control group described horses with the absence of thoracolumbar pathology on radiography and pathology and therefore did not involve non-clinical horses with radiographic abnormalities. This made a comparison between clinically unaffected horses with impingement and those with clinical symptoms and radiographic changes impossible.

Grading systems

Over the years multiple grading systems have been designed, all trying to encompass the many different radiographic findings of multiple SP, allowing interpretation the thoracolumbar spine as a whole (Figure 6) (Cousty et al., 2010; De Graaf et al., 2015; Denoix, J-M., Dyson, 2011; Gerhards, H., Hertsch, B., Jahn, P., & Brunken, 2007; Pettersson, H., B. Strömberg, 1987; Sager, 1997; Marieke Zimmerman et al., 2011). These studies have described common radiographic abnormalities of the SP; however, they unfortunately have some pitfalls. For example, not all studies have compared diseased to non-diseased animals, they have not been validated amongst different observers and they have not established a ''cut-off" grade for those which may have an increased likelihood of having clinical symptoms of primary back pain associated with radiographic findings. A limited number of studies described a grading system originating from a sum of grades per SP rather than a generalised summary of abnormalities (Erichsen et al., 2004; Marieke Zimmerman et al., 2011). Only until recently has it been described that inter- and intra-observer agreement on the severity of radiographic abnormalities offers only selective reliability when grading SP (Looijen et al., 2022). Most of all, a general consensus of its clinical relevance has never been established (Looijen et al., 2022).

Clinical relevance of impingement of spinous processes

A limited number of studies have compared clinically unaffected horses to those with clinical signs of back pain and their radiographic changes within the thoracolumbar spine. Both studies found that there is a wide range of radiographic abnormalities of the SP seen in horses with or without back pain, and the severity of the lesions of the SP was significantly associated with the presence of osteoarthritis of the articular process joints and clinical symptoms (Cousty et al., 2010; Marieke Zimmerman et al., 2011). Another study, without comparison, found widespread variation of radiographic and scintigraphic changes in riding horses without clinical signs of back problems which lead to the conclusion that clinically significant changes are not easily interpretated (Erichsen et al., 2004). These findings are supported by multiple studies which also revealed a lack of correlation between radiographic findings of SP and clinical symptoms (Geiger & Gerhards, 2015;

Holmer et al., 2007; Ranner & Gerhards, 2002; Rieland, 2002). Another body of evidence is also present showing good correlation between impingement of SPs and back pain and therefore a true scientific consensus is absent (Cousty et al., 2010; Hendrickson, 2020; Turner, 2011; M. Zimmerman et al., 2012). Zimmerman et al. 2012, found that in horses with primary back pain, there was no significant difference in radiographic abnormalities (M. Zimmerman et al., 2012). However, horses with severe radiographic abnormalities (above grade 5 out of a scale of 0-7) presented with a combination of back and sacroiliac pain, with and without hindlimb lameness, or sacroiliac pain with hind limb lameness (M. Zimmerman et al., 2012). In the group of clinically normal horses, 40% had medium-grade radiographic abnormalities of the SP(M. Zimmerman et al., 2012).

Pre-purchase examinations and impingement of spinous processes

Studies which investigated radiographic abnormalities of SP during PPE are limited. There is only one study performed in Germany and one in the Netherlands which compared radiographic alterations of the thoracolumbar spine without clinical signs of back pain on PPE (De Graaf et al., 2015; Holmer et al., 2007). The majority of horses in these studies had radiological abnormalities however, these were predominantly mild with only a few horses having higher grades (De Graaf et al., 2015; Holmer et al., 2007). Unpublished data of at least one thousand Warmblood horses, mainly used for dressage, showed potential correlation between mild radiographic abnormalities and age, gender and height. With taller and older horses, as well as geldings, being more prone to radiographic abnormalities. In addition, no differences were found in the future athletic results of horses with different grades of abnormal SP. On the contrary, follow-up done by De Graaf et al. 2015, found that there was no significant association between gender, age and discipline and clinical signs of developing back pain (De Graaf et al., 2015). A high grade of abnormal SP (3 out of 0-3) was associated with an increased risk of clinical symptoms on follow-up, however the sensitivity of a grade 3 in their study was low. Grade 3 changes involved impinging or overlapping SP with combined increased opacity, radiolucencies and severe remodelling and/or fusion (De Graaf et al., 2015). This study concluded that there was a high risk of developing clinical symptoms when having a grade 3 abnormality however, no warranty can be offered for absence of clinical signs for grade 0-2 (De Graaf et al., 2015). Holmer et al. 2007, stated that radiographic abnormalities were frequent even among clinically healthy horses and they stated that recent court decisions in Germany had decided that radiographic abnormalities unaccompanied by clinical symptoms in a horse are not seen as material defects and are therefore insignificant (Holmer et al., 2007). They argue whether radiographic examination of the SP as part of a general exam at PPE makes sense at all without a clinical suspicion of back pain (Holmer et al., 2007).

