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Incidence of facet joint osteoarthritis in dogs

A retrospective radiographical study

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Incidens av facettledsartros hos hund

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SUMMARY

Facet joint osteoarthritis is a degenerative disorder in the facet joints of the vertebral column. This disorder is a well known and common cause for neck and back pain in humans, but studies on incidence of facet joint osteoarthritis in dogs has previously not been carried out. Back and neck problems are common in dogs, and often caused by disorders related to intervertebral disc degeneration. Radiology, Computed tomography (CT) and Magnetic resonance imaging (MRI) are frequently used diagnostic tools when a dog is presented with back and/or neck pain. It is however not unusual that no underlying cause can be identified, and the back pain is then often attributed to epaxial muscle pain or discogenic pain without further diagnostic evidence. It was prior to this study hypothesized that facet joint osteoarthritis is a common disorder in dogs, and a possible source of neck and back pain that is often overlooked. This study aimed to investigate how common facet joint osteoarthritis is in dogs and thereby raise awareness of facet joint osteoarthritis as a differential diagnosis to neck and back pain.

The study was carried out in two major steps. First, a system for radiographical grading of facet joint osteoarthritis in dogs was evaluated for reliability. Radiographs of 30 cervical and 30 lumbosacral canine spines were evaluated for facet joint osteoarthritis by three observers, and inter- and intraobserver agreement was calculated.

Secondly, the incidence of facet joint osteoarthritis in a referral population of 285 dogs was determined. In addition to incidence, breed and age was also recorded. The case group consisted of 150 dogs radiographed because of neck or low back pain. The control group consisted of 135 dogs radiographed for other reasons than neck/back pain. An independent sample t-test was used to compare the case and control group.

The grading system was proven to be reliable in dogs. The interobserver agreement (weighted Kappa) were 0,65; 0,58 and 0,64, which represents moderate to substantial agreement. The intraobserver agreement were 0,92; 0,84 and 0,83, which represents almost perfect agreement.

A clear and significant difference in mean grade of facet joint osteoarthritis between the case group and control group was found. The incidence was 64 % in the case group and 24 % in the control group, which means that facet joint osteoarthritis is more common in dogs radiographed because of neck/back pain than in dogs radiographed for other reasons. A moderate correlation between severity (i.e. grade) of facet joint osteoarthritis and both age and breed size was found. Older dogs and large breed dogs had a higher mean grade in severity of facet joint osteoarthritis.

The clinical importance of facet joint osteoarthritis in dogs remains unknown. The facet joints are a potential source of spinal pain in human, but the same has yet not been proven for dogs. The aim of this study was not to prove that the facet joints are a potential source of pain in dogs, but simply to determine the incidence of facet joint osteoarthritis in dogs with and without clinical signs of neck/back pain. In this study, a significant higher incidence of facet joint osteoarthritis was found among dogs radiographed because of neck or low back pain, than dogs radiographed for other reasons than neck/back pain. This suggests that facet joint

osteoarthritis either contribute to neck/back pain, or that facet joint osteoarthritis is associated with other disorders that cause neck/back pain. Injections of local anesthetics into severely affected facet joints have been used in human medicine to prove that facet joints are a potential source of pain. A similar study on dogs could possibly prove the clinical importance of facet joint osteoarthritis in dogs.

SAMMANFATTNING

Facettledsartros är en degenerativ sjukdom i ryggkotpelarens facettleder. Sjukdomen är en välkänd och vanlig orsak till nack- och ryggsmärta hos människor, men studier på förekomsten av facettledsartros hos hund har tidigare ej gjorts. Rygg- och nackproblem är vanligt hos hundar, och ofta orsakas problemen av intervertebraldisk-degeneration. Röntgen, datortomografi (DT) och magnetisk resonanstomografi (MRI) används ofta i diagnostiken av hundar med rygg- och/eller nacksmärta. Det är dock inte ovanligt att ingen underliggande orsak kan hittas, och smärtan tillskrivs då ofta ryggmuskulatur eller intervertebraldiskar. Som grund för denna studie låg en hypotes om att facettledsartros är vanligt hos hundar, och utgör en potentiell orsak till smärta som ofta förbises. Syftet med denna studie var därför att undersöka hur vanligt facettledsartros är hos hund, och därmed belysa facettledsartros som en differentialdiagnos till nack- och ryggsmärta.

Studien gjordes i två huvudsakliga steg. Först utvärderades tillförlitligheten av ett graderingssystem för facettledsartros hos hund. Röntgenbilder av 30 cervicala respektive 30 lumbosacrala hundryggar bedömdes av tre veterinärer, som var och en gjorde två bedömningar av varje bild. Deras bedömningar jämfördes sedan dels de två bedömningarna emellen, och dels inbördes.

I det andra steget i studien bestämdes incidensen av facettledsartros i en studiegrupp om 285 hundar. Förutom incidens noterades även ras och ålder. Fallgruppen bestod av hundar som hade blivit röntgade på grund av nack- eller ländryggssmärta. Kontrollgruppen bestod av hundar som hade blivit röntgade av andra orsaker än nack- eller ryggsmärta.

Tillförlitligheten hos graderingssystemet som användes i studien vad hög. De tre veterinärernas bedömningar av facettleder överensstämde med varandra. Med viktad Kappa-analys beräknades sambandet vara 0,65: 0,58 och 0,64, vilket motsvarar ett måttligt till starkt samband. Även varje veterinärs två bedömningar överensstämde väl, och viktad Kappa för detta var 0,92; 0,84 och 0,83, vilket motsvarar nästan perfekt samband.

En tydlig och signifikant skillnad i medelgrad av facettledsartros hittades med fall- och kontrollgrupperna. Incidensen var 64 % i fallgruppen och 24 % i kontrollgruppen, vilket betyder att facettledsartros är vanligare hos hundar som röntgas på grund av nack/ryggsmärta än hos hundar som röntgas av andra anledningar. En måttlig korrelation mellan grad av facettledsartros och både ålder och rasstorlek hittades, det vill säga äldre hundar och hundar av stora raser hade högre medelgrad av facettledsartros.

Den kliniska relevansen av facettledsatros hos hund är ännu ej utredd. Facettlederna är en potentiell orsak till nack/ryggsmärta hos människor, men det samma har ännu ej bevisats hos hund. Syftet med den här studien var dock endast att bestämma incidensen av facettledsartros hos hundar med och utan kliniska tecken på nack/ryggsmärta. I denna studie kunde en tydlig skillnad i incidens av facettledsartros bevisas mellan hundar röntgade på grund av nack/ryggsmärta jämfört med hundar röntgade för andra orsaker än nack/ryggsmärta. Detta tyder på ett samband mellan antingen facettledsartros och nack/ryggsmärta, eller mellan facettledsartros och andra sjukdomar som primärt ger nack/ryggsmärta. Inom

humanmedicinen har lokalanestesi i förändrade facettleder använts för att bevisa facettledernas roll i smärta. En liknande studie på hund skulle kunna ge oss mer information om den kliniska relevansen av facettledsartros hos hund.

CONTENT

INTRODUCTION

The canine vertebral column is composed of seven cervical, thirteen thoracic, seven lumbar and three fused sacral vertebrae. In addition there are a variable number of caudal vertebrae. The interposing vertebrae are joined together at the ventral side through an intervertebral disc and at the dorsal aspect though two dorsolaterally located facet joints (Dyce et al., 2002a). The facet joints are synovial joints and act as a stabilizing unit of the vertebral column (Vasseur et al., 1980).

Facet joint osteoarthritis (OA) is a degenerative disorder of the facet joints which, in dogs, is often seen as an incidental finding on radiography. Facet joint OA is only regarded as the cause of back pain when there is severe OA compressing neural tissue and when no other pathology is seen. As there are only few publications on this topic, which may be because it is an uncommon disorder in dogs or that many veterinarians does not recognize this problem and that many patients pass undiagnosed. Facet joint OA has been proven to be a common disorder in humans (Kalichman et al., 2008, Manchikanti, 1999) and a fairly common disorder in horses (Girodroux et al., 2009), but the incidence in dogs remains unknown. To the author's knowledge there are to this date no studies on the incidence or prevalence of facet joint OA in dogs.

