Title

Current dorsal myelographic column and dural diameter reduction rules do not apply at the cervicothoracic junction in horses

Journal

Veterinary Radiology & Ultrasound, 59(6)

ISSN

1058-8183

Authors

Estell, Krista

Spriet, Mathieu

Phillips, Kathryn L

et al.

Publication Date

2018-11-01

DOI

10.1111/vru.12662

Peer reviewed

HHS Public Access

Author manuscript

Vet Radiol Ultrasound. Author manuscript; available in PMC 2019 November 01.

Published in final edited form as:

Vet Radiol Ultrasound. 2018 November ; 59(6): 662–666. doi:10.1111/vru.12662.

Current dorsal myelographic column and dural diameter reduction rules do not apply at the cervicothoracic junction in horses

Krista Estell[1], **Mathieu Spriet**[2], **Kathryn Phillips**[2], **Monica Aleman**[3], and **Carrie J. Finno**[4]

[1]Department of Large Animal Clinical Sciences, Marion DuPont Scott Equine Medical Center, Leesburg, VA, 20176, USA

[2]Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California, Davis, CA, 95616, USA

[3]Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis, CA, 95616, USA

[4]Department of Population Health and Reproduction, School of Veterinary Medicine, University of California, Davis, CA 95616 USA

Abstract

Previously published myelographic studies do not report findings at the junction between the seventh cervical (C7) and first thoracic vertebrae (T1). Modern digital radiographic equipment allows improved visualization of C7-T1. Based on clinical experience, we hypothesized that 50% reduction of the dorsal myelographic column (DMC) or 20% reduction of the dural diameter (DD), criteria commonly used as a supportive finding for spinal cord compression in the cervical vertebral column, do not apply at C7-T1. A myelographic study was performed on twelve healthy, neurologically normal horses. Our hypothesis was confirmed; using established criteria 6/12 horses would have been classified as having evidence of spinal cord compression at C7-T1. The dorsal myelographic column reduction at C7-T1 was 48 ± 12%, while the C6-C7 dorsal myelographic column reduction was 33 ± 17% (mean ± SD) (P=0.010). The dural diameter reduction at C7-T1 (22.0 ± 6.7%) was significantly greater than the dural diameter reduction at

Corresponding author: Mathieu Spriet 1 Shields Ave Davis CA 95616, mspriet@ucdavis.edu.

Authors Contributions

Category 1

- **a.** Conception and Design: Estell, Spriet, Aleman, Finno
- **b.** Acquisition of Data: Estell, Spriet, Phillips, Finno
- **c.** Analysis and Interpretation of Data: Estell, Spriet, Phillips, Finno

Category 2

- **a.** Drafting the Article: Estell, Spriet
- **b.** Revising Article for Intellectual Content: Estell, Spriet, Phillips, Aleman, Finno

Category 3

- **a.** Final Approval of the Completed Article: Estell, Spriet, Phillips, Aleman, Finno

C6-C7 (13.2 ± 9.5%) (P=0.0007). Further measurements and comparisons suggested that the apparent greater reduction of dorsal myelographic column and dural diameter at C7-T1 was due to larger intravertebral measurements at C7 rather than smaller intervertebral values at C7-T1. Based on these findings, alternative criteria should be used at C7-T1 when assessing clinical cases for cervical stenotic myelopathy. Reduction of the dorsal myelographic column by 60% or of the dural diameter by 30% would avoid high numbers of false positive myelographic cases at C7-T1.

Keywords

cervical stenotic myelopathy; vertebra; contrast column; dural diameter

Introduction

Contrast myelography has been used for decades to establish a diagnosis of cervical stenotic myelopathy in horses.[1] Previous studies have established reference ranges and evaluated diagnostic criteria for identifying extradural spinal cord compression from the second through the seventh cervical vertebrae.[2, 3] Commonly used decision criteria for the diagnosis of extradural spinal cord compression include > 50% reduction of the dorsal myelographic column (dorsal myelographic column), 20% reduction in the total dural diameter (DD), and reduction of the dorsal myelographic column to < 2mm.[2–5] (Fig. 1) Improvements in radiographic equipment has allowed for imaging of the equine cervicothoracic region (junction of the seventh cervical (C7) and first thoracic (T1) vertebrae). However, there are no studies establishing normal myelographic findings in horses at C7-T1. Additionally, previous studies have primarily described normal values in Thoroughbreds, with Warmbloods underrepresented in the literature although Warmbloods are commonly affected by cervical stenotic myelopathy.[2, 6, 7]

