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Recognition and Breed Specificity of Canine Spondyloarthropathy

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Abstract

Human diseases sometimes represented across phylogenetic lines. Their recognition is at times compromised by differential (between human and veterinary medicine) use of diagnostic terms. A major impetus to such change is recognition of additional treatment options that would not be considered for the replaced diagnosis/category. Canine syndesmophytes are recognized as identifier for spondyloarthropathy. This study examines the breed-specificity of those changes.

The axial skeletons and peripheral joints (when available) of 1323 dogs, identified to breed, were examined for evidence of syndesmophytes and sacroiliac joint disease.

Syndesmophytes were found in 315 of 1323 axial skeletons examined, extremely common in Boxer and German Shephard; rare, in Beagle, Chihauahua, Dachshund, Maltese and Pug. First noted at 2 years of age, its prevalence increased geometrically over the next 13 years. All affected individuals weighed more than 2 kilograms and prevalence increased geometrically through 39.9 kilograms. Spondyloarthropathy was present in 17.3% of brachycephalic, contrasted with 35.0% of mesticephalic dogs [Chi square = 16.972, $p < 0.0001$].

Presence of syndesmophytes identified the underlying arthritis as spondyloarthropathy, not osteoarthritis. Recognition of the vertebral findings as characteristic of this inflammatory arthritis affords an opportunity for controlling the disease process and improving quality of life of the afflicted dog.

Keywords: Spondyloarthropathy; Arthritis; Dog; Breed

Introduction

Describing, diagnosing and categorizing vertebral pathology has long been a source of confusion for all health care providers, whether for humans or other animals [1-8]. Spur-like overgrowth of vertebral margins [parallel to vertebral endplates] had been considered a disease process in humans [6,7], until it was recognized that such spurs are as common in asymptomatic individuals and seem to represent simply a manifestation of the aging process [6,9]. Thus, they are now referred to as spondylosis deformans, rather than as osteoarthritis [9,10].

There is another bone proliferation that forms at vertebral margins. Rather than projecting perpendicular to the vertebral centra [parallel to the vertebral endplate], they occur as ossification in the outer layers of the intervertebral disk [1,10-12]. This occurs in the anulus fibrosus [the correct spelling of that often misspelled structure]. The term syndesmophyte has been applied to such structures. When syndesmophytes originate at the vertebral endplate margin, they are termed marginal syndesmophytes. When they originate on the vertebral body but are not contiguous with the endplate margin, they are referred to as non-marginal syndesmophytes [10]. The latter must be distinguished from ossification of the anterior longitudinal ligament, which is separate from the vertebral body. That ligamentous calcification appears as if wax had dripped along the longitudinal aspect of the vertebral column [9,10]. The key to distinguishing syndesmophytes from ligamentous ossification is the observable space between the ossification and the vertebral body in the latter [referred to as diffuse idiopathic skeletal hyperostosis].

Part of the confusion related to recognition of syndesmophytes, and the significance of vertebral alterations, derives from a misunderstanding of the pathophysiology and natural history of vertebral osteophytes [4,6]. Osteophytes on adjacent vertebral endplates are sometimes referred to as kissing osteophytes [10,13]. At one time, it was mistakenly thought that these would eventually meet in the middle and fuse [4,5]. Thus, such vertebral bridging was erroneously labeled as stage 4 or as stage 5 osteoarthritis [4,5]. We know now that vertebral centra spurs should not be classified as osteoarthritis, but rather as spondylosis deformans and that the natural history of such spurs does not include fusion [9,10].

New bone formation perpendicular to vertebral endplate margins is a different process, one that is now categorized as spondyloarthropathy [1,3,10,14]. The difference is critical to recognize as it affords a therapeutic approach which is effective in controlling the disease, something which is neither possible nor appropriate for spondylosis deformans [9]. Thus, recognition of spondyloarthropathy affords an opportunity for control of disease and improvement of quality of life – as has been documented in gorillas [14], as well as in humans [15,16].