Back pain, in general, is however a common problem in dogs which is most often caused by diseases related to intervertebral disc degeneration such as hernias or instability of the vertebral column (Bergknut et al., 2012). It is not uncommon that no underlying cause can be identified in dogs presenting with back pain, even using advanced diagnostic imaging modalities such as Computer tomography (CT) and MRI (Magnetic resonance imaging). The back pain is then often attributed to epaxial muscle pain or discogenic pain without further diagnostic evidence.

It is also possible that a substantial number of dogs with back pain pass unnoticed as it is difficult for the owners to identify the problem unless the dog shows overt signs of pain. This study aims to investigate how common facet joint OA is in dogs and thereby raise awareness of facet joint OA as a differential diagnosis to neck/back pain, and to determine if any particular breeds or age groups are more often affected.

Several causes for facet joint OA, including for instance trauma, ageing and inflammation have been described (Weisbrode, 2007). The best known disease where facet joint OA is one of the main causes of clinical signs (along with malformation of the vertebral body), is the osseous form of cervical spondylomyelopathy (wobbler) which is most often seen in young (1-2 years) giant breed dogs. In these patients the bony proliferation of the facet joints can be so severe that it compresses the spinal cord and exiting spinal nerves, thereby causing neurological deficits (da Costa, 2010).

Aim and Hypotheses

The aims of this study were to determine the incidence of facet joint OA in a referral population of dogs and to investigate whether facet joint OA is more common in dogs with

back pain as compared to a control group of dogs without back pain. This was based on testing the following hypotheses:

a) **Incidence.** Facet joint OA is relatively common in dogs with neck and/or back pain. Facet joint OA also occurs in dogs without clinical signs of neck/back pain, but significantly more seldom.
b) **Breed predisposition.** Facet joints osteoarthritis is more common in large breed dogs, especially in German Shepherd Dogs, Great Danes, Scottish Deerhounds and Dobermans.
c) **Age correlation.** The incidence of facet joint OA increases with age.

No system for radiographic grading of facet joint OA has been evaluated for reliability in dogs. Before the incidence of facet joint OA in dogs can be determined, the reliability of a grading system for facet joint OA must be evaluated.

a) Incidence

Back pain can have its origin in different anatomical structures, such as intervertebral discs, facet joints, ligaments of the vertebral column, meninges, spinal nerves, epaxial muscles and the vertebral periosteum (Webb, 2003). The incidence of back pain in dogs is not known but given that intervertebral disc related disorders alone (requiring a veterinary consultation) have a reported lifetime prevalence of 3.5% (Bergknut et al. 2012), back pain overall must be considerably more common.

Facet joint OA is common in humans with chronic back pain and the facet joints are a common source of pain (however not necessarily due to osteoarthritis) in patients with neck and back pain. Between 15 and 66,7 % of humans with chronic low back pain have facet joint OA (Kalichman et al., 2008, Manchikanti, 1999, Schwarzer, 1994) and the facet joints are the source of pain in 15 to 45 % of humans with chronic low back pain (Manchikanti, 1999, Schwarzer, 1994).

The high prevalence in humans suggests that facet joints OA could be a common disorder also in dogs. However, due to different biomechanical stresses in the human and canine spine, for instance the s-shaped vertebral column in humans and upright walking in humans, it is hypothesized that dogs have a high incidence of facet joint OA, but not as high incidence as seen in humans.

b) Breed predisposition

Due to the relatively high tensile properties of the cartilage in facet joints (equally the strength of cartilage origin from the patellar groove), it has been suggested that the facet joints are likely to be exposed to significant tensile loads (Elder et al., 2009).

Since biomechanical stress on the facet joints is likely to be higher in large breed dogs, it is hypothesized that facet joint OA is more common in large breed dogs. The area of the facet joints are in some dogs increased by so called ventral facets on the articular processes. By increasing the joint area, these ventral facets increase the loading capacity of the joints. Ventral facets are more often found in large breed dogs than in small breed dogs, but whether

these ventral facets are a result of functional adaption to heavy loading or a congenital attribute has not been established (Breit, 2002).

Considering that facet joint OA is present in dogs suffering from the osseous form of cervical spondylomyelopathy, a similar breed predisposition as seen for cervical spondylomyelopathy is hypothesized to be present for cervical facet joint OA as well, i.e. being common in large breed dogs in general (da Costa, 2010) and Great Dane, Doberman and Basset Hound in particular (Lewis, 1992).

Seiler et al. (2002) found that German Shepherd Dogs have a different conformation of the lumbar vertebral facet joints as compared to control dogs. This was confirmed by Suwankong et al. (2008), who found that German Shepherd Dogs have significant more acute/sagitally oriented facet joint angle and greater tropism at L7-S1 compared to other shepherd breed dogs and other breeds in general. Since abnormalities in conformation of the joint surface is a possible cause for osteoarthritis (Weisbrode, 2007), the aberrant conformation of the facet joints in German Shepherds Dogs suggests this breed may have a higher prevalence of osteoarthritis in their lumbar facet joints than other breeds. The role of facet joint conformation in facet joint OA is however not fully understood, and Grogan et al. (1997) have for instance showed that tropism is not a major factor in the etiopathogenesis of facet joint OA in humans, whereas age, spinal level and overall facet joint angle are. The facet joint angle affects the range of motion of the lumbar and lumbosacral back (Benninger et al., 2006), and German Shepherd Dogs have significantly reduced range of motion in all directions of the L7-S1 junction compared to other breeds (Benninger et al., 2004).

Kinzel et al. (2003) evaluated 14 Scottish Deerhounds for neck pain, and 9 of these were diagnosed with cervical facet joint OA. During the four years long study, no dog of any other breed was diagnosed with facet joint OA in the same clinic which is indicative that it is a hereditary disorder.

c) Age correlation

Kalichman et al. (2008) have shown that the prevalence of facet joint OA in humans increases with age. A similar age correlation of facet joint OA is expected in dogs as well although it has not yet been proven. Given that cervical spondylomyelopathy affects dogs as young as a few months old, and the mean age of debut in large breed dogs is as low as 3,8 years (da Costa, 2010), facet joint OA is expected to be found in young dogs as well.

LITTERATURE REVIEW

Anatomy of the facet joints

The facet joints, sometimes called zygapophysial joints (Dreyer and Dreyfuss, 1996), are synovial joints interposing adjacent vertebrae in the vertebral column. They consist of the cranial and caudal articular processes that are located dorso-laterally on the vertebral arches. (Budras et al., 2007, Dyce et al., 2002a)

The major stabilizing ligaments of the spine are the facet joint capsules, the flaval ligaments, the dorsal longitudinal ligaments and the intervertebral disks. The facet joint capsules enclose the facet joints and allow substantial motion. The thickness of the cervical facet joint capsules in 15 medium sized dogs (10,5-25,9kg) were measured to be 1,0-1,5 mm. During cervical flexion the facet capsules tightens and thus counteracts the flexion. (Vasseur et al., 1980)

Average thickness of facet joint cartilage in L3-4 and L4-5 in 2-4 y.o. male Mongrel Dogs with no clinical evidence of facet joint OA was measured to be 0,49 ±0,10 mm (Elder et al., 2009). As a reference, thickness of articular cartilage of the femoral condyle in the stifle joint has been measured to be 0,6-1,3 mm for dogs (3 y.o., breed not specified) and 1,5-2 mm for horses (Frisbie et al., 2006).

The facet joints are innervated by the medial branches of the dorsal rami, which derive from the spinal nerves (Bogduk and Long, 1979, Dreyer and Dreyfuss, 1996, Dyce et al., 2002b, Forsythe and Ghoshal, 1984). The facet joints have been proven to be a possible source of spinal pain (Manchikanti, 1999, Schwarzer, 1994).

