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# Traumatic spinal cord injury caused by suspected hyperflexion of the atlantoaxial joint in a 10-year-old cat

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## Abstract

**Case summary** A 10-year-old cat presented 5 days after a traumatic event with acute recumbency followed by some clinical improvement. The neuroanatomical localisation was the C1–C5 spinal cord segments. Initial survey radiographs, including lateral flexed views, showed no convincing abnormalities. Magnetic resonance imaging (MRI) revealed a marked focal intramedullary lesion at the level of the dens and suspected oedema extending over C2–C3 vertebrae, suggesting early syrinx formation. The cat made an initial excellent recovery on restricted exercise without medical treatment. The MRI changes largely resolved on follow-up MRI 4 weeks later yet recurred following a relapse 4 months later. At this stage, a post-traumatic syrinx had developed. Moreover, the suspected atlantoaxial instability was finally diagnosed on radiography with fully flexed lateral views. A hyperflexion injury causing tearing of the atlantoaxial ligaments was considered most likely given the lack of malformations or fractures. The cat made a full recovery on conservative management.

**Relevance and novel information** This is the first report of sequential MRI findings in a cat with atlantoaxial instability. Moreover, post-traumatic syringomyelia formation following atlantoaxial injury has not been reported. Sequential MRI aids in the diagnosis of hyperflexion injury if survey radiographs fail to identify atlantoaxial instability.

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## Case summary

A 10-year-old male neutered domestic shorthair cat was referred to the neurology service of the University of Glasgow Veterinary School 5 days after having run with great speed head-on into a door. Following this incident, the cat appeared painful and the initial post-traumatic ataxia progressed quickly to recumbency within 12 h. The cat was treated with 30 mg/kg intravenous (IV) methylprednisolone sodium succinate (Solu-Medrol; Pfizer) and strict rest. The discomfort resolved within 24 h and the neurological deficits slowly improved.

At presentation, the physical examination was normal. Neurological examination showed a borderline ambulatory symmetrical tetraparetic cat with absent paw positioning and reduced hopping reactions in all limbs. Mentation, cranial nerve examination, spinal reflexes and spinal palpation were unremarkable. The neuroanatomical localisation was the C1–C5 spinal cord segments. A traumatic lesion such as a fracture or luxation, a traumatic intervertebral disc herniation or a vascular incident were considered most likely, and an inflammatory, infectious or neoplastic process less likely.

Complete blood count, serum biochemistry profile, clotting profile, thyroxine level, thoracic radiographs and abdominal ultrasound were unremarkable. Survey radiographs of the cervical spine in lateral (neutral and flexed) and ventrodorsal views taken under general anaesthesia showed no convincing abnormalities. Magnetic resonance imaging (MRI) of the cervical spine was performed using a 1.5-Tesla MRI unit (Siemens Magnetom Essenza; Siemens), which revealed a well-defined rounded intramedullary lesion (0.5 cm in diameter) at the level of the atlantoaxial joint (Figure 1). The lesion was