Spondyloarthropathy has been recognized in most mammalian families [11,17-30]. It is clearly documented in non-domestic canids [31] and felids [31] and present in their domestic relations [personal observation]. The prevalence in wild-caught mammals varies between 1% and 35% [1,20]. Specifically in non-domestic canids, it ranges between 1 and 10%, except for outliers: The maned wolf *Chrysocyon*, 40%, the fennec fox *Fennecus*, 18%; and the raccoon dog *Nyctereutes*, 13%. Given the importance of domestic canids to our lives, it seems appropriate to determine the frequency of their affliction by this treatable disease [15,32,33].

As hip disease and what has been called "spondylosis deformans" seem to be somewhat breed selective and given the chondrodysplastic nature of some dog breeds [4,7,34-47], it was desired to also assess breed specificity of this spondyloarthropathy and examine relationship to other breed categories.

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Materials and Methods

The skeletonized dog collection of the Veterinary Medical University of Vienna, Austria consists of 1323 dogs identified in life as to breed, with age and weight recorded at the time of death. The vertebral columns of 1323 dogs were examined for presence of syndesmophytes and sacroiliac joints were assessed for erosions or fusion [48]. The collection also included the long bones. Five breeds that were sufficiently represented in the collection were selected for prevalence assessment.

Diagnosis of spondyloarthropathy was based on evidence of vertebral centra overgrowh that were perpendicular to the vertebral endplates (ossification within the anulus fibosus) [1,10,12,31,49]. Osteoarthritis was identified on the basis of remodeling of a synovial-lined joint with osteophyte formation, sclerosis of the subchondral plate or formation of small intraosseous distal metaphyseal (subchondral) cysts [1,50]. Spondylosis deformans was recognized by bony vertebral centra overgrowths that derived from and were parallel with the vertebral endplates [9]. Prevalence of syndesmophytes diagnostic of spondyloarthropathy was assessed as a function of age and weight in the overall group and by breed using t-test, Chi square and regression analysis statistical tests. As breed preference appears to be somewhat nationality dependent [51], only 8 breeds were sufficiently represented for comparative analysis between the urban Vienna, Austria anatomical study and the rural Kansas, USA radiologic study.

The breed-specific results of a pilot study of the thoracic and lumbar vertebral column of 300 dogs, performed at the Veterinary College of Kansas State University to determine feasibility of lateral x-rays for recognition of syndesmophytes, were compared to those found in this anatomical study by Chi square statistical tests.

This study was carried out in strict accordance with the recommendations in the Guide for the Care and Use of Laboratory Animals of the National Institutes of Health. All animals examined in this study were previously donated for scientific research to the University of Veterinary Medicine, Vienna.

Results

Syndesmophytes (Figure 1) characteristic of spondyloarthropathy were found in 315 of 1323 axial skeletons examined (Table 1). They were predominantly (80%) of the non-marginal variety, independent of breed. There was no significant difference in the prevalence of syndesmophytes, as detected anatomically or radiologically (Table 2).

Variation of the prevalence of spondyloarthropathy by breed is presented in Table 1.

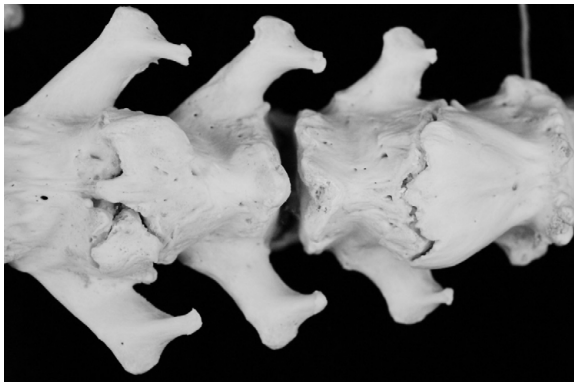

Figure 1: Ventral view of lumbar spine. Bridging syndesmophytes.