Thoracolumbar articular process joints

The articular process joints of the thoracolumbar spine are another region which should be closely investigated in horses with back pain or other clinical signs which may lead to further investigation of the thoracolumbar spine. According to Girodroux et al. 2009, osteoarthritis of the articular process joints may contribute to back pain, with or without association of other osseous abnormalities (Girodroux et al., 2009). Unfortunately, in this study there was no control group to investigate the prevalence of osteoarthritis in healthy horses. As previously stated, the severity of impinging SP has been associated with osteoarthritis of the articular process joints (Zimmerman et al., 2011). Horses with osteoarthritis of the articular process joints were more likely to have thoracolumbar pain than those with SP lesions alone, however, those with concurrent lesions of the SP and osteoarthritis of the articular process joints were associated with the highest likelihood of thoracolumbar pain (Zimmerman et al., 2012). As mentioned previously, high quality radiography with additional views to assess these joints is necessary and may be potentially challenging. This is mainly due to the variation in shape of these joints within the thoracic region as well as morphological differences between thoracic and lumbar articular process joints (Denoix et al., 2018). Within the cranial thoracic region, the joint spaces are oriented obliquely whereas further caudally they become more vertical (Beaumont et al., 2022). Within the caudal thoracolumbar area, the joints are more rounded with curved joint space (Beaumont et al., 2022). A mammillary process is dorsocranially present, elongating the shape of the cranial articular process (Beaumont et al., 2022). In the oblique views, this often overlies the joint space, making it difficult

to distinguish new bone formation along the base of the interspinous space (which is commonly seen) from a normal mammillary process (Beaumont et al., 2022; Manso-Diaz et al., 2018). Denoix proposed a grading system for the radiographic abnormalities associated with these articular process joints, however the fact remains that limited evidence is established for radiographic abnormalities within these low-motion joints (Cousty et al., 2010).

Other thoracolumbar anatomy

Other lesions associated with the thoracolumbar spine include spondylosis, stress fractures, traumatic fractures, intervertebral disc lesions and/or muscle injury. Spondylosis deformans occurs at a low prevalence in horses with back pain (Meehan et al., 2009). Similar to osteoarthritis of the articular process joints, spondylosis deformans can be found alone or in combination with other osseous abnormalities (Meehan, 2017). Lesions often are seen in the mid to caudal thoracic spine (T10-T14) and the majority of horses have more than one lesion(Meehan et al., 2009). In Zimmerman et al., they also found that the severity of spinous process lesions were significantly associated with the presence of spondylosis (Zimmerman et al., 2011). They state that this is an important feature and highlights the need for high quality and comprehensive radiographic evaluation of the thoracolumbar spine (Zimmerman et al., 2011). Infectious discospondylitis, on the other hand, is a much more severe condition during which horses often show additional neurological signs (Alward et al., 2007; Vandekerckhove et al., 2023). Radiographic signs of spondylosis and discospondylitis may be similar but often the latter encompasses aggressive radiographic signs such as cortical lysis, mottled punctate trabecular pattern and/or periosteal remodelling (Alward et al., 2007; Vandekerckhove et al., 2023). Other intervertebral disc lesions, with or without associated radiographic abnormalities of the opposing endplates, may be found further cranially (in the cervical spine) but have been described in the cranial thoracic spine and show a big variety of clinical signs (Dyson et al., 2019).

More uncommon lesions such as thoracolumbar fractures of either the SP or the vertebral bodies, often encompass severe clinical symptoms and are unlikely to be found at PPE (Collar et al., 2015; Ferguson, 1996; Frers et al., 2023; Mangla et al., 2022). However, one should consider the diagnosis of chronic fractures during PPE. Quite often those of the withers, which may look severely malformed and misshapen (Figure 7), can be found. Another reason for the presence of similar abnormalities found during PPEs, maybe due to preventative iatrogenic shortening performed in ponies for height limitations at FEI competitions. Rib fractures as a cause of poor performance has recently been described (Hall et al., 2023). They carry a fair prognosis and should be managed conservatively in most cases, ultrasonography and scintigraphy are useful tools but they have also been diagnosed on radiographs when apparent in their most dorsal portion (Hall et al., 2023). Rib fractures were most commonly diagnosed in the caudal ribs (Hall et al., 2023).