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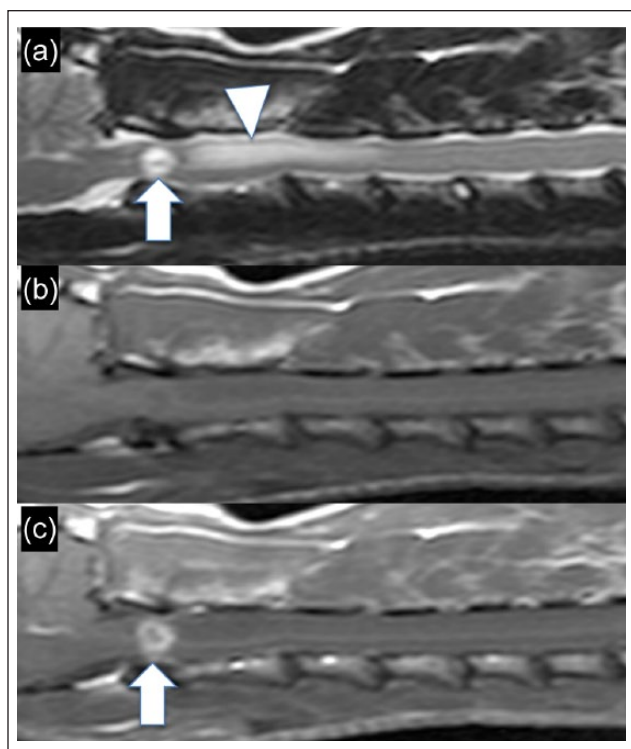
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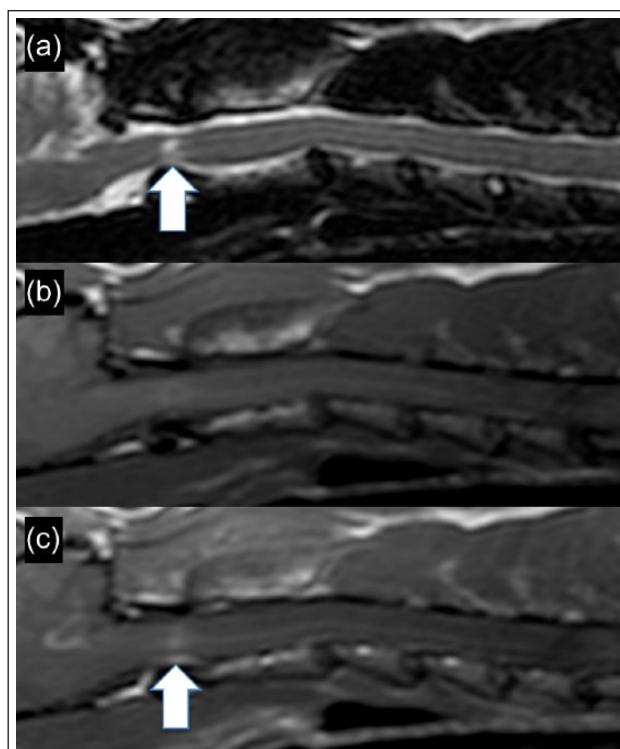


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**Figure 1** Sagittal (a) T2-weighted, (b) T1-weighted and (c) T1-weighted post-contrast magnetic resonance imaging scans of the cervical spine obtained at first presentation. A circular intramedullary T2-weighted hyperintense lesion showing peripheral contrast enhancement (arrow) is seen dorsal to the dens, with a more diffuse intramedullary T2-weighted hyperintense non-enhancing lesion (arrowhead) seen in the dorsal cord from C2 to C3

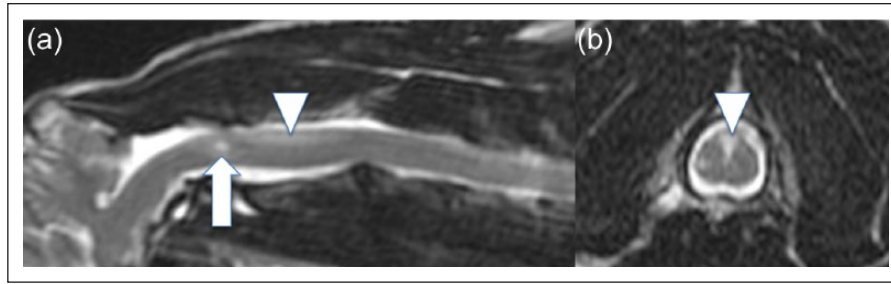
hyperintense with a small hypointense centre in T2-weighted images, hypointense in T1-weighted images and with marked ring enhancement after IV contrast administrations (gadopentetate dimeglumine, 94 mg/kg, Magnevist; Bayer HealthCare Pharmaceuticals), suggestive of oedema with a necrotic centre. A separate, less well-defined intramedullary lesion was located dorsally and extending from the cranial aspect of C2 to the caudal aspect of C3 vertebrae. This second lesion was hyperintense in T2-weighted and hypointense in T1-weighted images without contrast enhancement, suggesting oedema. Cervical cerebrospinal fluid analysis showed a mild inflammation characterised by a mild increased total nucleated cell count (8/ $\mu$ l, range 0–5) comprised of mainly macrophages, some mature lymphocytes and neutrophils, and a normal protein concentration. A traumatic or vascular (vascular malformation) lesion remained the main differential diagnoses, yet an inflammatory or neoplastic lesion could not be excluded at this stage owing to the contrast enhancement. The cat improved during hospitalisation without medication, and was discharged with ambulatory ataxia 5 days later