Osteoarthritis

Etiology

Several causes for facet joint OA, including for instance trauma, ageing and inflammation have been described (Weisbrode, 2007). A well known disease where facet joint OA is one of the main causes (along with malformation of the vertebral body) of clinical signs is the osseous form of cervical spondylomyelopathy (wobbler), which is most often seen in young (1-2 y.o.) giant breed dogs. Here the bony proliferation of the facet joints can be so severe that it causes compression of the neural tissue and thereby gives rise to secondary neurological deficits (da Costa, 2010).

The etiology of osteoarthritis in general is according to a review article in human medicine by Goldring and Goldring (2007) incompletely understood, however it is known that the etiology is multifactorial and involves degeneration of articular cartilage, intraarticular inflammation with synovitis and changes in periarticular and subchondral bone.

Etiologies for OA can be categorized into two main groups (Guilak, 2011):

- Normal stress but abnormal physiology in a joint
    - Inflammation
    - Aging
    - Sepsis

    - Genetic factors
    - Immune responses

- Normal physiology but abnormal stress in a joint
    - Obesity
    - Trauma
    - Malalignment
    - Joint instability
    - Abnormal anatomy

Genetic factors associated with OA were recently reviewed, and it was found that genetic factors are involved in all types of OA, i.e. both primary and post-traumatic OA. In addition, abnormalities in joint conformation increases the risk for OA. Physical, environmental and biomechanical stress in the joints were found to be important factors in the development of OA as well. (Sandell, 2012)

Pathogenesis

Osteoarthritis has a complex pathogenesis. Biomechanical stress in joints is necessary for sufficient blood supply of joint cartilage. On the other hand, abnormal, altered or harmful loading can cause disorder in the inflammatory and metabolic balances, which may lead to OA. (Guilak, 2011)

The etiologies mentioned above (abnormal stress and/or physiology) lead to damage of extracellular matrix, catabolic processes, mechanical failure and loss of normal repair functions. These processes lead to joint destruction, pain and disability, which all can cause abnormal stress and physiology and in that way initiate further destruction. (Guilak, 2011)

Cartilage consists of chondrocytes and extracellular matrix, whereof the latter is primary composed of collagen, proteoglycans and water (Junquiera and Carniero, 2003). The initial pathology seen for OA is a disruption of the smooth superficial layer of joint cartilage, leading to a roughening on the cartilage surface (Greisen et al., 1982) and thus exposing the underlying cartilage to abnormal stress and thereby fissures may be caused (Johnston, 1997).

A thinning of the cartilage is seen where pressure is elevated, contributing to an eventual fragmentation of cartilage and thereby exposing subchondral bone. Free cartilage fragments are phagocytized and can thereby trigger an inflammatory response in the joint. Breakdown of proteoglycans and cartilage will exceed synthesis, i.e. cartilage degradation. (Johnston, 1997). Eventually OA will cause thickening of the subchondral plate, development of osteophytes in the joint margins and cysts in the subchondral bone (Gilbertson, 1975, Goldring and Goldring, 2007, Johnston, 1997).

Facet joint osteoarthritis

Prevalence

Prevalence in dogs

Back pain is a common problem in dogs (Bergknut et al., 2012), however no studies concerning prevalence or incidence of facet joint OA in dogs have to the author's knowledge previously been published.

Prevalence in humans

The prevalence of facet joint OA in humans with chronic low back pain has been determined to be 45 % by Manchikanti (1999), 15 % by Schwarzer (1994) and 59,6 % in males and 66,7 % in females by Kalichman et al. (2008). Manchikanti (1999) and Schwarzer (1994) used diagnostic analgesia to prove that facet joint OA in fact was the source of pain. Kalichman et al. (2008) on the other hand did not use diagnostic analgesia and thus failed to prove facet joint OA being the source of pain. Kalichman et al. (2008) have also shown that the prevalence of facet joint OA in humans increases with age, with a peak at 60-69-years of age. Prevalence in the lumbosacral back is according to Kalichman et al. (2008) highest (45,1 %) in L4-L5.

The prevalence of unspecified neck pain among humans has been determined to be 43 %, and for chronic neck pain (>6 months duration) 22 % for women and 16 % for men (Guez et al., 2002). Manchikanti (2002) has established the prevalence of facet joints as the source of chronic spinal pain in humans to be 55 % in the cervical spine, 42 % in the thoracic spine and 31 % in the lumbar spine. The facet joints were however only evaluated by nerve blocks and not radiographically.

Prevalence in horses

A study by Girodroux et al. (2009) demonstrated that 12 % of horses with clinical signs of thoracolumbar pain have radiographic signs of facet joint OA. Whether the facet joints were the source of pain was not investigated.

In a post-mortem study by Haussler et al. (1999), degenerative changes (i.e. osteoarthritis) in thoracolumbar facet joints were recorded in 97 % (35 out of 36) thoroughbred racehorses. The degenerative changes included osteophytes, lipping of the articular surface and periarticular and intraarticular erosions. The clinical relevance of the pathological findings was not established.

In a post mortem study by Stubbs et al. (2010), osseous pathology (unspecified) of the spine was found in all 22 horses included in the study. 17 of these 22 (77 %) had severe osseous changes. None of the horses were euthanized because of back problems, but 68 % of them had been treated for back problems at some point in their lives.

Human grading system for facet joint osteoarthritis

To the author's knowledge there is to date no objective radiographic grading system available for facet joint OA in dogs. In human medicine however, several existing grading systems for

facet joint degeneration have been evaluated by Kettler and Wilke (2006). Kettler and Wilke (2006) suggest a scale of three to five grades, beginning with grade 0, with 0 being no detectable degeneration. Kettler and Wilke (2006) refers to a four grade system for cervical facet joint degeneration presented by Kellgren et al. (1963), to which Cote et al. (1997) later added a grade 0, as Kettler and Wilke (2006) advocate. The grading system with the added grade 0 is presented in Table 1.

Table 1. Radiographic grading of cervical facet joint degeneration on lateral views by Cote et al. (1997)

Grade 0	No degeneration
Grade 1	Doubtful osteophytes on margins of the articular facets of facet joints
Grade 2	Definite osteophytes and subchondral sclerosis in facet joints
Grade 3	Moderate osteophytes, subchondral sclerosis and some irregularity of articular facets
Grade 4	Many large osteophytes and severe sclerosis and irregularity of the facet joints

The interobserver reliability of this grading system was evaluated by Cote et al. (1997). Thirty lateral images of the cervical spine with a wide range of degeneration were selected and evaluated by three different observers. The intra class correlation coefficient (ICC) was determined to be 0,45. Kettler and Wilke (2006) point out that since facet joint degeneration is difficult to assess, a grading system with ICC >0,40, which represents moderate agreement, is to be considered a recommended grading system. However, an ICC >0,60 (substantial agreement) is of course desirable. The weighted Kappa (κ_w) coefficients in the reliability study by Cote et al. (1997) were 0,52; 0,54 and 0,81 the three observers in between.

MATERIAL AND METHODS

Reliability of grading system

Image assessment

Evaluation of a grading system for facet joint osteoarthritis

To evaluate the reliability of a grading system for facet joint OA 60 lateral radiographs of cervical and lumbosacral spines (30 of each) were selected, representing a wide range of level of degeneration. The choice of 30 images of each spine segment, and only lateral views, derives from the original reliability study of this grading system in human medicine (Cote et al., 1997).

Since facet joint OA is hypothesized to be more frequently occurring in large breed dogs, and these breeds obviously have larger vertebral bodies which makes evaluation of the facet joints easier, only large breed, non-chondrodystrophic dogs were included in this reliability study.

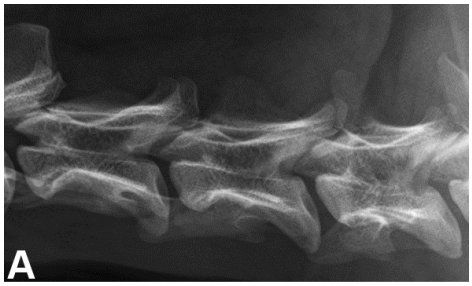
To test interobserver reliability, evaluation was performed by three veterinarians; a board certified veterinary radiologist (S. Veraa), a board eligible veterinary neurologist (N. Bergknut) and a final semester veterinary student (J. Larsson). To test intraobserver reliability, each veterinarian evaluated every image twice with two weeks in between. The clinical conditions of the dogs were unknown for all of the observers and the observers did not have access to each others' evaluations. The values from each observer's second round of evaluation were used to calculate the interobserver agreement.

