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1 **Original Investigation**

2

3 **Neurological signs and magnetic resonance imaging findings in twelve dogs with multiple**  
4 **myeloma**

5

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23 Keywords: canine, neoplasia, spinal.

24 **Abstract**

25           Vertebral lesions and associated neurological signs occur in dogs with multiple  
26 myeloma, however, veterinary literature describing magnetic resonance imaging (MRI)  
27 findings is currently lacking. The objective of this retrospective case series was to evaluate  
28 neurological signs and MRI findings in dogs with multiple myeloma, which presented for  
29 spinal pain or other neurological deficits.

30

31           Electronic records of four veterinary referral hospitals were reviewed. Dogs were  
32 included on the basis they had confirmed diagnosis of multiple myeloma, had presented for  
33 spinal pain or other neurological signs, and had undergone MRI of the vertebral column. MRI  
34 studies were evaluated and the anatomical location of lesion(s), signal intensity, presence of  
35 extra-dural material, degree of spinal cord compression, extent of vertebral lesions, and  
36 contrast enhancement were recorded.

37

38           Twelve dogs were included; most dogs ( $n = 8$ ) had a chronic progressive history, with  
39 varying degrees of proprioceptive ataxia and paresis ( $n = 11$ ), and spinal pain was a feature in  
40 all dogs. MRI findings were variable but more consistent features included the presence of  
41 multiple expansile vertebral lesions without extension beyond the outer cortical limits of  
42 affected vertebrae, and associated extradural material causing spinal cord compression. The  
43 majority of lesions were hyper- to isointense on T2 ( $n = 12$ ) and T1-weighted ( $n = 8$ )  
44 sequences, with variable but homogenous contrast-enhancement ( $n = 12$ ).

45

46           The MRI characteristics of multiple myeloma may be used to aid early identification  
47 and guide subsequent confirmatory diagnostic steps, to ultimately improve therapeutic  
48 approach and long-term outcome.

49 **Introduction**

50 Multiple myeloma is a malignant disorder characterised by systemic proliferation of  
51 neoplastic plasma cells.<sup>1-3</sup> This haematopoietic neoplasm has a predilection for bone marrow  
52 of the axial skeleton and is the most important myeloma-related disorder in dogs based on  
53 incidence and severity.<sup>3</sup> Neoplastic cells involved with multiple myeloma are usually  
54 functional and secrete an overabundance of a single type or component of immunoglobulin,  
55 otherwise known as M-component.<sup>1,3</sup> Clinical signs ultimately depend on the location of  
56 neoplastic cellular infiltration as well as circulating levels of M-component.<sup>4</sup> Therefore,  
57 patients can present with variable or non-specific clinical signs including lethargy and  
58 weakness, which can be misleading and make diagnostic investigation challenging.<sup>1,5</sup>

59  
60 The criteria for diagnosis of multiple myeloma includes at least two of the following:  
61 histopathological evidence of bone marrow plasmacytosis, detection of a monoclonal  
62 gammopathy in serum or urine, detection of light chain (Bence-Jones) proteinuria, and  
63 evidence of multiple osteolytic bone lesions.<sup>2,4</sup> Between 25-75% of dogs affected with  
64 multiple myeloma have radiographic evidence of bony lesions.<sup>3</sup> Furthermore, approximately  
65 50% of dogs with vertebral involvement have neurological manifestation of disease; spinal  
66 pain with accompanying neurological deficits are common clinical findings.<sup>4,5</sup> Multiple  
67 myeloma is associated with a number of other clinicopathologic abnormalities including  
68 hyperviscosity syndrome (HVS), hypercalcaemia and renal insufficiency.<sup>1,3-5</sup>

69  
70 Rusbridge and colleagues (1999) previously described clinical, neurological and  
71 radiographic findings in eight dogs affected by vertebral plasma cell tumours which  
72 presented with spinal pain and other neurological deficits.<sup>2</sup> None of the study subjects  
73 underwent magnetic resonance imaging (MRI) however. Kippenes and colleagues (1999)

74 previously reported MRI findings in dogs with vertebral tumours but only two of the dogs  
75 were diagnosed with vertebral plasmacytomas.<sup>6</sup> MRI offers several advantages over  
76 radiography as a diagnostic imaging modality for investigation of spinal disease, and is  
77 considered part of the ‘gold standard’ imaging for human multiple myeloma patients.<sup>7–10</sup>  
78 Veterinary literature describing MRI findings in dogs diagnosed with multiple myeloma is  
79 currently lacking.