Breed	Syndmophytes identified	Vertebral columns examined	Sacroiliac erosion/ fusion	Sacroiliac joints examined
Airdale Terrier	2	5		2
Bassett	2	3		
Beagle	1	17		10
St. Bernard	9	43	3	13
Bernese Mountain Dog	9	42	4	23
Mastiff, bobtail	5	7		
Bordeau	1	3		13
Boxer	20	28	1	21
Bracken	1	6		4
Bulldog, English	1	1		1
Pit Bull Terrier	0	1		1
Chihuahua	1	10		6
Chow chow	2	5		
Collie	6	26	4	19
Mastiff, Argentine	2	4		3
Dachshund, Wire Hair	2	34		23
Dachshund, Long Hair	0	14		13
Dachshund, Short Hair	0	26	1	17
Bulldog	3	7		4
Dalmation	2	6		5
Great dane	13	34	5	27
German Shepherd	81	164	17	109
Doberman Pinscher	9	25	5	18
Golden Retriever	3	32		8
Hovawart	3	7	2	5
Husky	5	15	1	15
Kuvasz	4	8		6
Irish Wolfhound	3	3		2
Labrador Retriever	4	11		8
Leonberger	4	11		5
Vizsla	4	8	1	5
Malamut	2	5		2
Maltese	1	16		8
Mastiff	1	4		3
Mastiff, Neopolitan	1	1		
Munsterlander	9	16	1	7
Pug	0	5		
Newfoundland	2	9		5

Table 1: Prevalence of syndesmophytes and erosion or fusion through articular portion of sacroiliac joints as a function of breed.

The prevalence of sacroiliac joint erosion or fusion was statistically indistinguishable from that of syndesmophytes in 8 of 77 breeds examined (Table 1). The exceptions were reduced prevalence of sacroiliac erosions or fusion in boxers (Chi square = 21.777, $p < 0.00001$), German Shepherds (Chi square = 32.497, $p < 0.00001$), Poodles (Fisher exact test, $p = 0.031$), Rottweilers (Chi square = 14.24, $p < 0.0001$), Cocker Spaniels ($p = 0.002$, Fisher exact test), King Charles Spaniels ($p = 0.001$, Fisher exact test), Staffordshire Terriers ($p = 0.015$, Fisher exact test) and Yorkshire Terriers ($p < 0.0001$, Fisher exact test). However, the ilia and sacra were not separable and the sacroiliac joints could not be visualized in 25% of Boxers, 35% of German Shepherds, 35% of Poodles, 32% of Rottweilers, 28% of Cocker Spaniels, 33% of King Charles Spaniels, 48% of Staffordshire Terriers and 35% of Yorkshire Terriers. Noted prevalence variation in those breeds may be related to inability to determine whether their sacroiliac joints were

actually fused or simply insufficiently prepared to allow separation of normal joint surfaces.

Utilizing Schmidt et al.'s [52] and Bannasch et al.'s [53] classification of dogs, spondyloarthropathy was present in 17.3% of brachycephalic (Table 2), contrasted with 35.0% of mesticephalic dogs (Chi square = 16.972, $p < 0.0001$). Evans [54] and Hussein et al. [55] classified dogs slightly differently, dividing dogs into brachycephalic, mesaticephalic and dolichocephalic, reclassifying German shepherds and dalmations (Table 3). That division and reclassification revealed syndesmophytes in 62/259 (23.9%) of brachycephalic, 105/382 (27.5%) of mesticephalic and 126/364 (34.6%) of dolichocephalic dogs. The latter prevalence was significantly greater (Chi square = 8.188, $p < 0.005$).

Spondyloarthropathy was first noted at 100 weeks (~2 years) and its prevalence increased geometrically though week 800 (~15 years), although it plateaued after 500 weeks (~10 years) (Table 4). Analysis by weight revealed no cases weighing less than 2 kilograms and geometrically increased through 39.9 kilograms, when its prevalence leveled off (Table 5).