The observers did prior to the study receive sample images showing each grade of facet joint OA as a guide line for the evaluation. All visible facet joints in each individual radiograph were evaluated and the grade given was based on the most degenerated facet joint.

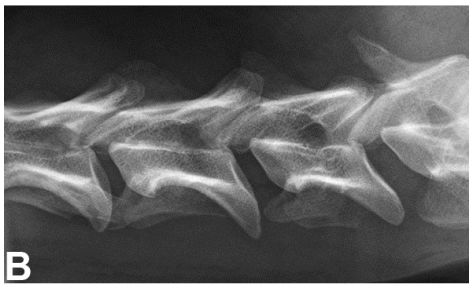
Example images

Using the grading system by Cote et al. (1997) presented above, a set of example images were selected (in consensus between the three observers) to demonstrate each of the five grades of facet joint OA. These example images were used as a reference by the evaluators for the validation study. The example images that were used are presented below in Figure 1 and 2.

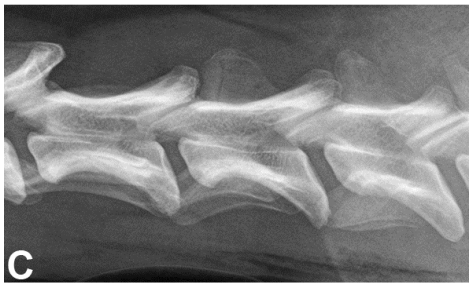
Figure 1. Cervical facet joints with all five different grades of facet joint osteoarthritis.



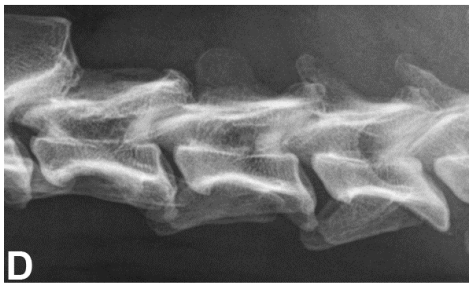
A) Grade 0, no degeneration.



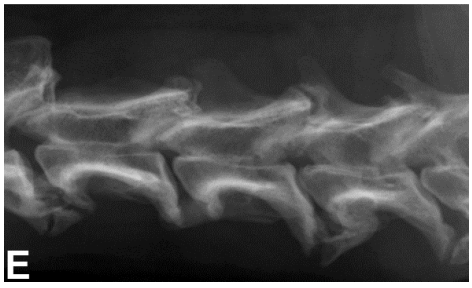
B) Grade 1, doubtful osteophytes on margins of the articular facets of facet joints.



C) Grade 2, definite osteophytes and subchondral sclerosis in facet joints.

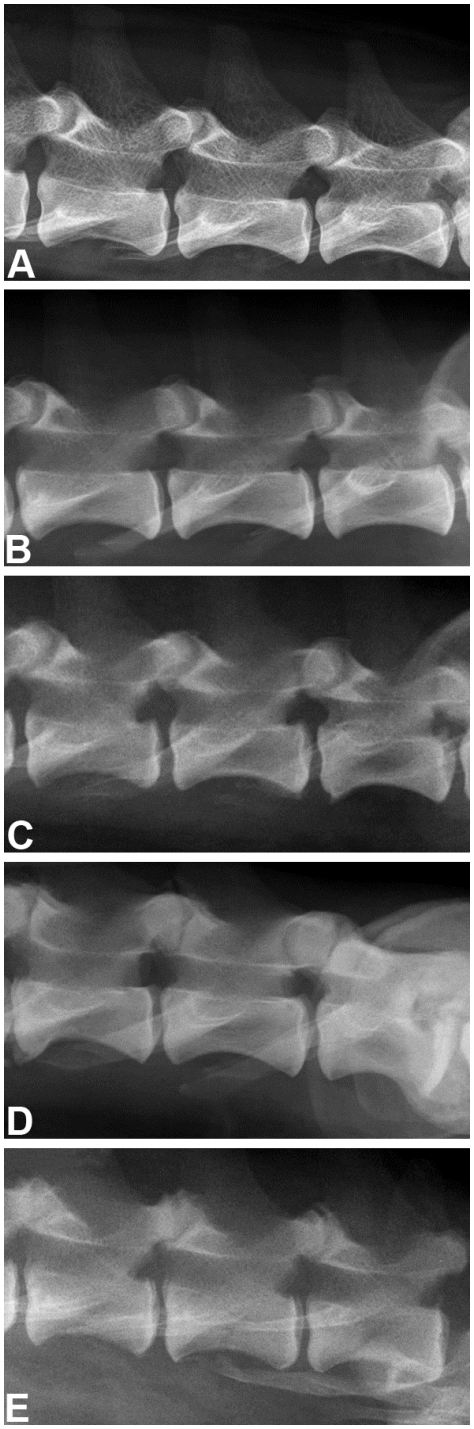


D) Grade 3, moderate osteophytes, subchondral sclerosis and some irregularity of articular facets.



E) Grade 4 , many large osteophytes and severe sclerosis and irregularity of the facet joints.

Figure 2. Lumbosacral facet joints with all five different grades of facet joint osteoarthritis.



A) Grade 0, no degeneration.

B) Grade 1, doubtful osteophytes on margins of the articular facets of facet joints.

C) Grade 2, definite osteophytes and subchondral sclerosis in facet joints.

D) Grade 3, moderate osteophytes, subchondral sclerosis and some irregularity of articular facets.

E) Grade 4 , many large osteophytes and severe sclerosis and irregularity of the facet joints.

Incidence of facet joint osteoarthritis

To evaluate if facet joint OA is more common in dogs with neck/back pain a retrospective study using the above mentioned grading system was set up. Radiographs of cervical and lumbosacral vertebral columns from two groups of dogs (a case group of dogs with neck/back pain and a control group of dogs radiographed for reasons other than neck/back pain) were

evaluated for facet joint OA and the occurrence of facet joint OA was there after compared between the two groups.

Since there are only few publications on facet joint OA in dogs, no definition has previously been proposed for when a dog positively has facet joint OA. Hence we have proposed this definition: at least one facet joint graded as at least Grade 2. Grade 2 means presence of at least one osteophyte, regardless of size and other osteoarthritis related changes. This definition was used in this study when incidence of facet joint OA was determined.

Animals

Dogs of all breeds, over the age of one year, subjected to radiological examination at Utrecht University Clinic for Companion Animals (Netherlands) between September 2007 and October 2013 where the cervical or lumbosacral part of the vertebral column was clearly visible were included. The radiographs were chosen in chronological order based on date of the examination independently of breed and gender. The criteria of minimum one year of age was set to exclude still growing dogs as ongoing vertebral growth may be mistaken for beginning OA.

Young dogs with fever in addition to the neck/back pain were excluded, as these patients were suspected to have spinal pain due to infection or inflammatory disease rather than primary spinal disorders. Dogs with spinal pain due to acute trauma (fractures and luxations) were excluded from the case group and instead included in the control group. Radiographs with poor image quality of the vertebral column were also excluded.

The control group consisted of dogs subjected to radiological examination for reasons other than neck/back pain but where the cervical or lumbosacral part of the spine were still clearly visible, e.g. laryngeal, esophageal and abdominal disorders. However, it was not established that these dogs did not have neck/back pain, only that the reason for radiological examination was not neck/back pain.

Radiographs from a total of 285 dogs, divided over 76 cervical cases, 64 cervical controls, 74 lumbosacral cases and 71 lumbosacral controls, were included in the study.

The breeds in this study were categorized into three size groups based on the breed standard's full weight (note: not the individual weight) according to the Swedish Kennel Club (SKK, 2013). The three size categories were chosen to be <8kg, 8-25kg and >25kg. A few of the breeds did overlap the weight categories. In these cases the breed was categorized to where it fit in the most.