80

81 By characterising the clinical and MRI features in dogs with multiple myeloma, this  
82 may aid early identification and guide subsequent confirmatory diagnostic steps; earlier  
83 diagnosis and treatment may improve long-term outcome.<sup>11</sup> MRI examination features may  
84 also have prognostic implications and could prove useful in monitoring response to  
85 treatment.<sup>8–10,12</sup> The purpose of this study was to retrospectively evaluate neurological signs  
86 and MRI findings in dogs diagnosed multiple myeloma, which presented for spinal pain or  
87 other neurological signs.

88

89

## 90 **Materials and Methods**

### 91 *Selection and description of subjects*

92 The study is based on a retrospective case series design and was granted ethical  
93 approval by the Clinical Research Ethical Review Board of the primary study institution  
94 (protocol number URN 2016 1635b). The electronic records of four large veterinary referral  
95 hospitals in the UK were reviewed between March 2005 and July 2017 to identify dogs  
96 diagnosed with multiple myeloma. All study dogs were client-owned and had presented for  
97 further investigation of suspected spinal disease. Dogs were included on the basis they had a  
98 confirmed diagnosis of multiple myeloma based on previously published criteria,<sup>2,4</sup> had

99 presented for spinal pain or other neurological signs with or without additional signs of  
100 systemic illness, and had undergone MRI examination of the vertebral column. Dogs were  
101 excluded if medical records or imaging studies were incomplete, or if diagnostic criteria of  
102 multiple myeloma were not met.

103

#### 104 *Magnetic resonance imaging studies*

105 Although protocols and sequences could vary between institutions, MRI studies were  
106 completed with dogs under inhalational general anaesthesia using a 1.5 Tesla MRI unit  
107 (Intera, Philips Medical Systems, Eindhoven, Netherlands; Signa GE Medical Systems,  
108 Milwaukee, USA; Siemens Symphony, Camberley, UK; Siemens Magnetom, Erlangen,  
109 Germany). All dogs underwent 2D acquisition studies which included a minimum of fast  
110 spin-echo (FSE) T2-weighted (T2W) (time of repetition, TR 3000-3700ms/ time of echo, TE  
111 83-120ms) and T1-weighted (T1W) (TR 400-620ms/ TE 8-15ms) sequences. FSE T1-  
112 weighted sequences were also completed immediately following manual administration of  
113 intravenous gadolinium (T1WGd) (0.1mmol/kg gadopentetate dimeglumine). Sequences in  
114 sagittal and transverse planes were available in all dogs. Slice thickness was 2-4mm with an  
115 inter-slice gap of 2.3-4.3mm in the sagittal plane, and slice thickness was 2-5mm with an  
116 inter-slice gap of 3.3-5.3mm in the transverse plane. Where available, short-tau inversion  
117 recovery sequences (STIR) (TR 8.2-26ms/ TE 50-3420ms) were reviewed. All imaging  
118 studies were assessed using a PACS workstation DICOM viewer (Osirix Imaging Software,  
119 version 3.9.2, Bernex, Switzerland). MRI sequences were independently reviewed and  
120 described by a board-certified neurologist (E.B.), and a board-certified radiologist (M.P.),  
121 blinded to the clinical history and presenting signs of each case. Anatomical location of  
122 lesion(s), signal intensity, presence of extra-dural material, degree of spinal cord  
123 compression, extent of vertebral lesions, and contrast enhancement were recorded. Signal