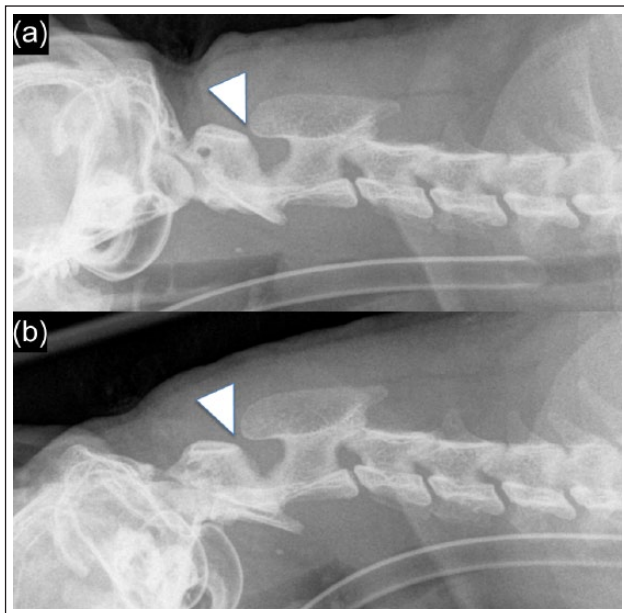
**Figure 2** Sagittal (a) T2-weighted, (b) T1-weighted and (c) T1-weighted post-contrast magnetic resonance imaging scans of the cervical spine obtained 4 weeks after first presentation. The intramedullary lesion seen dorsal to the dens shows a significant reduction in size (arrow), and the more caudal diffuse T2-weighted hyperintense lesion has resolved

on restricted exercise only. Re-examination 4 weeks later showed only occasional ataxia in all limbs with mildly reduced hopping reactions in the hindlimbs. Repeat MRI of the cervical spine revealed marked improvement of the intramedullary changes (Figure 2). A focal central intramedullary hyperintense lesion remained visible on T2-weighted images dorsal to the dens, isointense on T1-weighted images with a mildly hyperintense ring and mild focal contrast enhancement. The less-defined lesion caudally had largely resolved. The cat made a complete recovery on an increasing exercise protocol followed by normal outdoor activity.

The cat relapsed 4 months later and presented with acute non-painful recumbency after having been outdoors. Neurological examination revealed a tetraparetic cat recumbent in the hindlimbs, absent paw positioning in the left fore and hindlimb and normal spinal reflexes. Mild discomfort was suspected on dorsal extension of the neck. Repeat MRI of the cervical spine revealed a similar intramedullary lesion just dorsal to the dens, and this time a syrinx was visible caudally (Figure 3). Cervical cerebrospinal fluid analysis was unremarkable. Cervical



**Figure 3** Sagittal (a) T2-weighted and transverse (b) T2-weighted at the level of mid-C2 magnetic resonance imaging scans of the cervical spine obtained 4 months after initial presentation following recurrence of clinical signs. The intramedullary lesion seen dorsal to the dens is still present (arrow), with a diffuse T2-weighted hyperintense midline intramedullary lesion seen in the dorsal cord at the level of C2 (arrowhead), suspected to represent early syrinx formation



**Figure 4** Lateral (a) neutral and (b) flexed radiographs of the atlantoaxial region of the cervical spine obtained 4 months after initial presentation following recurrence of clinical signs, showing a slight widening of the space between the laminae of C1 and C2 on the flexed view (arrowhead)

radiographs showed only on the fully flexed lateral views a mildly increased distance visible between C1 and C2 spinous processes, supporting the diagnosis of atlantoaxial instability (Figure 4). A hyperflexion injury causing tearing of the atlantoaxial ligaments was considered most likely. Spinal fixation was declined and the cat recovered on restricted exercise. The 24 month follow-up by telephone revealed that the cat had returned to normal outdoor activity with no repeat episodes and no evidence of cervical discomfort.