Statistical analysis

The intra- and interobserver agreement on the grading system for facet joint osteoarthritis in dogs used in this study was calculated using weighted Kappa-statistics. The equivalency between agreement and Kappa is presented below (Table 2).

Table 2. Equivalency between agreement and Kappa presented by Landis and Koch (1977)

Kappa	Strength of agreement
<0,00	Poor
0,00-0,20	Slight
0,21-040	Fair
0,41-0,60	Moderate
0,61-0,80	Substantial
0,81-1,00	Almost perfect

Normal distribution of severity (grade) of facet joint OA was verified through Q-Q plot. The grades of osteoarthritis for each facet joint were used to calculate a mean grade for each dog.

An independent sample t-test was used to evaluate if there was a significant difference in mean grade between the case and control groups. The level of significance was set at $p > 0.05$. SPSS 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) was used to conduct the statistical tests.

Correlation between age and facet joint OA, respectively breed size and facet joint OA, was evaluated using Pearson product-moment correlation coefficient (Pearson's rho) for age correlation and Spearman's rank correlation coefficient (Spearman's rho) for breed size correlation. According to Taylor (1990) a rho ≤35 is considered to represent low correlation, 0,36-0,67 moderate and 0,68-1,0 high strength of correlation.

RESULTS

Animals

The mean age of all the dogs in the study was 6,7 years (SE ±3,6 years). The youngest dog was one year old, and the oldest was 16 years old. Sixty-three different breeds were represented in the study, and they were as earlier mentioned divided into three weight categories (Table 3).

Table 3. Distribution of breeds represented in the study, and the breeds' respective weight category.

Breed	Number of dogs
Mixed breed	28
<8 kg	
Bichon Frisé	1
Border Terrier	2
Cavalier King Charles Spaniel	5
Chihuahua	5
Jack Russell Terrier	11
King Charles Spaniel	1
Maltezer	3
Pinscher, miniature	1
Poodle, toy	1
Shih Tzu	1
Tibetanian Spaniel	1
West Highland White Terrier	1
Yorkshire Terrier	2
8- 25 kg	
Airedale Terrier	2
Australian Kelpie	1
Basset Fauve de Bretagne	1
Beagle	6
Belgian Shepherd Dog	1
Border Collie	7
Bull Terrier	1
Dachshund	5
Dutch Sheepdog	1
English Bulldog	1
English Cocker Spaniel	1
French Bulldog	7
German Shorthaired Pointer	1
Kooiker	5
Poodle, miniature	1
Schnauzer	1
Scottish Shepherd Dog	1
Shetland Sheepdog	4
Spanish Water Dog	1

Staffordshire Bullterrier	1
Hungarian Viszla	2
>25 kg	
American Bulldog	3
American Staffordshire Terrier	3
Anatolian Shepherd Dog	1
Basset Hound	1
Bernese Mountain Dog	8
Bloodhound	1
Bouvier des Flandres	3
Boxer	8
Bullmastiff	1
Cane Corso	5
Chowchow	2
Dalmatian	4
Dobermann	4
Dogo Argetino	1
Dogue de Bordeaux	2
Drentse Patrijshond	2
Flatcoated Retiever	6
German Shepherd Dog	22
Golden Retriever	7
Great Dane	6
Labrador Retriever	46
Leonberger	1
Newfoundland	4
Rhodesian Ridgeback	5
Riesenschnauzer	1
Rottweiler	9
Weimaraner	7
White Shepherd Dog	2

Inter- and intraobserver agreement

The intraobserver weighted Kappa (κ_w) for the three observers were 0,92 (JL); 0,84 (SV) and 0,83 (NB) (mean $\kappa_w \approx 0,86$) (see reference in *Table 2)*.

The interobserver κ_w between the three observers were found to be 0,65 (JL-SV); 0,58(JL-NB) and 0,64 (SV-NB) (mean $\kappa_w \approx 0,62$).

Incidence of facet joint osteoarthritis

Among the 285 dogs, a total of 1453 pairs of facet joints were evaluated. There was a clear and significant difference (p=0,0001) in mean grade of facet joint OA between the case groups and control groups (Figure 3).

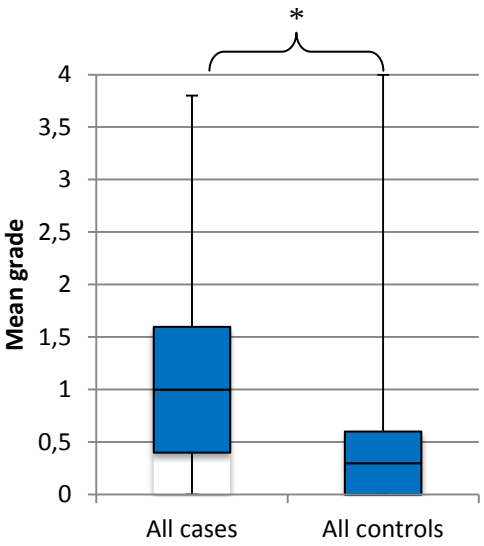


*Figure 3. Mean grade of facet joint osteoarthritis in case respectively control groups. *p=0,0001.*

In addition to a higher mean grade of facet joint in the case group compared to the control group (Figure 3), the facet joints in the case group had higher incidences of Grade 1-4 and lower incidence of Grade 0 compared to the control group (Table 4)

Table 4. Distribution of incidence of facet joint osteoarthritis by grade, case group compared to control group

	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4
All cases	33 %	32 %	22 %	7 %	6 %
All controls	65 %	25 %	7 %	2 %	1 %

There was also significant difference in mean grade of facet joint OA between the cervical case group and the cervical control group (p=0,0001), and between the lumbosacral case group and the lumbosacral control group (p=0.001) (Figure 4).

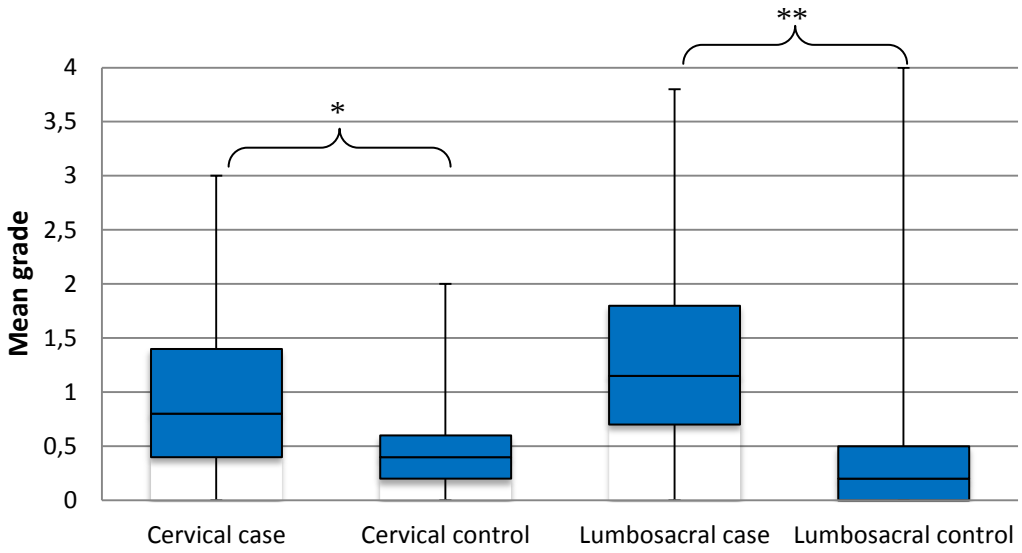


*Figure 4. Difference in mean grade of facet joint osteoarthritis between case and control groups.*p=0,0001 **p=0,001 (independent sample t-test)*

Incidence

The incidence of facet joint OA found was 64 % in the case group and 24 % in the control group (Figure 5).