124 intensity was subjectively categorised as hyperintense, isointense, or hypointense relative to  
125 normal spinal cord. The postcontrast enhancement was subjectively categorised as mild when  
126 there was contrast enhancement that was hypointense compared to fat tissue on T1W  
127 sequences, and marked when the contrast enhancement was isointense to fat tissue on T1W  
128 sequences. The contrast enhancement was categorized as homogenous when there was  
129 uniform enhancement and heterogeneous when it was dissimilar throughout the enhanced  
130 area. Extent of vertebral lesions was based on the presence of signal intensity changes  
131 involving one-third, two-thirds, or the entire vertebral structure. Furthermore, the character of  
132 vertebral lesions was recorded as either remaining largely within the outer cortical limits of  
133 affected vertebrae, or extending beyond them. Finally, degree of spinal cord compression was  
134 subjectively graded as mild, moderate or marked if there was a reduction in  $\leq 25\%$ ,  $\leq 50\%$  or  
135  $> 50\%$  respectively in cross-sectional area of the spinal cord, as measured in transverse  
136 section at the point of maximal compression.

137

### 138 *Data recording and analysis*

139 Information retrieved from medical records included: signalment, history, general  
140 physical and neurological examination at presentation, MRI examination findings, results of  
141 any adjunctive imaging studies (ultrasound, radiography, computed tomography (CT)),  
142 histopathology results, and bone marrow aspirate findings. Post mortem reports where  
143 available were reviewed. At the time of initial presentation all dogs were fully examined and  
144 their neurological status recorded by a board-certified neurologist or neurology resident-in-  
145 training under supervision. Dogs were retrospectively assigned a neurological grade at initial  
146 presentation (S.W.). Neurological grade was based on a previously validated system for  
147 evaluation of myelopathies as follows: 0, paraplegia with absent deep nociception; 1,  
148 paraplegia with absent superficial nociception; 2, paraplegia/ tetraplegia with intact

149 nociception; 3, non-ambulatory paraparesis/ tetraparesis; 4, ambulatory paraparesis/  
150 tetraparesis and ataxia; 5, spinal pain only; and 6, no dysfunction.<sup>13</sup>

151

152

## 153 **Results**

### 154 *Case Subjects*

155 Twelve dogs were included in the study. Dogs had a mean age of 7.7 years at initial  
156 presentation (median: 7.3 years, range: 4.4 - 11.9 years) and a mean body weight of 29 kg  
157 (median: 28.0 kg, range: 19 - 47 kg). Eight dogs were male (six neutered) and four were  
158 female (two neutered). Breeds included Golden Retriever ( $n = 3$ ), Staffordshire Bull Terrier  
159 ( $n = 2$ ), Cross Breed ( $n = 1$ ), Doberman ( $n = 1$ ), Scottish Terrier ( $n = 1$ ), Cocker Spaniel ( $n =$   
160 1), Flat Coat Retriever ( $n = 1$ ), Beagle ( $n = 1$ ), and Rottweiler ( $n = 1$ ).

161

### 162 *Clinical Presentation*

163 Duration of clinical signs prior to presentation ranged from one to 42 days (median:  
164 14 days). Most dogs ( $n = 8$ ) had a chronic progressive history, often with varying degrees of  
165 proprioceptive ataxia and paresis ( $n = 11$ ), and spinal pain was a feature in all dogs. Onset of  
166 clinical signs was classified as acute and progressive in a further three dogs. One dog  
167 presented with a peracute onset paraplegia with intact nociception; this dog was diagnosed  
168 with a pathological compression fracture of the vertebral body of T10 in addition to a  
169 diagnosis of multiple myeloma. Neuroanatomical localisation varied but, in most dogs,  
170 clinical signs were consistent with a single neuroanatomical localisation ( $n = 8$ ), and most  
171 frequently involved T3-L3 spinal cord segments ( $n = 7$ ). One other dog exhibited signs  
172 consistent with a single neuroanatomical localisation which involved L4-S3 spinal cord  
173 segments. Four dogs demonstrated clinical signs which were consistent with a lesion



