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Surgical treatment of dorsal hemivertebrae associated with kyphosis by spinal segmental stabilisation, with or without decompression

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ABSTRACT

This retrospective case series examined the effectiveness of spinal segmental stabilisation, with or without decompression, in nine dogs with neurological deficits associated with dorsal hemivertebrae. Data on signalment, preoperative neurological status, imaging findings, surgical techniques and outcome were evaluated.

All cases occurred in young or adult, small-breed dogs with neurological signs ranging from progressive moderate pelvic limb ataxia to non-ambulatory paraparesis. Six dogs also showed urinary and faecal incontinence. In each dog, one or more dorsal thoracic hemivertebra(e) were detected by radiography and MRI. In all dogs, hemivertebra(e) were associated with kyphosis and reduced vertebral canal diameter. All dogs were surgically managed with spinal segmental stabilisation, using Steinmann pins and orthopaedic wires and/or sutures attached to the spinous processes. Three dogs also underwent additional decompressive surgery. Post-operative follow-up ranged from 1.5 to 5.5 years.

Immediate or delayed post-operative complications occurred in three dogs, including implant migration or loosening. Eight dogs showed long-term gait improvement, with resolution of incontinence if previously present. At 2–6 years post-surgery, four dogs were neurologically normal, three had mild residual ataxia, one had moderate ambulatory paraparesis, and one dog relapsed 3.5 years after surgery, resulting in severe paraparesis. Spinal segmental stabilisation techniques, with or without decompression, can result in satisfactory outcomes in small dogs with hemivertebrae and mild to moderate neurological signs. Further adaptations might be required to avoid implant loosening and allow continued growth in immature dogs.

Introduction

Congenital vertebral malformations are commonly observed in the thoracic spine of small, screw-tailed dog breeds (Bailey and Morgan, 1992). In most cases they are incidental imaging findings (Done et al., 1975; Bailey and Morgan, 1992; Jeffery et al., 2007; Meheust and Robert, 2010; Moissonnier et al., 2011) but vertebral malformations can result in vertebral column malangulation that can lead to vertebral canal stenosis and static spinal cord compression (Philips et al., 1997). In addition, they can create vertebral instability, causing acute or repetitive spinal cord injury due to dynamic compression (Shapiro and Herring, 1993; Philips et al., 1997; Hughes et al., 1998).

Failure of formation of the vertebral body during the developmental phases of chondrification and resegmentation, also called type I congenital vertebral malformation, typically leads to abnormal vertebral body shapes, i.e. wedge shaped vertebrae, vertebral body shortening, or other shape alterations, such as butterfly vertebra. The general term 'hemivertebra(e)' has been used for all these abnormalities (Tanaka and Uhthoff, 1981; Kirberger, 1989; Bailey and Morgan, 1992). Dorsal, ventral and lateral wedging of the vertebral body might result in pressure-induced malformation of adjacent vertebral bodies and/or abnormal spinal curvature (kyphosis, lordosis or scoliosis, respectively; Bailey and Morgan, 1992). The terms dorsal, ventral and lateral (wedge-shaped) hemivertebrae, respectively, will be used here.

Surgical management of cases with clinical signs associated with hemivertebra with vertebral column malangulation can be challenging, and there are only a few reports of such cases in the veterinary literature. A single case report describes a successful outcome in a young Labrador retriever following partial ventral corpectomy and fixation with pins and polymethylmethacrylate (PMMA; Meheust and Robert, 2010). Two case series describe a total of 12 small breed dogs treated with fixation using pins and PMMA, with or without hemilaminectomy, with

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good outcomes reported in 11/12 dogs (Aikawa et al., 2007; Jeffery et al., 2007). In one of those dogs, segmental stabilisation with two Steinman pins and polypropylene sutures combined with PMMA was used (Jeffery et al., 2007).

Our study is the first case series to describe and assess the outcome of spinal segmental stabilisation either as a sole therapy, or combined with decompression, for the management of clinically significant dorsal hemivertebrae. The surgical technique, with pins and wires and/or sutures, was based on the previously reported 'spinal stapling' technique used primarily for the management of fractures in small-breed dogs (Cage, 1973; Matthiesen, 1983; McAnulty et al., 1986), and subsequently modified (McAnulty et al., 1986). Clinical data were reviewed for all cases treated by spinal segmental stabilisation at three institutions with post-operative follow-up ranging from 1.5 to 5.5 years.

Materials and methods

Inclusion criteria

Medical records (2008–2013) for dogs with clinical hemivertebrae that were surgically managed by spinal segmental stabilisation, with or without concomitant decompressive procedures, were retrieved from the clinical databases of the Queen's Veterinary School Hospital, University of Cambridge, the Hixson-Lied Small Animal Hospital, Iowa State University and the Small Animal Teaching Hospital, University of Liverpool. Only cases with complete medical records and radiographic and magnetic resonance imaging (MRI) records were included.

Data retrieved

Information extracted from the medical records for each case included signalment, duration of clinical signs prior to presentation, neurological findings at first consultation, survey radiographic and MRI findings, results following conservative management, surgical procedures performed, neurological findings immediately following surgery, at discharge, and at first revisit (1–6 months post-operatively). Long-term outcome was assessed by serial re-examination of each dog at the participating hospital (except for dog 4) and/or telephone interviews with the owner (all dogs). Post-operative follow-up time varied between 1.5 and 5.5 years.