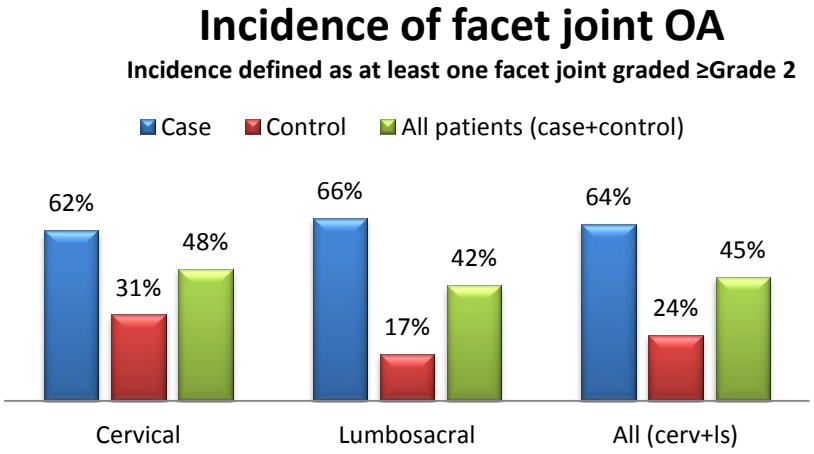


Figure 5. Incidence of facet joint osteoarthritis (percentage of dogs with at least one facet joint graded ≥Grade 2.)

Age correlation

Pearson's rho was 0,38 at a significance level of p=0,01, which is considered a moderate correlation between age and mean grade of facet joint OA (Figure 6).

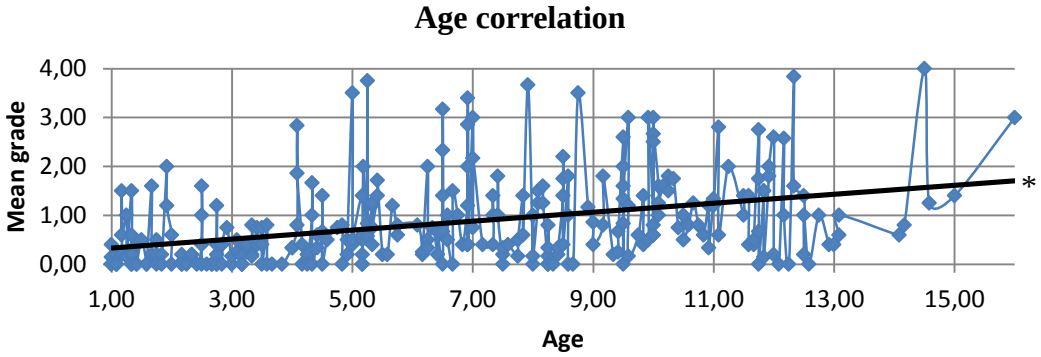


*Figure 6. Correlation between age and grade of facet joint OA. *Pearson's rho=0,38.*

Breed predisposition

Breed size predisposition

The highest mean grade was recorded in the large breed category (>25kg) with a mean grade of 1,03 (±0,97). The lowest mean grade was recorded in the small breed category (<8kg) with a mean grade of 0,41 (±0,53). The mid size breed category had a mean grade of 0,69 (±0,71) and the mixed breed category (of which weight was unknown) had a mean grade of 0,79 (±0,67) (Figure 7). The correlation between breed size and mean grade of facet joint OA was of moderate strength (Spearman's rho=0,51) with p=0,01.

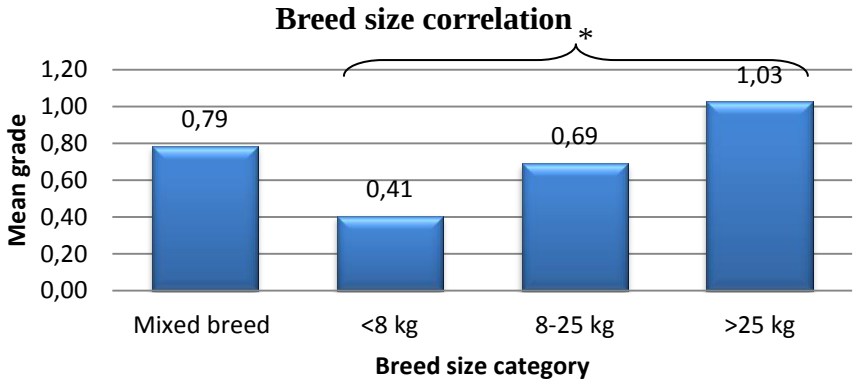


*Figure 7. Mean grade of facet joint osteoarthritis within breed size categories.*Spearman's rho=0,51.*

Breed predisposition

Table 5. The mean grade of facet joint osteoarthritis within breeds is presented in decreasing order. Only breeds represented by at least four dogs were included for this comparison.

Breed	N.o. dogs	Mean grade	Std. error	Mean age
Cane Corso	5	2,25	1,36	5,3
Boxer	8	2,01	1,39	6,4
Great Dane	6	1,36	0,94	4,9
Rhodesian Ridgeback	5	1,28	1,31	4,7

Border Collie	7	1,15	1,03	7,0
German Shepherd Dog	22	1,12	1,14	5,6
Shetland Sheepdog	4	1,04	0,57	6,7
Newfoundland	4	1,01	0,44	5,3
Dalmatian	4	0,99	1,28	3,5
Bernese Montain Dog	8	0,93	0,72	5,4
Rottweiler	9	0,88	0,37	9,5
Labrador Retriever	46	0,82	0,73	5,9
Mixed Breed	28	0,79	0,68	6,6
Flatcoated Retiever	6	0,77	0,64	8,6
Golden Retriever	7	0,77	0,79	7,15
Jack Russell Terrier	11	0,73	0,80	7,7
Weimaraner	7	0,70	1,29	8,3
Dobermann	4	0,70	0,77	7,8
Kooiker	5	0,65	0,62	5,7
French Bulldog	7	0,46	0,55	13,4
Beagle	6	0,45	0,56	9,6
Dachshund	5	0,44	0,55	6,3
Cavalier King Charles Spaniel	5	0,28	0,28	5,2
Chihuahua	5	0,08	0,18	2,9

Spinal level predisposition

No difference in mean grade of facet joint OA between all cervical and all lumbosacral facet joints was found (Figure 8).

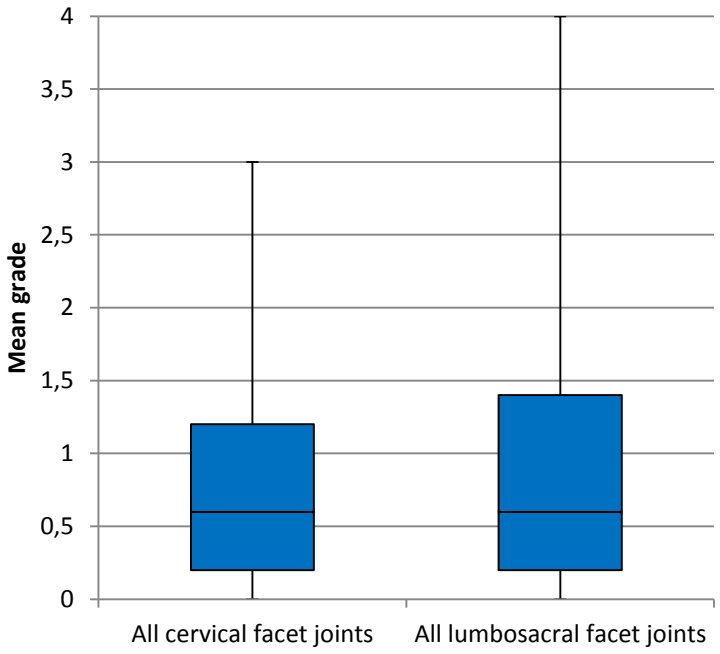


Figure 8. Comparison of mean grade of facet joint osteoarthritis between all cervical and all lumbosacral facet joints.

Mean grade of facet joint OA at each specific facet joint was compared between case and control groups. In the cervical spine case group the highest and lowest mean grades were recorded at C3-C4 and C6-C7, respectively (Figure 9). In the lumbosacral spine case group the highest and lowest mean grades were recorded at L1-L2 and L6-L7, respectively (Figure 10). However, the values of L1-L2 and L7-S1 were based on less than 20 dogs (7-19), whereas the values of all other facet joints presented were based on ≥46 dogs.