Breed	Anatomical		Radiologic		Statistical analysis
	Total #	# afflicted	Total #	# afflicted	
Boxer	28	20	3	1	ns, Chi square = 1.7995
King Charles Spaniel	29	8	4	1	Fisher exact test = 39.8%
Dachshund	74	2	9	1	Fisher exact test = 27.2%
Golden Retriever	32	3	7	1	Fisher exact test = 42.2%
Great Dane	34	13	3	1	ns, Chi square = 0.0282
German Shepherd	164	81	5	3	ns, Chi square = 0.5560
Labrador Retriever	11	4	16	1	ns, Chi square = 0.0036
Maltese	16	1	5	1	p = 0.38, Fisher exact test
ns: non-significant					

Table 2: Comparison of prevalence of syndesmophytes recognized anatomically and radiologically.

Mesaticephailc	Prevalence	Brachycephalic	Prevalence
Golden Retriever	3/22	Chihuahua	1/10
Hovawart	3/7	Pekinese	4/30
Bernese Mountain Dog	9/42	English and French Bulldogs	3/7
Irish Wolfhound	3/3	Lhasa	1/2
Doberman Pinscher	9/25	Shitzu	0/12
Rottweiler	24/50	Yorkshire terrier	17/84
Spitz	3/13	Pug	0/5
Dalmation	2/6		
Jack Russell Terrier	1/6	**Total**	8/21
German Shepherd	81/164		
Dachshund	2/74		
Husky	5/16		
Collie	6/26		
Staffordshire Terrier	9/21		
Vizsla	4/8		
Weimaraner	2/2		
Munsterlander	9/16		
Rhodesian Ridgeback	2/4		
Total	177/505		

Table 3: Delineation of mesaticephalic and brachycephalic breeds [53], with syndesmophyte prevalence.

Age in weeks	Number affected	Number examined	Percent affected
< 100	0	152	0
100-199	3	35	9
200-299	6	38	16
300-399	9	36	25
400-499	15	41	37
500-599	27	58	47
600-699	12	26	46
700-799	15	30	50
> 800	4	7	57

Table 4: Variation in prevalence of spondyloarthropathy as a function of age.

Weight in kilograms	Number affected	Number examined	Percent affected
< 2	0	30	0
2-4.9	11	90	12
5-9.9	14	106	13
10-14.9	12	72	17
15-19.9	8	42	19
20-24.9	20	60	30
25-29.9	28	85	33
30-39.9	71	186	38
40-49.9	41	95	43
50-59.9	7	24	30
60-69.9	6	17	35
70-90	6	16	38

Table 5: Variation in prevalence of spondyloarthropathy as a function of weight.

Peripheral joint erosions (predominantly subchondral in distribution) were present in 12 of 23 Boxer long bones (12 erosions localized to stifles (knees), 1 to hip and 1 to shoulder) available for examination, 10 of 65 Dachshund long bones (8 stifles, 3 shoulders, 1 elbow), one of 12 Golden Retriever long bones (hip), one of five Staffordshire Terriers (stifle) and 10 of 155 German Shepherds (5 stifles, one shoulder, 1 ankle and 3 hips). The prevalence of peripheral joint involvement was indistinguishable from that of axial involvement (syndesmophytes), with the exception of the dachshund's more prevalent peripheral joint affliction (Chi square = 7.056, $p < 004$).