174 involving two different neuroanatomical locations based on neurological deficits and  
175 presence of spinal pain; these included C1-C5 and C6-T2 spinal cord segments in three dogs,  
176 and C1-C5 and L4-S3 spinal cord segments in one dog. An equal proportion of dogs showed  
177 evidence of lateralisation of clinical signs. Most dogs ( $n = 9$ ) were assigned to grade 4  
178 neurological status at initial presentation. One dog presented with spinal pain only and was  
179 therefore assigned a grade 5. One dog presented with non-ambulatory paraparesis and was  
180 therefore assigned a grade 3. One dog presented paraplegic with intact nociception and was  
181 assigned a grade 2. Regarding non-neurological findings, one dog presented with marked  
182 polyuria and polydipsia and was diagnosed with IRIS stage III renal failure,<sup>14</sup> two dogs had  
183 intermittent pyrexia, and eight dogs demonstrated non-specific signs of lethargy and  
184 inappetence.

185

### 186 *Imaging Findings*

187 Solitary vertebral lesions were identified in three dogs (25%) while in the remaining  
188 nine dogs (75%), multiple vertebral lesions were identified on MRI. The most frequently  
189 affected region was T3-L3 vertebrae with all dogs demonstrating some evidence of  
190 pathological change. Seven dogs (58%) each had involvement of C1-C5 vertebrae and L4-S3  
191 vertebrae, while five dogs (42%) had involvement of C6-T2 vertebrae. Eight dogs (67%) had  
192 lesions in more than one region of the vertebral column.

193

194 MRI appearance of vertebral lesions was associated with variable signal changes  
195 which showed no association with duration of clinical signs prior to presentation or any other  
196 clinical data. On T2W sequences, vertebral lesions were hyperintense in four dogs (33%),  
197 hyper- to isointense in seven dogs (58%), and isointense in one dog when compared to  
198 normal spinal cord (Fig. 1A, 2, 3A). On T1W sequences, vertebral lesions were hyperintense

199 in four dogs (33%), hyper- to isointense in three dogs (25%), iso- to hypointense in four dogs  
200 (33%), and isointense in one dog when compared to normal spinal cord (Fig. 1B, 3B).  
201 Additional STIR sequences were completed in eleven dogs and revealed lesions as  
202 hyperintense when compared to normal spinal cord in all of them (Fig. 3C). Contrast  
203 enhancement was present in all cases and was variable in intensity (from mild to marked) but  
204 homogeneous (Fig. 1C, 3D). Vertebral lesions were often asymmetrical, and although lesions  
205 variably affected all parts of the vertebrae, the vertebral body and arch tended to be more  
206 frequently involved. Lesions were often extensive involving two-thirds of vertebral structure  
207 in six dogs and the entire vertebral structure in three dogs. Vertebral lesions were generally  
208 consistent with expansile mass lesions which did not extend beyond the outer cortical limits  
209 of affected vertebra ( $n = 9$ ) and were responsible for varying degrees of spinal cord  
210 compression (Fig. 1). The degree of spinal cord compression was categorised as moderate ( $n$   
211 = 6) or marked ( $n = 6$ ) and there was no association with neurological grade at presentation.  
212 One dog was also found to have a compression fracture of the vertebral body of T10.