Neurological status

A full neurological examination was performed in each dog pre-operatively and at variable time points post-operatively. A grading scale was created to define the gait abnormalities and neurological deficits in each dog, allowing comparisons between the different assessment times (Table 1). The score for each dog was derived retrospectively, i.e. based on clinical notes, for the first presentation and rechecks, except for the last recheck, for which the score was derived prospectively. Usually, the same clinician at each centre evaluated the neurological status of each case from the initial presentation to the final recheck.

Table 1
Graded scale of ataxia and paraparesis.

Grade	Neurological status characterisation	Gait description, including neurological deficits
0	Neurologically normal	Normal gait. No neurological deficits.
1	Mild and inconsistent ataxia	Gait seems to be normal most of the time, but occasional crossing of the pelvic limbs might occur. Subtly delayed postural reactions in one or both pelvic limbs.
2	Mild and consistent ataxia	Mildly uncoordinated gait with frequent crossing of the pelvic limbs. Delayed postural reactions in one or both pelvic limbs.
3	Moderate ambulatory paraparesis	Markedly uncoordinated gait with frequent crossing and dragging in one or both pelvic limbs and occasional pelvic limb collapse. Markedly delayed postural reactions in one or both pelvic limbs.
4	Severe ambulatory paraparesis	Severely incoordinated gait with frequent crossing and dragging of pelvic limbs and frequent pelvic limb collapse. Severely delayed or absent postural reactions in one or both pelvic limbs.
5	Non-ambulatory paraparesis	Permanent pelvic limb collapse, with voluntary movement in both limbs but inability to walk without support. Markedly delayed or absent postural reactions.

Neuroimaging

Lateral and ventrodorsal radiographic projections of the spine were evaluated. The modified Cobb method was used to measure the vertebral column malangulation (McMaster and Singh, 2001; Moissonnier et al., 2011). In this method, the angle formed between two lines drawn parallel to the cranial extremity of the most cranial vertebra and the caudal extremity of the most caudal vertebra of the vertebral column malangulation was measured on lateral radiographs at initial presentation (Fig. 1). Sagittal and transverse T1-weighted and T2-weighted MR images of the thoracic vertebral column were obtained using a 0.25 T (MR GRANDE S.P.A., Esaote; dogs 1–3), 1.5 T (Signa Excite, GE Healthcare; dogs 4–6) or 1 T (Magnetom, Siemens; dogs 7–9) magnet. The MR images were examined for possible associated spinal cord lesions. Vertebral canal stenosis was quantified on T2-weighted MR images by the division of the vertebral canal height (distance between the ventral and the dorsal surface of the vertebral canal) at the site of the most severe compression, relative to the canal height at the T2 vertebral level. The result was expressed as a percentage reduction in vertebral canal height. One person (MC) measured the modified Cobb angle and the vertebral canal height reduction in all cases.

Surgical procedure

Spinal segmental stabilisation with Steinmann pins and orthopaedic wires (or polypropylene sutures) was performed to stabilise the spine at the level of the hemivertebra and its adjacent vertebrae, as previously described (McAnulty et al., 1986; Jeffery et al., 2007). A bilateral dorsal approach was made to the thoracic vertebral column with preservation of the supraspinous ligament, interspinous ligaments and caudal articular processes. The size, length and number of the Steinmann pin(s) were based on dog size, age and imaging findings. Orthopaedic wires were attached to the spinous processes. In two cases, polypropylene sutures (Prolene, Ethicon) were used in combination with orthopaedic wires.

In three cases, partial lateral corpectomy (Moissonnier et al., 2004; Flegel et al., 2011) or dorsal laminectomy was additionally performed at the level of vertebral canal stenosis. As part of the corpectomy, pediculectomy, also referred to as mini-hemilaminectomy (Jeffery, 1988), was performed at the initial stages of the procedure on the same side as the corpectomy. The decision as to whether or not decompression was performed was mainly dependent on the surgeon's preference, rather than the degree of spinal cord compression.

Radiographs were taken immediately after surgery in all dogs to ensure the correct placement of the implants. Post-operative analgesia was dependent on the requirements of each dog, and consisted of a combination of non-steroidal anti-inflammatory drugs, opioids and/or ketamine/lidocaine continuous infusions.

Results

Signalment

Nine dogs met the criteria for inclusion (Table 2). All were small screw-tail breeds, including six Pugs, two English bulldogs and one Pomeranian. There were four males and five females and median

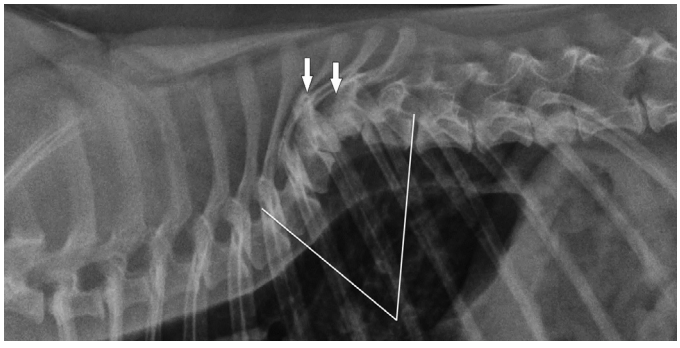

Fig. 1. Lateral view of the thoracic vertebral column of dog 4. Thoracic dorsal hemivertebrae at T8 and T9 (arrows). Marked kyphosis centred at T7–T9. Vertebral column malangulation was measured with the aid of the modified Cobb angle (angle between the two lines).