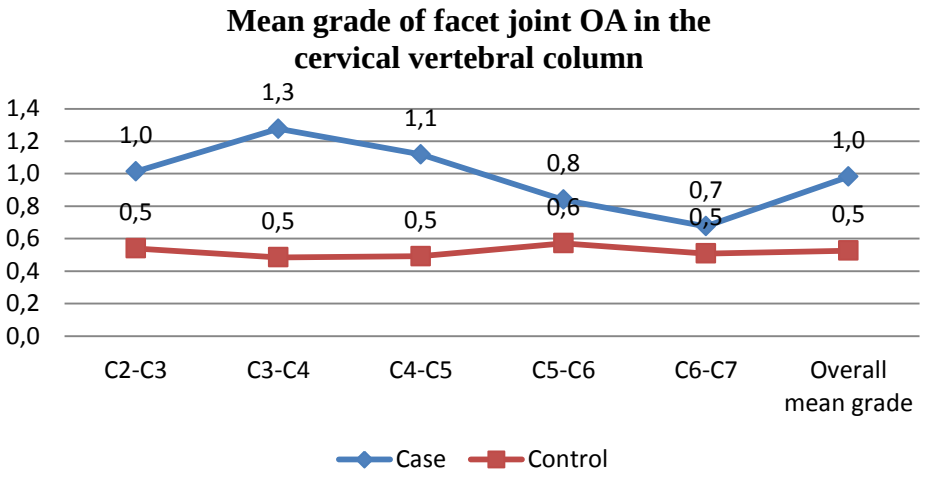


Figure 9. Mean grade of facet joint osteoarthritis at different levels of the cervical vertebral column.

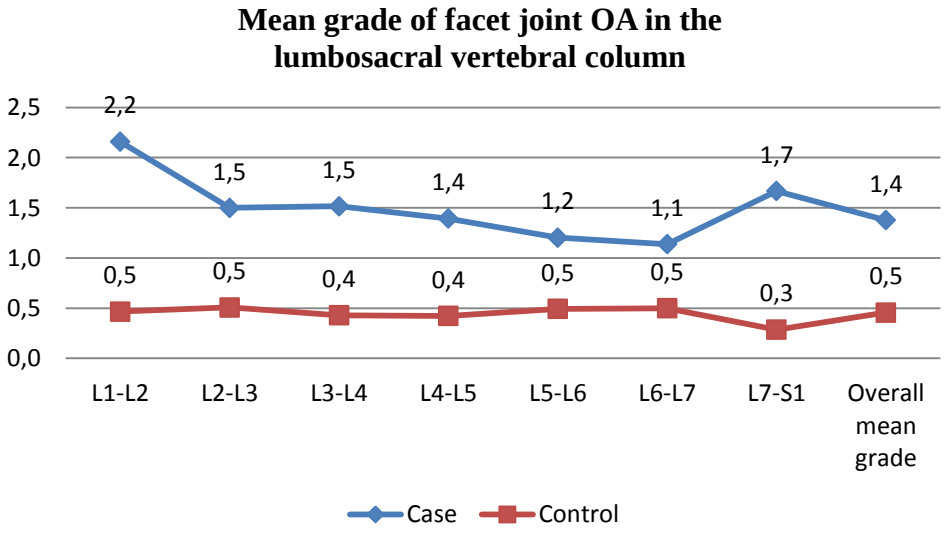


Figure 10. Mean grade of facet joint osteoarthritis at different levels of the lumbosacral vertebral column.

The highest incidence of facet joint OA, defined as at least one facet joint graded as at least Grade 2, at each specific joint in the cervical respectively lumbosacral spine was found at C3-C4 respectively L7-S1 (Figure 11 and 12).

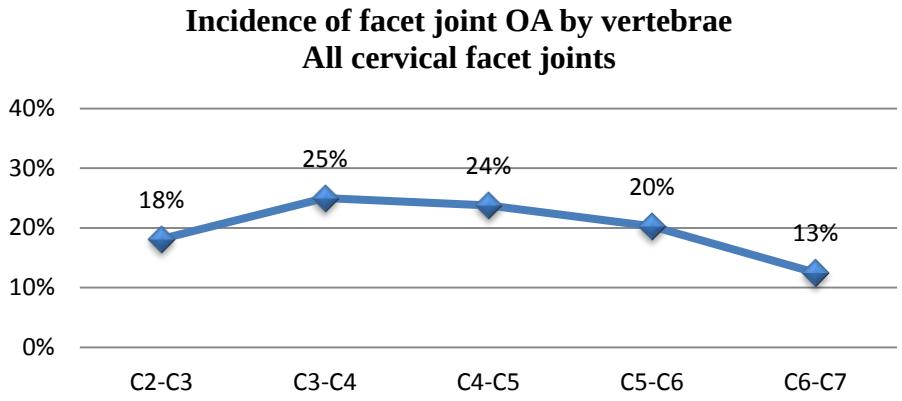


Figure 11. Incidence of facet joint osteoarthritis (n.o. of dogs with ≥Grade 2 at each facet joint) in the cervical spine.

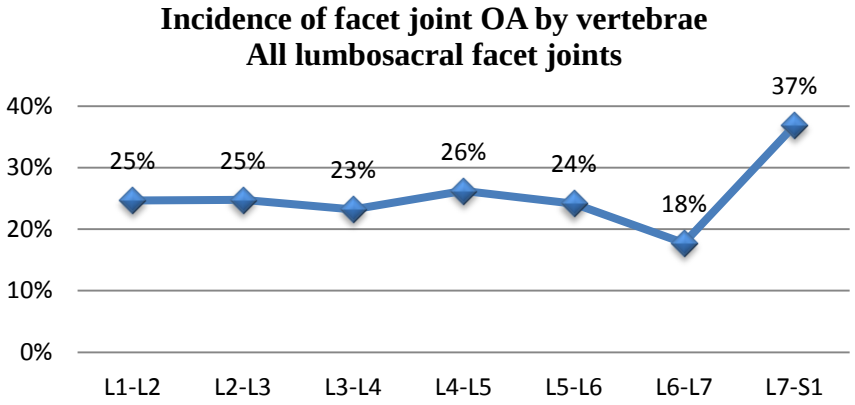


Figure 12. Incidence of facet joint osteoarthrits (n.o. of dogs with ≥Grade 2 at each facet joint) in the lumbosacral spine.

DISCUSSION

Observer agreement for a new grading system of facet joint osteoarthritis in dogs

The grading system for facet joint OA in dogs that was evaluated for inter- and intra observer agreement and in this study had an interobserver κ_w 0,65; 0,58 and 0,64. A κ_w of 0,41-0,60 represents moderate agreement and κ_w of 0,61-0,80 represents substantial agreement. The intraobserver κ_w was 0,92; 0,84 and 0,83, which represents almost perfect agreement. The reliability of the grading system did thereby meet up to the criteria to be classified as a recommended grading system. In the original study where this grading system first was tested (on human facet joints), the interobserver was κ_w 0,52; 0,54 and 0,81. In comparison, this study with its interobserver κ_w of 0,65; 0,58 and 0,64, had a higher interobserver agreement.

To the author's knowledge, this study is the first to test the reliability of a grading system for facet joint OA in dogs. It has been pointed out by Kettler and Wilke (2006) that degeneration of facet joints (in humans) is difficult to assess, and this affects the reliability of any grading system. The interobserver reliability should therefore not be expected to exceed a κ_w of 0,60, which represents substantial agreement. Instead, a grading system with moderate agreement ($0,41 \leq \kappa_w \leq 0,60$) should be considered as a recommended grading system.

The high intraobserver agreement validates that this grading system has a high objectivity and could therefore reliably be used by a single observer in the latter part of the study. The example images (Figure 1 and 2) were used as a reference throughout the whole study to add additional validity.