Neoplasia's of the thoracolumbar spine or of its associated soft tissues often carries a guarded prognosis with severe clinical symptoms of ataxia (Finding et al., 2014; Nikolaou et al., 2015). However, one case report described surgical removal of an osteoma involving two SP which had a good prognosis and only clinical symptoms of back pain (Owen et al., 2019). Radiographical findings included the presence of a circular area of increased radiopacity at the level of the interspinous space of T12 and T13 (Owen et al., 2019).

Conclusion

PPE are performed by many equine clinicians all over the world and as stated by the German Equine Veterinary Association: "The most important aspect of assessing the current physical condition of a horse during the pre-purchase assessment is a thorough clinical examination. The radiographic examination is a complementary examination and represents only a small section of the range of findings during a pre-purchase examination"(Röntgen-Leitfaden (2018) - Leitfaden Fur Die Röntgenologische Beurteilung Bei Der Kaufuntersuchung Des Pferdes, 2018). The latter statement thoroughly summarises what every equine practitioner should bear in mind while performing a PPE. They should use this in every aspect and part of the examination before advising positively or negatively. Unfortunately, questions asked by clients such as: "Do these radiographic abnormalities indicate current disease? Are these radiographic abnormalities indicators of increased risk of disease? Is there a risk for resale of this horse?", cannot be answered yet and will regret-

tably remain difficult to answer in the future. The need for more studies involving follow-up of radiographic alterations, in combination with comparison of those with and without back pain, is important. A consensus for a reliable and repeatable grading system is of high priority. Due to the previously described limitations using different grading systems on PPE, the interpretation might be variable, non-repeatable and therefore at risk of being unreliable. The combination of growing evidence of a lack of correlation in between clinical symptoms and radiographic abnormalities of the thoracolumbar spine makes us conclude that taking radiographs of the back during PPE should not be performed unless clinical examination indicates otherwise. A ridden examination of the horse, with a familiar and well-experienced rider, is advised for an objective point on view.

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Figures

Figure 1: Laterolateral radiographs of the caudal thoracic (a) and cranial lumbar (b) spine. Cranial is to the left. Articular process joint (black circle), intervertebral disc space (also known as the intercentral joint) (three black lines). Note the metallic markers placed on the skin dorsal to T11-T12 and T17-T18 interspinous spaces.

Figure 2: a. Oblique radiograph of the thoracolumbar spine, with a magnified view of the articlar process joint. b. Transverse computed tomographic (CT) image of the thoracic spine to demonstrate how the projection is acquired. Cranial is to the left on the radiograph, the camera is on the left of the horse in the CT image. Left intervertebral foramen (*) and right intervertebral foramen (**).

Figure 3: Positioning of radiopaque markers (a) to correctly obtain and overlap sequential LL views of the caudal thoracic spine (b). This figure is modified from the textbook A Practical Guide To Equine Radiography (Manso-Diaz et al., 2018).

Figure 4: Laterolateral radiographs of the thoracolumbar spine with multiple mild radiographic abnormalities shown. This figure is modified from Looijen et al,. 2022 (Looijen et al., 2022). Cranial is to the left. (a) Interspinous space with impingement of the SP (box). (b) Small osseous cyst-like lesion (circle), mild narrowing of the interspinous spaces (small rectangular boxes) and dorsal remodelling of the spinous process (rectangular box). (c) Isolated opacities dorsal to the SP (rectangular boxes) and a small area of radioluceny and remodelling at the cranial margin of the spinous process (circle).

Figure 5: Laterolateral radiographs of the thoracolumbar spine with multiple moderate radiographic abnormalities shown. This figure is modified from Looijen et al,. 2022 (Looijen et al., 2022). Cranial is to the left. (a) Beak shaped remodelling at the craniodorsal aspect of the spinous process suggestive of enthesopathy of the supraspinous ligament (circle) and remodelling at the craniodorsal aspect of the spinous process suggestive of enthesopathy of the interspinous ligament (rectangular boxes). (b) Large osseous cyst-like lesion within the mid portion of a spinous process (circle) and severe remodelling and sclerosis of the spinous processses (rectangular box).