Discussion

Syndesmophytes were found in 23.8% of axial skeletons examined. The prevalence of this marker of spondyloarthropathy was indistinguishable from that of sacroiliac joint erosion or fusion in 69 of the breeds examined. The perception of reduced prevalence of sacroiliac joint disease in 8 additional breeds [Boxers, German Shepherds, Poodles, Rottweilers, Cocker Spaniels, King Charles Spaniels, Staffordshire Terriers and Yorkshire Terriers] may be an artifact, as the ilia and sacra were not separable [precluding assessment of sacroiliac joint erosions or articular surface bridging] in one quarter to one half of the available skeletons representing those breeds. The prevalence of peripheral joint involvement [stifle, shoulder, hip, ankle and/or elbow] was indistinguishable from that of axial involvement [syndesmophytes], in all assessed breeds, with the exception of dachshunds in which peripheral joint erosions were more prevalent.

Examination of the prevalence of spondyloarthropathy by breed revealed significant differences (Table 1). Testing the comparability of anatomical and radiologic studies (Table 4) revealed no significant difference in the prevalence of syndesmophytes, suggesting that data acquired from either approach can be utilized interchangeably in future studies.

Geometric increase in prevalence was noted from two to 15 years

of age, with no younger animals affected (Table 4). Weight-related prevalence similarly increased from 2 kilogram to 39.9 kilograms, when, contrary to age-relationships, it leveled off. Clearly, susceptibility increases over the life of dogs, with weight being a major factor, until 40 kilogram mass was achieved.

In an attempt to unravel the relationship of spondyloarthropathy susceptibility, it seemed appropriate to assess the potential contribution of the various dog breed classification systems, independent of the controversy each might engender. Prevalence as a function of breed type classification is significantly affected by the system utilized. According to the classification of Schmidt et al. [52] and Bannasch et al. [53], mesticephalic dogs were afflicted twice as frequently as brachycephalic dogs (Table 3).

Utilizing the categorization and identification by Bannasch et al. [53], the prevalence of spondyloarthropathy in chondrodysplastic dogs [Basset Hound, Dachshund and Pekingese] was 8 of 107 (7.48%) contrasted with 142 of 291 (48.80%) in non-chondrodysplastic dogs (Boxer, Doberman, Leonberger, Rottweiler, Dalmation, German Shepherd, Mastiff and Saluki), significant at Chi square = 56.879, $p < 0.00001$. Evans and deLahunta [56] categorized breeds as sporting hound, working, terrier, toy, non-sporting and herding. Spondyloarthropathy was present in 24 of 92 (26.0%) of sporting dogs included in this study [i.e., Golden Retriever, Labrador Retriever, English and Irish Setter, Cocker Spaniel, Vizsla and Weimaraner). This compared to 9 of 99 (9.1%) of hounds (i.e., Beagle, Dachshund, Greyhound, Rhodesian Ridgeback, Irish Wolfhound), 108 of 282 (38.3%) of working dogs (i.e., Boxer, Saint Bernard, Doberman, Great Dane, Husky, Kuvasz, Mastiff, Newfoundland, Rottweiler, Schnauzer), 15 of 56 (26.8%) of terriers (i.e., Bull Terrier, Cairn Terrier, Fox Terrier, Scottish Terrier, Staffordshire Bull Terrier, West Highland Terrier), 23 of 56 (26.8%) of toy (i.e., Chihuahua, Maltese, Papillon, Pug, Shih Tzu, King Charles Spaniel, Yorkshire terrier), 22 of 74 (29.7% of non-sporting breeds (i.e., Bulldog, Shar-pei Chow Chow, Dalmation, Poodle, Spitz), and 87 of 191 (45.5%) of herding breeds (i.e., Collie, German Shepherd, Puli). Hounds and toy dogs were afflicted significantly less often than the other categories (Chi square = 53.884, $p < 0.00001$). Herding dogs were especially susceptible (Chi square = 8.598, $p < 0.005$). Reclassifying German shepherds and Dalmations, according to Evans [54] and Hussein et al. [55] resulted in equal prevalence of spondyloarthropathy in brachycephalic and mesticephalic dogs, but their additional category [dolichocephalic dogs] was affected significantly more often. Utilization of Bannasch et al.'s classification [53] revealed disproportion sparing of chondrodysplastic dogs. If their study proves representative of chondrodysplastic and non-dysplastic dogs, it suggests possibility of an inbreeding that protects against development of spondyloarthropathy?