Incidence of facet joint osteoarthritis

Prior to this study it was hypothesized that facet joint OA is common in dogs with neck/back pain, but occurs in dogs without neck/back pain as well. This study proved that facet joint OA can be found in 64 % of dogs with cervical or lumbosacral pain. Since this study was retrospective and the control group was not with certainty free from neck/back pain, the study could not prove that facet joint OA occurs in dogs without neck/back pain as well. However, a significant difference in incidence of facet joint OA was found between case and control groups, suggesting that facet joint OA is related to neck/back pain.

The following definition of incidence of facet joint OA was proposed and used in this study: at least one facet joint graded as at least Grade 2. This definition ensures that all dogs with facet joint osteophytes, regardless of size, are categorized as dogs with facet joint OA, without specifying severity.

The case group included dogs with neck/back pain for any reason except for infection (i.e. discospondylitis). The reasons for neck/back pain included for instance intervertebral disc disease, degenerative lumbosacral stenosis (including cauda equina syndrome) and cervical spondylomyelopathy (wobbler). Many of these disorders may be related to spinal instability. Cervical spondylomyelopathy is for instance known to be associated with spinal instability (da Costa, 2010), and intervertebral disc degeneration can lead to both intervertebral disc

herniation and spinal instability (Bergknut, 2011). Likewise has joint instability, joint malalignment and anatomical abnormalities been presented as etiologies for OA (Guilak, 2011). It is therefore likely that spinal instability can influence the development of facet joint OA. If so, facet joint OA may well occur concurrently with other disorders related to spinal instability (e.g. cervical spondylomyelopathy and intervertebral disc degeneration). Although the facet joints are important components in stabilization of the vertebral column, all cases of facet joint OA are probably not related to spinal instability, since OA can be caused by abnormal joint stress, for instance obesity, trauma, malalignment and abnormal anatomy, as well (Guilak, 2011).

The role of the facet joints in pain has been discussed greatly in human medicine. Using local analgesia, Manchikanti (1999) and Schwarzer (1994) found that in 15-45 % of humans with neck or back pain, the facet joints are the source of pain. This study did no attempts to prove that facet joints can be a source of pain, but it is likely safe to say that facet joint OA does generate pain in dogs. How severe pain facet joint OA can cause, and at what grade of facet joint OA clinical signs of pain first can be seen, is however unclear. A study that combines radiology and local analgesia to try to correlate clinical signs with radiological findings would therefore be interesting to conduct.

Age correlation

Differing to what was hypothesized, that facet joint OA would be found primary in old dogs, the correlation between age and grade of facet joint OA was only moderate. Even though this shows that older dogs have more severe facet joint OA than young dogs, it was surprising that quite severe facet joint OA occurs in young dogs as well. One explanation for this could be anatomical abnormalities and joint malformation as etiologies for OA. These etiologies are obviously present at birth, opposed to for instance ageing and trauma, and thus have the potential to cause facet joint OA also in young dogs.

Breed predisposition

A moderate correlation between breed size and mean grade of facet joint OA was found (Figure 7), more specifically a higher mean grade was found in large breed dogs as compared to small breed dogs. This was consistent to our original hypothesis that a higher body weight will increase the rate of degeneration disregarding the etiology.

Eight of the ten breeds with the highest mean grade of facet joint OA were large breed dogs (Table 5). These conclusions were not statistically verified, but they are in line with the conclusion that large breed dogs tend to be more affected by facet joint OA than small breed dogs (Figure 7).

When it comes to specific breeds, it was hypothesized that facet joint OA would be especially common in German Shepherd Dogs, Great Danes, Scottish Deerhounds and Dobermanns. This hypothesis was true for German Shepherd Dogs and Great Danes. There were unintentionally no Scottish Deerhounds included in this study, which is likely due to it being a reasonably uncommon breed in the Netherlands. Dobermann has a mean grade of facet joint OA of 0,70, which can be compared to the mixed breed group's mean grade of 0,79 and the

top notation of 2,25 that was found in Cane Corso. The mean grade in Dobermanns is then rather low in comparison, but only four Dobermanns were included in the study making it a quite low number to draw substantial conclusions from. The result was nevertheless surprising, since Dobermann is both a large breed and has a high prevalence of cervical spondylomyelopathy (wobbler) (Lewis, 1992). The reason for this is likely that cervical spondylomyelopathy in Dobermanns is more often associated with intervertebral disc degeneration and less related to facet joint OA than osseous cervical spondylomyelopathy. Another breed that had surprisingly low mean grade of facet joint OA was Dachshund with 0,44. This was surprising since Dachshund has a high prevalence of intervertebral disc disease (Bergknut et al., 2012). However, intervertebral disc disease occurs most often in the thoracal spine in Dachshunds (Rohdin et al., 2010) and facet joint OA was only recorded in the cervical and lumbosacral spine in this study. If the thoracic spine had been included as well, it is likely that a higher mean grade of facet joint OA would have been recorded among Dachshunds.

Spinal level predisposition

No significant difference in mean grade of facet joint OA was found between the cervical and the lumbosacral spine (Figure 8). When mean grade and incidence of facet joint OA is presented for each specific joint (Figure 9-12) a peak can be seen in the mid cervical spine and in the most cranial and caudal lumbosacral spine. As mentioned previously the values for L1-L2 and L7-S1 were based on less than 20 dogs (7-19), whereas the values of all other facet joints presented were based on ≥46 dogs. With this in mind, any conclusions of the peaks in mean grade and incidence at L1-L2 and L7-S1 should be drawn with caution. A peak at L7-S1 is however interesting (and expected) as spinal instability is one possible etiology to degenerative lumbosacral stenosis and the fact that the L7-S1 junction carries the highest load of all canine intervertebral discs (Suwankong et al., 2008), both factors that can contribute to facet joint OA.

Potential biases

A number of biases must be taken into consideration when interpreting the results. First and foremost this study was retrospective, which as discussed earlier causes the problem with not knowing if the dogs in the control group were actually pain free. An effort was made to exclude radiographs of poor quality (e.g. too oblique or poor radiographic exposure), but radiographs with some level of obliqueness and poor exposure were inevitably included in the study. Poor radiographic quality could possibly have disguised a few cases of facet joint OA and in addition the degree of OA needs to be significant before it is even visible on radiographs indicating that the numbers reflected. As this bias was present in both the case and control groups it most likely did not have any other effect on the results than a slight underestimation of the actual numbers.

Furthermore, the grading system was proven to be reliable for use in dogs. However, only non-chondrodystrophic dogs were included in the reliability study, whereas both non-chondrodystrophic and chondrodystrophic dogs were included in the following incidence study. The differing conformation of the vertebrae between chondrodystrophic dogs and non-

chondrodystrophic dogs may interfere with the evaluation of the facet joint. The grading system not being proven reliable in chondrodystrophic dogs, but still used when determining the incidence of facet joint OA in these breeds is a bias, but it is unclear how this bias, if at all, affected the incidence of facet joint OA found in the different breed types.

If a follow up study would be conducted, it is recommended to use CT in addition to radiographs as a more accurate evaluation of the facet joints can be made using CT. Also, injections of local anesthetics into severely affected facet joints may make it possible to prove the clinical importance of facet joint OA, and to see in how large proportion of dogs with neck/back pain that facet joints OA is the source of pain.

Conclusions

A grading system for facet joint OA earlier used in human medicine was in this study proven to be reliable also for use in non-chondrodystrophic dogs. The incidence of facet joint OA in dogs, defined as at least one facet joint with at least Grade 2 (definite osteophytes and subchondral sclerosis in facet joints), was found to be 64 % in dogs with neck or low back pain. Facet joint OA was detected more often in dogs that underwent radiographic examination due to neck/back pain compared to dogs that underwent radiographic examination of the same spinal segments due to reasons other than neck/back pain. Facet joint OA is more severe (i.e. higher mean grade of facet joint OA) in large breed dogs than small breed dogs. There is also a moderate correlation between increasing age and increasing mean grade of facet joint OA, although facet joint OA is found in young dogs as well.

The clinical importance of facet joint OA in dogs remains unknown. The facet joints are a potential source of spinal pain in human, but the same has not been proven for dogs. The aim of this study was not to prove that the facet joints are a potential source of pain in dogs, but simply to determine the incidence of facet joint OA in dogs with and without clinical signs of neck/back pain.

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