Figure 6: Overview of the several different grading systems of the SP of the thoracolumbar spine. This figure is modified from Petterson et al., 1987, mod. Petterson (1996), Sager (1997), Denoix and Dyson (2003), Gerhards (2007), Cousty et al., 2009 and Zimmerman et al., 2011

Figure 7: Laterolateral radiograph of the cranial thoracic SP (withers) showing severe remodelling of the dorsal aspect of the SP likely indicating multiple chronic healed fractures.

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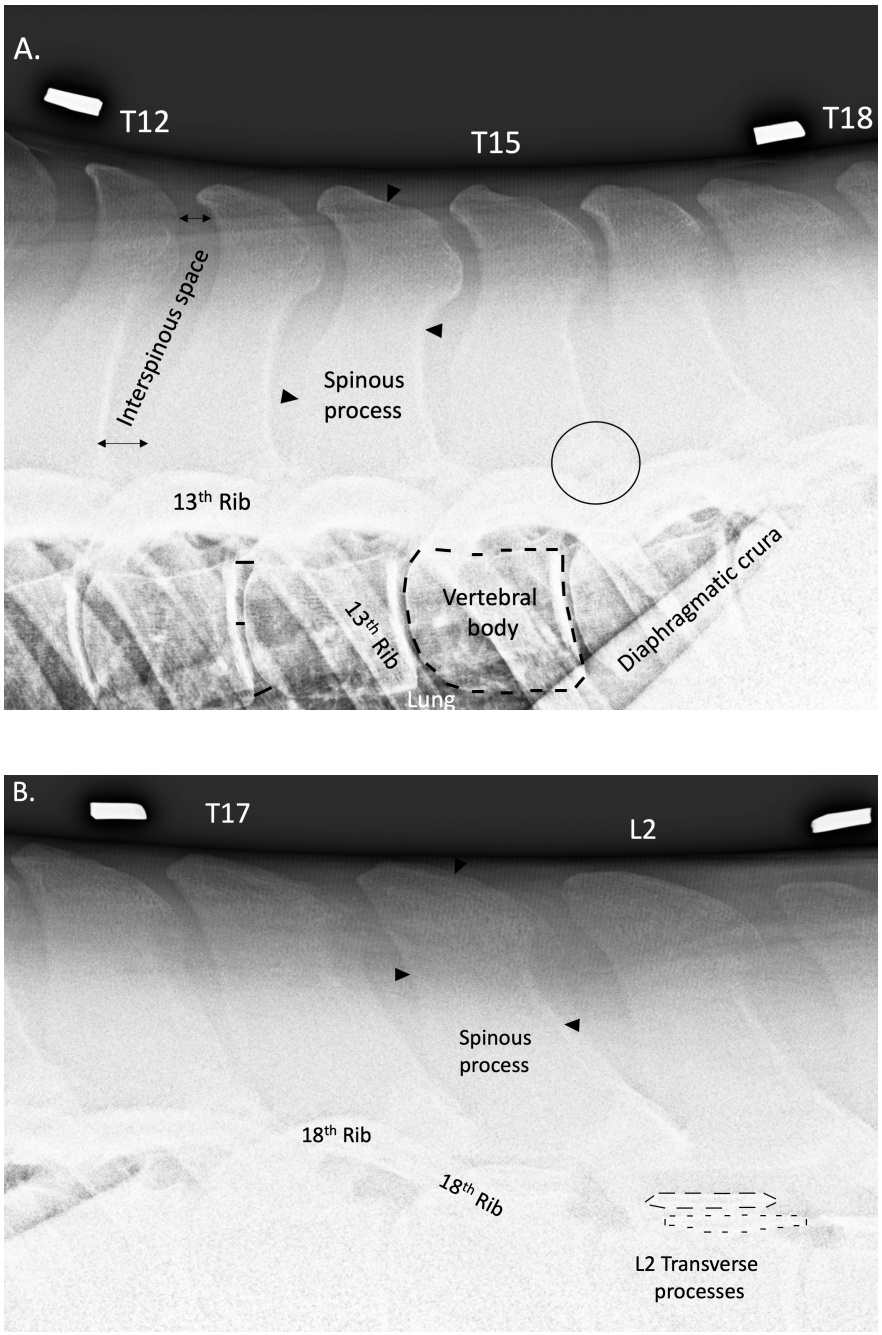