This study has examined only one component of spondyloarthropathy [1,10,57]. It provides a basically unbiased survey of disease epidemiology, because recognized vertebral disease was not the indication for skeletal retention. Delineation of the frequency of peripheral joint disease would require additional x-rays not part of routine clinical evaluation, but would be worthwhile to consider.

Relationship of dog size to frequency of spondyoarthropathy is as noted previously in wild caught animals [58]. There is precedent for correlation with size. The allometry of thermal variables in mammals is a classic example [59]. The prevalence of spondyloarthropathy was detected as effectively by radiologic as by anatomical analysis. Interestingly, the prevalence appears indistinguishable in populations separated by geography [an ocean] and by environment [urban versus rural].

While non-steroidal anti-inflammatory drugs are often used in management of acute symptoms, the issue of controlling the underlying disease requires suppressive [also referred to as disease modifying] medications which require periodic monitoring to assure safety [32,60]. This is exemplified by gold sodium thiomalate, methotrexate and leflunomide, which require monthly review of laboratory white blood count, hemoglobin, platelet count and liver and kidney function [61]. Hydroxychloroquine requires similar testing and a form of periodic eye examination. While peripheral vision may be assessable clinically in a veterinary practice, assessing subtleties of color vision would likely prove elusive. Perhaps the suppressive medication most conducive to veterinary application is sulfasalazine [62,63], as has been documented for gorillas [14]. Monitoring can be extended to quarterly with sulfasalazine, a regimen more amenable to/acceptable in clinical practice.

Treatment efficacy also provides indirect evidence for the appropriateness of the spondyloarthropathy diagnosis, in contrast to that of spondylosis deformans or osteoarthritis. Fish oil supplements have been helpful in management of inflammatory disease in dogs [64] as they have in humans [65], but have no effect on osteoarthritis or spondylosis deformans [9].

Spondyloarthropathy is divisible in humans to five varieties [1,2,66]. One is associated with the skin disease, psoriasis. A second is associated with the inflammatory bowel diseases, ulcerative colitis and regional enteritis, also called Crohn's disease, a recognized disease occurring in dogs [67]. A third variety is ankylosing spondylitis, a term used by some in a semantically confusing manner as an alternative to the term spondyloarthropathy - for describing this category of disease [68,69]. However, the term ankylosing spondylitis, as utilized here identifies a specific variety of spondyloarthropathy in which there is uniform development of syndesmophytes, starting symmetrically at the sacroiliac joints and working cephalad [1,10]. Such uniform involvement is consistently found with ankylosing spondylitis and inflammatory bowel disease-related arthritis, in contrast to the other forms of spondyloarthropathy, in which vertebral involvement is discontinuous and sporadic in distribution.

The fourth variety of spondyloarthropathy is referred to as reactive arthritis. It is characterized by reactive new bone formation and often has associated rash, eye inflammation, genitourinary irritation and diarrhea. Formerly referred to as Reiter's syndrome, that name was deemed inappropriate with recognition that Reiter was a war criminal. The term reactive arthritis relates to the peculiar indirect relationship of this phenomenon to food poisoning – infectious agent diarrhea. It is not a direct infection and may even post-date the infection by months. The fifth variety is one that includes individuals that do not fit into any of the above spondyloarthropathy categories. It is referred to as undifferentiated spondyloarthropathy and appears to represent the preponderance of what has been observed in humans, dogs, and for that matter, in non-domesticated mammals [11,17-31,70]. The clinical overlap between reactive arthritis and undifferentiated spondyloarthropathy precludes clear separation of those disorders. Reactive arthritis is a known complication of infectious agent diarrhea [food poisoning] with *Salmonella, Shigella, Yersinia, Camplyobacter* and enteropathic *Escherichia coli*, although sexual transmission related to *Chlamydia* has been suggested [1,71].