213

214 In all cases on MRI there was evidence of extradural material extending into the  
215 vertebral canal causing variable spinal cord compression (Fig. 1). This was detected at a  
216 single site in eight dogs (67%) or multiple sites in four dogs (33%), and when present was  
217 always found at the same site as a vertebral lesion. Location of extradural material was in the  
218 region of T3-L3 vertebrae in nine dogs (75%). Other regions included C1-C5 vertebra in four  
219 dogs (33%), C6-T2 vertebra in five dogs (42%) and L4 vertebra to sacral vertebra in five  
220 dogs (42%). Extradural material was hyperintense in six dogs (50%), hyper- to isointense in  
221 five dogs (42%) and isointense in one dog when compared to normal spinal cord on T2W  
222 sequences. On T1W sequences, extradural material was hyperintense in seven dogs (58%),  
223 hyper- to isointense in four dogs (33%) and isointense in one dog when compared to normal

224 spinal cord. Mild to marked homogenous contrast enhancement of extradural material was  
225 present in all cases. MRI also identified additional bony lesions affecting ribs ( $n = 2$ ),  
226 occipital bone of the skull ( $n = 1$ ) and scapula ( $n = 2$ ), along with enlarged thoracic lymph  
227 nodes and hepatic nodules in one case.

228

229 Three dogs had CT imaging of the abdomen and thorax following MRI. In two cases,  
230 this revealed further vertebral lesions in addition to those identified on MRI, as well as other  
231 lesions affecting ribs ( $n = 1$ ), sacrum ( $n = 1$ ), scapula ( $n = 1$ ), and the ileum of the pelvis ( $n =$   
232 1). Seven dogs had radiographic imaging of the abdomen, thorax and vertebral column;  
233 lesions were identified affecting ribs, sternum, scapula, sacrum and pelvis and were  
234 consistent with those identified on MRI. Four dogs had abdominal ultrasound following MRI  
235 which revealed mass lesions affecting the liver ( $n = 2$ ) and spleen ( $n = 1$ ); cytological  
236 evaluation of fine needle aspirate samples collected from lesions was consistent with a  
237 diagnosis of round cell neoplasia in all cases.

238

239 Confirmatory antemortem histopathological diagnosis was achieved in nine dogs  
240 following biopsy of bony lesions taken from a variety of sites, as identified on diagnostic  
241 imaging studies. Biopsy sites included ileum of the pelvis, vertebrae, rib, and scapula. Four  
242 dogs were euthanised shortly after diagnosis; post mortem examination was consistent with a  
243 diagnosis of multiple myeloma in all cases.

244

245

## 246 **Discussion**

247 This study documents the neurological signs and MRI characteristics of dogs with  
248 multiple myeloma which presented with spinal pain or other neurological deficits. Although

249 there was a significant amount of variability in imaging characteristics detected on MRI,  
250 some more consistent features identified were the presence of extradural material and  
251 multiple expansile vertebral lesions which did not extend beyond the outer cortical limits of  
252 affected vertebra, and that were hyper- to isointense on T2W and T1W sequences, and  
253 variably but homogenously contrast-enhancing. The imaging features identified in this study  
254 may help to distinguish multiple myeloma from other differential diagnosis which include  
255 primary vertebral tumours or other less likely causes such as osteomyelitis. In comparison to  
256 multiple myeloma, vertebral neoplasms of an osseous lineage often disrupt cortices of  
257 affected vertebrae due to bony lysis and proliferation.<sup>11</sup> Primary bone tumours also more  
258 frequently involve a single vertebrae in comparison to multiple myeloma which typically  
259 resulted in involvement of multiple vertebral segments.<sup>11</sup> Regarding pathological signal  
260 intensity changes, replacement of normal bone marrow by oedema and inflammatory or  
261 neoplastic cells increases T2W relaxation and is reflected as areas of high signal intensity on  
262 T2W sequences.<sup>19</sup> These same pathological changes account for decreased T1W relaxation  
263 and hence reveal corresponding areas of low signal intensity, as in the case of osteomyelitis  
264 or other vertebral neoplastic lesions.<sup>6,19,20</sup> An unusual feature associated with multiple  
265 myeloma however was the fact most lesions showed variable evidence of hyperintensity on  
266 T1W sequences, which could be used as an additional identifying feature. This is consistent  
267 with previous reports which demonstrated that vertebral plasmacytomas were hyperintense  
268 on T1W sequences when compared to spinal cord parenchyma and when also compared to  
269 other types of vertebral tumour; one possible explanation is the presence of haemorrhage  
270 within myelomatous lesions of the vertebral bone marrow.<sup>6,12,21</sup> Other studies in the human  
271 literature have suggested that bone marrow fat cell content of patients affected with early  
272 stage multiple myeloma may be increased, which may account for the relative T1W  
273 hyperintensity of lesions in certain patients.<sup>8,10</sup> In the current study this theory was not