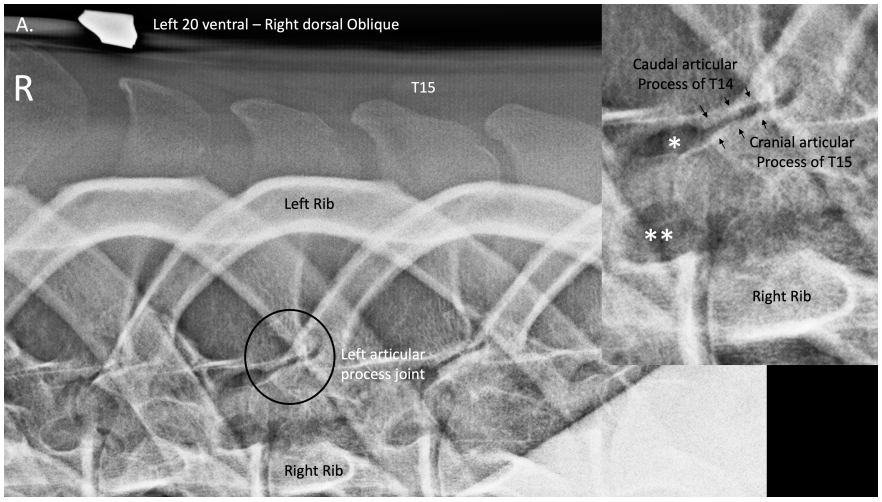

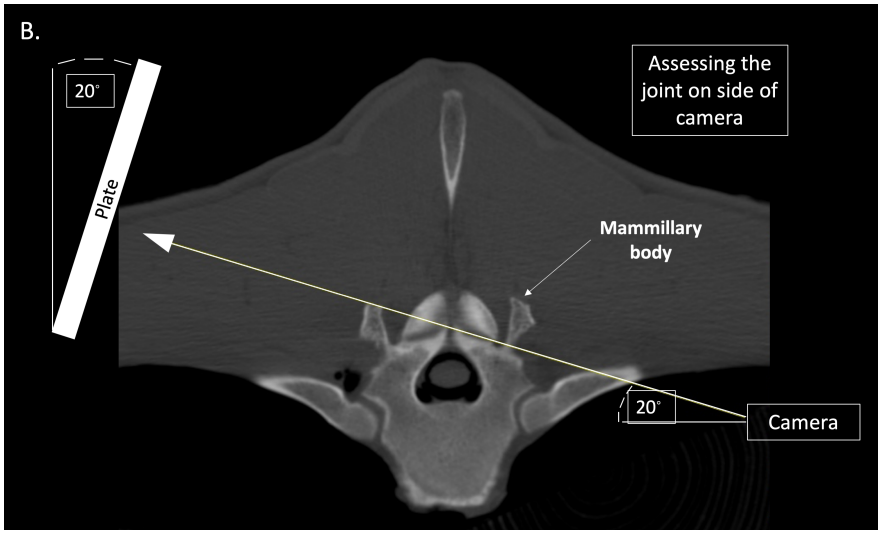

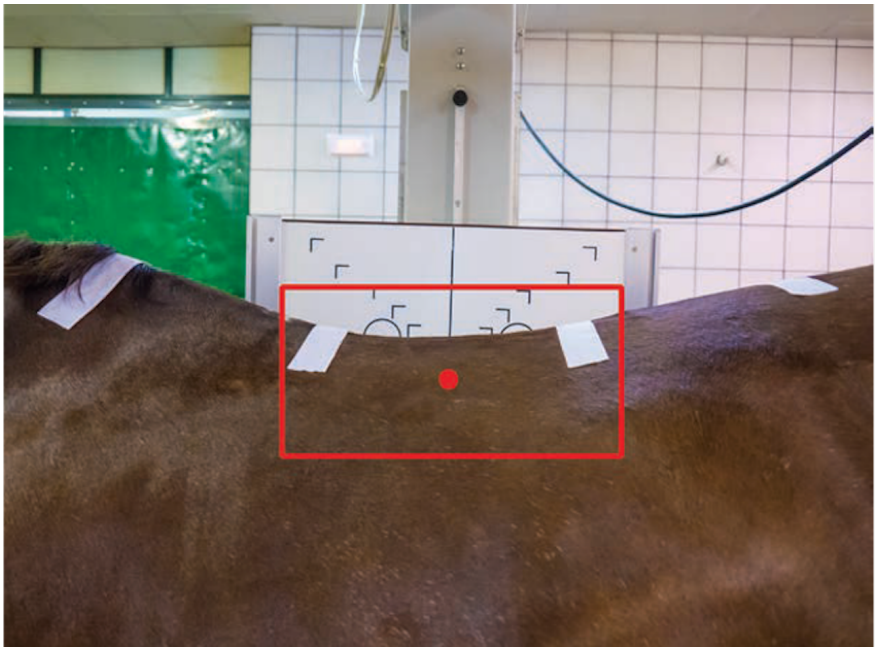

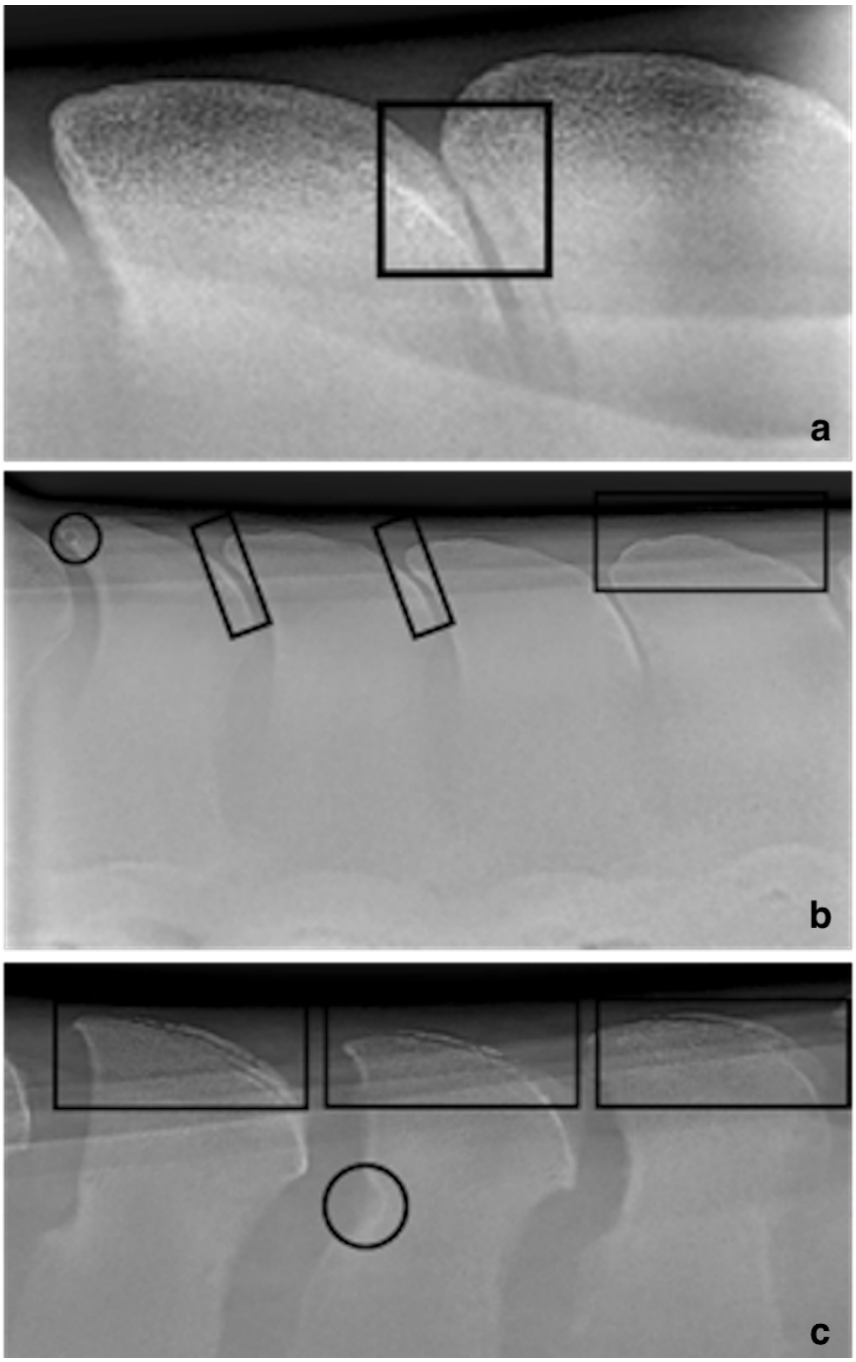

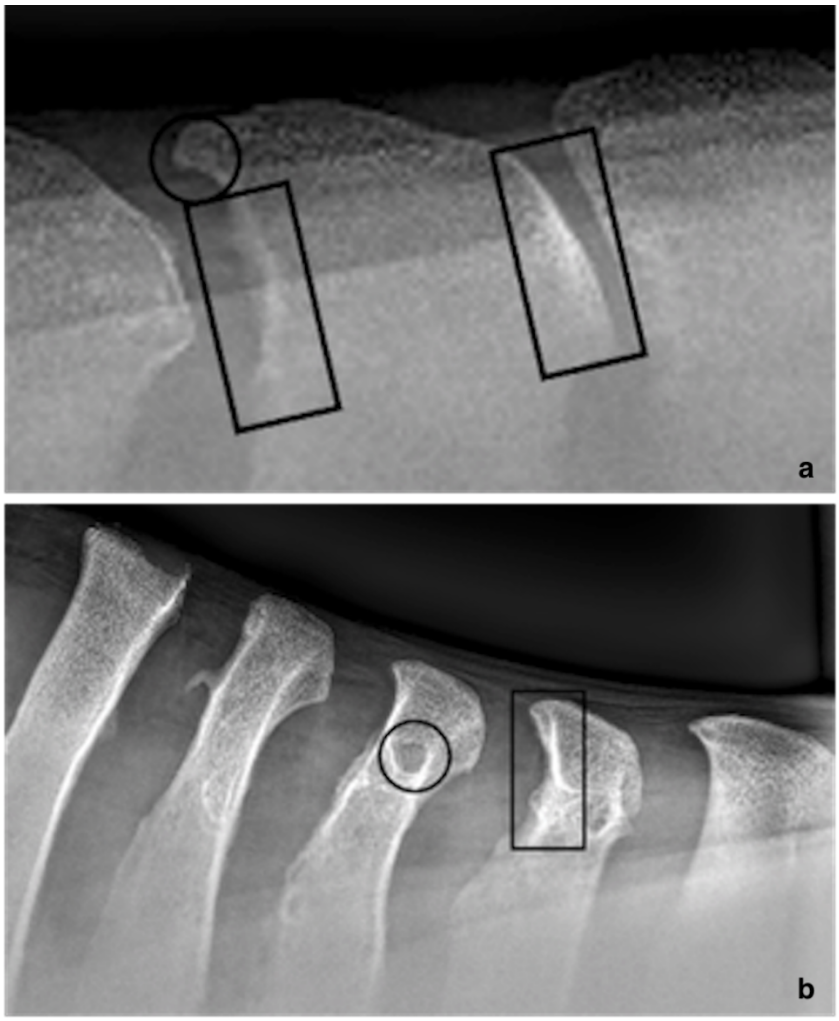

TABELLE 1B: *Vergleich der Graduierungsschemata*

Petterson et al. (1987)	mod. Petterson (1996)	Sager (1997)
Grad 0: Ohne besonderen Befund	Grad 0: Normaler Abstand zwischen den Dornfortsätzen	Grad 0: Ohne besonderen Befund
Grad I: Verkürzter Abstand ohne sonstige Veränderungen zwischen zwei oder mehreren Dornfortsätzen	Grad I: Engstand zwischen zwei oder mehr