## Discussion

Atlantoaxial instability is sporadically reported in cats but MRI features of the associated spinal cord injury are

rarely reported.<sup>1–4</sup> The cat's history was suggestive of a traumatic aetiology, yet initial radiography, including flexed views of the lateral cervical spine, failed to achieve a diagnosis. Atlantoaxial instability was finally diagnosed at the time of relapse on fully flexed lateral views only. Owing to the lack of visible malformations and fractures, a traumatic hyperflexion injury causing tearing of the atlantoaxial ligaments was suspected. Similarly, MRI findings of 'dens contusions' of the spinal cord in two cats and a dog, characterised by a focal area of signal change dorsal to the dens, were previously reported in a conference proceeding. The authors postulated that a traumatic episode resulted in sufficient flexion at the atlantoaxial joint for the dens to cause spinal cord contusion in the absence of permanent bony or ligamentous damage.<sup>4</sup> The lack of neck pain at the time of relapse may further support the suspected ligamentous injury. In dogs, 53–61% of patients with atlantoaxial subluxation showed cervical discomfort.<sup>5</sup> In humans, purely ligamentous injuries represent 10% of all injuries to the cervical spine, and there is little evidence on which injury mechanism is likely to result in a purely soft tissue injury.<sup>6</sup> Plain radiography provides the diagnosis in most instances, yet advanced diagnostic imaging may be necessary to evaluate the full extent of the injury.<sup>7</sup> In humans, up to 57% of cases with severe cervical spine injury are falsely negative on conventional radiography.<sup>8</sup>

Sequential MRI aided in ascertaining a traumatic aetiology in this cat. Unusually, the MRI features were characterised by two lesions. The focal well-defined rounded intramedullary spinal cord lesion was suspected to present cord contusion inflicted by the dens being acutely propelled into the spinal cord. The lesion was hyperintense on T2-weighted images with a hypointense necrotic centre and marked ring enhancement. The necrotic centre appeared hyperintense 4 weeks later, suggesting fluid accumulation. The second lesion was suggestive of oedema expanding over the C2–C3 vertebrae. This lesion resolved 4 weeks later, yet a small syrinx was noticed at its place 4 months later. Case studies in dogs with

atlantoaxial instability do not report such a focal lesion with ring enhancement, nor post-traumatic syringomyelia as such.<sup>9–12</sup> One study found syringomyelia associated with atlantoaxial instability in two dogs, yet both were associated with enlarged ventricles and one was also associated with the caudal occipital malformation syndrome, suggesting the syrinx might be unrelated to the atlantoaxial instability.<sup>9</sup> Nonetheless, a review article stated that this phenomenon has not been described in veterinary literature, yet reported from the author's own experience that over time disturbances in cerebrospinal fluid flow at the site of the spinal cord injury can result in the development of syringomyelia.<sup>13</sup> In humans, post-traumatic syringomyelia is a disorder that occurs infrequently following spinal cord injury in proximity to the traumatic epicentre and can even develop years after the initial injury.<sup>8,14,15</sup> The precise mechanism of its development is uncertain, yet it is postulated that factors include narrowing or obstruction of the subarachnoid space, central canal occlusion, myelomalacia, and alterations in intramedullary water permeability.<sup>14</sup>

The occipitoatlantoaxial region is stabilised by the atlantoaxial joint capsule, the dorsal atlantoaxial ligament, and the transverse, apical and alar ligaments, with the latter three ligaments directly attached to the dens.<sup>12</sup> All ligaments were identified on MRI in dogs but not reported in cats.<sup>12</sup> In our cat, the apical and transverse ligament appeared intact, yet the alar ligament could not be convincingly identified. A ligament abnormality such as a rupture or tear could not be convincingly identified in our cat, which might be influenced by the lack of specific sequences such as proton density.<sup>12</sup> Owing to the risk of spinal cord injury, collection of cerebrospinal fluid from the cerebellomedullary cistern is contraindicated in cervical spinal instability, yet was performed in this cat as instability was initially not identified and to obtain a sample close to the lesion. The lack of deterioration following cerebellomedullary cistern sampling may support a tearing of the ligamentous structures over a rupture. Nevertheless, the combination of sequential MRI and repeat radiography led to a final diagnosis of atlantoaxial instability in this cat.

## Conclusions

This case demonstrates the clinical challenge of diagnosing a hyperflexion injury of the atlantoaxial joint without radiographic evidence of fracture, malformation or instability. Sequential MRI reported for the first time the associated spinal cord contusion and post-traumatic syringomyelia in a cat. Sequential MRI can aid in the diagnosis of atlantoaxial instability if survey radiographs fail to achieve a diagnosis.

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**Conflict of interest** The authors do not have any potential conflicts of interest to declare.

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