274 supported as corresponding areas were hyperintense on STIR sequences and no association  
275 could be found with any imaging characteristics and duration of clinical signs prior to  
276 presentation. Repeat imaging to compare and monitor progression of lesion intensity,  
277 utilisation of additional MRI sequences such as T2W gradient echo, or histopathological  
278 evaluation of lesions would be beneficial to help determine the cause of signal intensity  
279 changes. The unique imaging features identified in this study may help to distinguish  
280 multiple myeloma from other types of vertebral neoplastic or other less likely infectious  
281 lesions and guide subsequent confirmatory diagnostic steps. <sup>6</sup>

282

283         The variability in imaging characteristics in the current study may reflect the  
284 differences in pathological bony changes associated with different stages of multiple  
285 myeloma. In the human literature, between three and five imaging patterns have previously  
286 been described based on MRI examination features.<sup>8-10,12</sup> These patterns include normal bone  
287 marrow, focal marrow lesions, diffuse homogenous marrow involvement, combined focal  
288 and diffuse marrow involvement, or variegated patterns with multiple small lesions on a  
289 background of normal marrow.<sup>8-10</sup> Interestingly, the presence of certain MRI patterns has  
290 previously been correlated with clinicopathological changes including the percentage bone  
291 marrow plasmacytosis and haemoglobin values.<sup>12,22</sup> In addition, MRI patterns also have  
292 reported in association with survival data and diffuse marrow infiltration has been correlated  
293 with more advanced disease features and increased tumour mass.<sup>8,9,22,23</sup> Due to the small  
294 numbers of cases in this study we were unable to consistently identify any specific MRI  
295 patterns or correlate lesion characteristics with outcome. Further research utilising a larger  
296 study population would be necessary to define any potential MRI patterns and their possible  
297 prognostic implications in dogs diagnosed with multiple myeloma which manifest with spinal  
298 pain or neurological signs as a presenting complaint.

299

300 In the current study, neurological signs tended to be chronic, progressive, and  
301 associated with spinal pain, which is consistent with previous reports.<sup>2,5</sup> One dog was slightly  
302 unusual in its clinical presentation and presented with a peracute history. This dog was  
303 diagnosed with a pathological compression fracture of the vertebral body of T10 secondary to  
304 an osteolytic vertebral lesion. Pathological fractures have previously been reported in  
305 association with multiple myeloma.<sup>2</sup> It is important to be aware of this as a potential  
306 complication and not exclude the condition as a differential diagnosis despite the uncommon  
307 acute clinical presentation. An equal proportion of cases showed evidence of lateralisation of  
308 neurological signs and neuroanatomical localisation most frequently localised to T3-L3  
309 spinal cord segments; this was consistent with imaging findings in which most lesions were  
310 identified within this region of the vertebral column. The degree of spinal cord compression  
311 did not reflect the neurological grade at presentation. This may be explained by the lack of  
312 contusive injury which is typically associated with acute spinal cord compressive lesions and  
313 can contribute to neurological deterioration.<sup>17</sup> Significant compression of the spinal cord can  
314 often be tolerated, particularly in those cases where it occurs slowly over an extended period,  
315 such as in the current study.<sup>17,18</sup>

316

317 The findings of the current study suggest that multiple myeloma is a condition which  
318 most frequently affects middle-aged to older dogs of medium to large breed, which is  
319 agreement with the findings from previous literature.<sup>5,15</sup> Earlier reports suggested the German  
320 Shepherd Dog breed may be overrepresented.<sup>5</sup> This was not something we appreciated  
321 however and this was not a breed represented in the current study. Although males  
322 constituted the majority of the study population, it is impossible to comment whether a sex