Dornfortsätzen mit Sklerosierungen und/oder osteolytischen Bereichen	Grad I: Dorsale Zubildungen auf den dorsalen Dornfortsatzenden
Grad II: Verkürzter Abstand mit leichter Sklerosierung und/oder leichter Rarefikation zwischen zwei oder mehreren Dornfortsätzen	Grad II: Berührung zwischen zwei oder mehr Dornfortsätzen mit sklerotischen und/oder osteolytischen Bereichen	Grad II: „Nasenbildung" am kranio-dorsalen Dornfortsatzende
Grad III: Kontakt mit Rarefikation zwischen zwei oder mehreren Dornfortsätzen	Grad III: Berührung und Überreiten mit sklerotischen und/oder osteolytischen Bereichen zwischen zwei oder mehreren Dornfortsätzen	Grad III: Verkürzter Abstand ohne sonstige Veränderung
Grad IV: Kontakt mit Rarefikation zwischen drei oder mehreren Dornfortsätzen		Grad IV: Verkürzter Abstand mit leichter Sklerosierung zwischen zwei oder mehreren Dornfortsatzenden
Grad V: „Überreitende" Dornfortsätze mit Sklerosierung und/oder Rarefikation von zwei Dornfortsätzen		Grad V: Kontakt mit Rarefikation zwischen zwei oder mehreren Dornfortsätzen
		Grad VI: Überlappende Dornfortsätze mit Sklerosierung und/oder Rarefikation bei zwei oder mehreren Dornfortsätzen