In addition to symptoms such as pain and impaired movement, spondyloarthropathy in humans may be complicated by associated eye [e.g., iritis], epidermal [skin, genital and oral rash], pulmonary [e.g., fibrosis], genitourinary [e.g., pyuria] and cardiac [e.g., a sub-aortic septal bump] manifestations [61,72-74]. It would be worthwhile to

screen affected individuals for evidence of such involvement and for peripheral joint erosions, reactive bone and/or fusion and for facet joint erosion and fusion [1,10,75].

A major challenge to interdisciplinary science is our shared vocabulary, which is often quite disparate in meaning [1,76]. Spondylitis has often been used as a non-specific term for spinal alterations [3,7,36,39,41], Even the diagnostic/pathognomonic manifestation of spondyloarthropathy has suffered such semantic challenge. Syndesmophytes are calcifications within the anulus fibrosus that bridge vertebral spaces in the cranial-caudal direction [1,10], but are sometimes referred in both the veterinary and human medical literature as bridging spondylosis deformans [3,5,7,8,36,39,40,77]. As spondylosis deformans was appropriately recognized as an asymptomatic entity, perceived bridging forms of that entity have been considered an incidental finding on domesticated canine and feline radiographs, traditionally considered a finding with unknown significance [4,5].

The purpose of a definition is to provide clarity and offer prognostic and therapeutic options. When dictionary definitions do not reflect usage [especially across disciplinary lines], they have outlived their usefulness and we suggest that terms need to be defined anew in publications dealing with the subject – at least as a convention for communication. This is especially true for the category spondyloarthropathy, variously referred to as ankylosing spondylitis [using that term to designate the category, rather than the specific disease] and as spondylarthritis ankylopoetica [7]. The literature is even more confusing, as the term ankylosing spondylitis has even been used to describe the bone spurs of spondylosis deformans [4,34,36,47]. Another semantic application of ankylosing spondylitis was its use to describe osteophytes of synovial [darthrodial] joints of the vertebral column [78]. That again is at variance with the definition utilized in this report and actually does represent osteoarthritis, not spondylosis deformans.

There is another source of confusion. The term spondyloarthropathy has been used by some as a general term for any affliction of the vertebral column [79]. We suggest in this manuscript restriction of that term to the specific disease as outlined above. Similarly, the term spondylosis has often been used as a general term for vertebral column disease [44]. Lascelles [77] prefers to use the term spondylosis deformans for any vertebral centra pathology, apparently considering all as "degenerative." However the term, spondylosis deformans, in this manuscript is utilized to designate a specific variety of vertebral alteration, vertebral osteophytes. Although disk space narrowing, endplate sclerosis and diskospondylitis or discospondylitis [also sometimes used to designate infection] may be associated with discospondylitis [10,80], they are not direct manifestations of spondyloarthropathy and are not further discussed in this manuscript.

The differential diagnosis of spondyloarthropathy includes trauma, infection, diffuse idiopathic skeletal hyperostosis (DISH), hypervitaminosis A and calcium pyrophosphate deposition disease (CPPD) [1,10]. Rheumatoid arthritis is not in the differential, as it does not cause anulus fibrosis ossification [1,10,81,82]. The reports of alleged rheumatoid arthritis in dogs [83] illustrate a semantic issue that reflects not only inter-disciplinary issues, but has been a problem in human medicine. The term rheumatoid arthritis has been applied to a specific disease and also used as a general term for inflammatory arthritis. The rheumatoid arthritis diagnosed in dogs actually reflects that second usage and is very different from the specific disease [1,10,81,82,84-86]. Presence of bone proliferation and intra-articular bone ankylosis in the spondyloarthropathies clearly distinguishes the canine affliction from rheumatoid arthritis [87,88].