323 predilection exists based on the small numbers. Despite this, previous studies have suggested  
324 males may be overrepresented.<sup>16</sup>

325

326         The study is inherently limited by its retrospective design. The variation in clinical  
327 approach and diagnostic imaging protocols between different study organisations may also  
328 have introduced an element of systematic bias. This could ultimately have impacted on the  
329 conclusions drawn. The small study population also limits the conclusions drawn from the  
330 data. Future work utilising a larger study population with standardised diagnostic evaluation  
331 and imaging protocol would be of benefit. Based on operator experience in the current study  
332 along with previous literature, a minimum of T2W, STIR, T1W and T1WGd sequences  
333 should be utilised as standard when performing MRI examination of cases with suspected  
334 multiple myeloma.<sup>12,24</sup>

335

336         In conclusion, the majority of dogs affected by multiple myeloma with vertebral  
337 involvement present with a chronic, progressive, painful T3-L3 myelopathy. The degree of  
338 spinal cord compression did not reflect the neurological grade of dogs affected. More  
339 consistent MRI features associated with multiple myeloma include the presence of extradural  
340 material and multiple vertebral lesions which largely remain within cortical limits, and are  
341 hyper- to isointense on T2W and T1W sequences, with variable but homogenous contrast  
342 enhancement. By recognising these distinguishable imaging characteristics, this may lead to  
343 earlier diagnosis and treatment with the possibility of improving long-term outcome. Further  
344 research is needed however to define the MRI features and prognostic implications in dogs  
345 diagnosed with multiple myeloma which manifest with spinal pain and neurological signs as  
346 a presenting complaint.

347

348

349 **Author Contributions**

350 Category 1

351 (a) Conception and Design: Sophie Wyatt, Elsa Beltran

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363

364

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368

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372



373

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438 **Figure Legends**

439 Fig. 1. Six-year six-month male entire Cocker Spaniel, presenting with a chronic,  
440 progressive, painful, non-lateralised C1-T2 myelopathy. Transverse T2-weighted  
441 (T2W), A, T1-weighted (T1W), B, and T1W post contrast (T1WGd), C, images. Note  
442 the single vertebral lesion which does not extend beyond the cortical limits of the  
443 affected C4 vertebrae (arrow, 1A). The lesion is hyper- to isointense on T2W and T1W  
444 images relative to spinal cord, with moderate homogenous contrast enhancement.  
445 There is associated extradural material (asterisk, 1C) causing moderate spinal cord  
446 compression with extension into the left intervertebral foramen.

447

448 Fig. 2. Ten-year two-month male neutered Scottish Terrier, presenting with a chronic,  
449 progressive, painful, non-lateralised T3-L3 myelopathy. Transverse T2-weighted  
450 (T2W) images at the level of L3 vertebrae, A, L4 vertebrae, B, L5 vertebrae, C, and L6  
451 vertebrae, D. There are multiple vertebral lesions which largely remain within cortical  
452 limits of affected vertebrae (asterisk). Lesions are hyper- to isointense relative to spinal  
453 cord and cause variable spinal cord compression from none to marked.

454

455 Fig. 3. Ten-year eight-month male neutered Golden Retriever, presenting with chronic  
456 progressive thoracolumbar spinal pain only. Sagittal T2-weighted (T2W), A,  
457 transverse T1-weighted (T1W), B, sagittal short tau inversion recovery (STIR), C, and  
458 transverse T1W post contrast (T1WGd), D, images. Note the single vertebral lesion  
459 affecting L2 vertebral body which is hyperintense on T2W and STIR images, hyper- to  
460 isointense on T1W images relative to spinal cord, with mild homogenous contrast  
461 enhancement, and marked spinal cord compression at this level (asterisk, 1D).