Dornfortsätze Bereich Sattellage und Lendenwirbelsäule

	Zwischenräume über 8 mm **ohne** reaktive Veränderungen		I
	Zwischenräume 2 bis 8 mm **ohne** reaktive Veränderungen		II
	Zwischenräume kleiner 2 mm **ohne** reaktive Veränderungen		II – III
	Zwischenräume 2 bis 8 mm **mit** reaktiven Veränderungen (Sklerosierungssaum, Zubildung)		II - III
	Berühren der Dornfortsätze **ohne** deutliche reaktive Veränderungen		III
	Berühren der Dornfortsätze **mit** starker Sklerosierung und/oder Zubildung		III – IV
	Berühren der Dornfortsätze **mit** Zystoiden Defekten		III – IV
	Dornfortsatz **mit** Zystoidem Defekt		III – IV
	Überlappen (Überlagerung) der Dornfortsatzenden		III – IV
	Zubildung dorsal		II
	Zubildung(en),kraniale und/oder kaudale Kontur		II - III
	Zubildung nasenförmig, dorsal, kranial und/oder kaudal gerichtet		II
	Zubildung nasenförmig **mit** Aufhellungslinie		II – III
	Verschattung, dorsal, kappenartig		II – III
	Gesamtklasse	I II III IV	

TABLE 1: Radiological interpretation of impingement of the dorsal spinous processes (DSP) and osteoarthritis of synovial intervertebral articulations (SIA)

Impingement of DSP[*]:

Grade 1	Narrowing of the interspinous space with mild sclerosis of the cortical margins of the DSP
Grade 2	Loss of the interspinous space with moderate sclerosis of the cortical margins of the DSP
Grade 3	Severe sclerosis of the cortical margins of the DSP, caused in part by transverse thickening, or radiolucent areas
Grade 4	Severe sclerosis of the cortical margins, osteolysis, and change in shape of the DSP

Osteoarthritis of SIA[†]

Periarticular proliferation of SIA was graded as follows:

Grade 1	Slight periarticular proliferation less than 25 per cent of the size of the SIA
Grade 2	Severe periarticular proliferation more than 25 per cent of the size of the SIA

Sclerosis of SIA was graded as follows:

Grade 1	Partial sclerosis of SIA (less than 50 per cent) with partial visualisation of the joint space
Grade 2	Total sclerosis of SIA (more than 50 per cent) with no visualisation of the joint space

[*] Denoix and Dyson (2003)
[†] Cousty and others (2009)

Grade	Description
0	• Normal interspinous space width (>4 mm) • Rim of mild increased opacity (<2 mm) of the margins of the SPs • No radiolucencies • No modelling at the cranial or dorsal aspect of the SPs
1	• Mild increased opacity of the margins of the SPs • Mild radiolucency • Mild narrowing of the interspinous space (3–4 mm) • Mild modelling at the dorsal aspect of the SP
2	• Narrowing of the interspinous space (<3 mm) with mild increased opacity of the cortical margins of the SPs and/or mild radiolucency • Normal interspinous space with moderate increased opacity of the margins and/or moderate radiolucencies • Impinging SPs without increased opacity of the margins or radiolucencies • Overlapping SPs without increased opacity of the margins or radiolucencies • Mild modelling at the cranial aspect of the SP without increased opacity or radiolucencies
3	• Impinging SPs with mild to moderate increased opacity of the margins and/or mild radiolucencies • Narrowing interspinous space with moderate increased opacity of the margins and/or moderate radiolucencies • Overlapping SPs with mild increased opacity of the margins and/or mild radiolucencies • Moderate modelling at the dorsal or cranial aspect of the SP
4	• Impinging SPs with moderate to severe increased opacity of the margins and/or moderate radiolucencies • Overlapping SPs with moderate increased opacity of the margins and/or moderate radiolucencies • Severe modelling at the dorsal or cranial aspect of the SP
5	• Impinging SPs with severe increased opacity, severe radiolucencies, osteolysis and change in shape of the SPs
6	• Fusion of SPs with severe increased opacity of the margins, severe radiolucencies and osteolysis
7	• Severe congenital abnormalities: fused SPs, bony bridges between SPs