Isolated vertebral bridging may complicate spinal column trauma and may rarely occur at sites of vertebral compression fractures [10]. Pyogenic infectious agents [e.g., Staphylococcus] and chronic infectious agents such as *Mycobacterium tuberculosis, Mycobacterium bovis* and *Brucella* have been sources of spondylitis and infectious arthritis in carnivores [1,89-91]. Absence of disorganized and filigree bone reaction excludes an infectious etiology [10]. The diagnostic syndesmophytes of spondyloarthropathy are easily distinguished from the osteophytes of spondylosis deformans. The latter project parallel to the vertebral endplate, while syndesmophytes project along the longitudinal body axis [1,5,11,12,87]. Diffuse idiopathic skeletal hyperostosis similarly projects along the long axis, but is separate from the vertebrae, as if the animal had stood upright and wax had dripped down its spinal column [92,93]. Hypervitaminosis A may produce ligamentous [e.g., anterior longitudinal ligament] ossification that is distinguishable from DISH only histologically [93,94]. The microscopic appearance of DISH is that of Haversian bone; that of hypervitaminosis A, disorganized, non-Haversian bone [1,92]. Calcium pyrophosphate deposition disease (CPPD) is recognized on the basis of a calcified sheet reflecting onto the articular surface or of calcification within the intervertebral disk [1,95].

Adult animals have been the subject of this study because spondyloarthropathy appears to be acquired during early adulthood, at least in canids, felids and primates [11,19,22-24,27,29,31]. The anatomical alterations found in this study are indistinguishable from those seen in humans [1]. Anthropomorphizing, it is assumed that clinical signs in afflicted humans would likely occur in dogs.

One cannot close without considering prevalence of disease. Prevalence of this disease has been independent of captive or free ranging lifestyle in non-domestic animals [11,17-28,30,96,97], with one exception. Harris [96,97] observed that 34.5% of a special collection of red fox *Vulpes vulpes* skeletons had what he termed spondylosis deformans. Examination of his descriptions and illustrations reveals pathology actually characteristic of spondyloarthropathy [1,10-12]. That prevalence [96,97] contrasts what was observed in the same species of wild-caught foxes in museum collections. The latter revealed no spinal pathology [31]. Harris' afflicted foxes were "killed in suburban London," where they had apparently filled the environmental niche occupied by raccoons, chipmunks, squirrels, mice and skunks in American cities [98]. Could an explanation relate to closer association of foxes with humans in London? Could fecal-oral contamination [e.g., *Salmonella, Shigella, Yersinia, Camplobactor* or *Escherichia coli*] be responsible, as it was for 19th century Americans [49]?

Why has spondyloarthropathy achieved such population penetrance in dogs? Why has natural selection not eliminated such susceptibility to infection or autoimmunity [another pathophysiological hypothesis]? Of course, dog breeding actually does represent a very different form of selection [99,100]. As breeds reflect selective breeding [51,99], what is there in that selective breeding that increases or decreases susceptibility to spondyloarthropathy? Dogs are bred to aesthetic, not health-based standards which at times compromise breed health and welfare [101,102]. The query as to prevalence of disease addresses potential, as yet unrecognized benefits associated with susceptibility or that are in linkage disequilibrium with spondyloarthropathy [103,104]. This may be analogous to protection of sickle cell anemia and of lymphocyte immunoreceptors against malaria [105,106].

Conclusions

Spondyloarthropathy was identified in 315 of 1323 axial skeletons examined, especially Boxer and German Shephard, rarely Beagle, Chihauahua, Dachshund, Maltese and Pug. First noted at 2 years

of age, its prevalence increased geometrically over the next 13 years, especially in mesticephalic dogs. Presence of syndesmophytes identified the underlying arthritis as spondyloarthropathy, not osteoarthritis. Recognition of the vertebral findings as characteristic of this inflammatory arthritis affords an opportunity for controlling the disease process and improving quality of life of the afflicted dog.

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