The objective of this study was to assess the dorsal myelographic column and dural diameter at the cervicothoracic junction in a population of neurologically normal Warmblood and Thoroughbred horses and to compare them with values obtained at the junction of the sixth and seventh cervical vertebrae (C6-C7). Based on clinical experience, we hypothesized that at C7-T1, a reduction of the dorsal myelographic column by more than 50% and of the dural diameter by more than 20% would be present in neurologically normal horses, suggesting that the criteria previously established for the cervical vertebral column do not apply to the cervicothoracic junction.

Methods

Animals

This was an experimental analytical study using 12 healthy Thoroughbred and Warmblood horses from a research herd. This protocol was approved by the Institutional Animal Care and Use Committee at the University of California, Davis. Twelve horses were included after confirmation of normal neurological status based on independent examination by two board-certified equine internists (KE, CF). Neurologic examinations were performed as previously described.[8] Lateral survey cervical radiographs were obtained under standing sedation

(detomidine, 0.01–0.02 mg/kg IV). Horses were excluded from the study if major radiographic abnormalities were detected by a board-certified radiologist (MS). Mild enlargement of the caudal articular processes did not result in study exclusion.

Myelographic study acquisition

All horses were placed under general anesthesia in right lateral recumbency and prepared for a routine contrast myelogram. The atlanto-occipital region was clipped and aseptically prepared. An 18G 5 ½ in. spinal needle (BD Medical; Franklin Lakes, NJ USA) was carefully advanced into the subarachnoid space. Approximately 60 ml of cerebrospinal fluid was passively obtained and 50–60 ml of iohexol contrast agent (Omnipaque 300 mgI/ml, GE Healthcare, Chicago, IL) was injected slowly over 5 min. Immediately after contrast injection, the horse's head was elevated at an approximately 60° incline for 5 min. Lateral radiographs were obtained using a suspended high voltage in-house generator and large plate digital radiology system (EDR6 Sound Eklin, Carlsbad, CA). Radiographic technique was optimized based on size of the horse; 125–135 kVp and 32–50 mAs were used. Caudal cervical views were obtained first, followed by middle and cranial cervical views. All the radiographs used in this study were obtained in a neutral neck position. Horses were recovered from general anesthesia and monitored closely for 24 hours post-myelogram.

Data analysis

Four authors (KE, MS, KP, CF) independently assessed the myelographic studies for 50% reduction of the dorsal myelographic column at C6-C7 and C7-T1. Myelographic studies were classified as abnormal if at least 3 of the 4 authors identified a >50% reduction of the dorsal myelographic column. The heights of the maximal intravertebral dorsal myelographic column, minimal intervertebral dorsal myelographic column, maximal intravertebral total dural diameter, minimal intravertebral total dural diameter and minimal intervertebral ventral contrast column were measured at C6-C7 and C7-T1 by a single author (MS). All measurements were performed three times. The mean of the three measurements was used for statistical analysis, after ensuring that less than 10% variation occurred between measurements. The reduction of the dorsal myelographic column was calculated as the difference between the maximal intravertebral dorsal myelographic column and the minimal intervertebral dorsal myelographic column divided by the maximal intravertebral dorsal myelographic column. The reduction of the dural diameter was similarly calculated. As the data was normally distributed, the measurements obtained at C7-T1 were compared with the C6-C7 measurement using the paired student t test. Statistical significance was set at $P<0.05$. Results are reported as mean ± standard deviation (SD).

Results

Seven Thoroughbreds and five Warmbloods (eight mares, three geldings, and one stallion), ranging in age from 6–17 years (median 9 years), were included in the study. Five horses weighed < 550 kg, seven horses were > 550 kg. All myelographic studies were completed and all horses recovered safely from general anesthesia. After recovery from anesthesia, three horses displayed clinical signs of partial seizures which were responsive to diazepam (0.05–0.1 mg/kg IV). After the third horse displayed seizure activity (sixth myelogram) the

dose of contrast agent was decreased; 50 ml was given to horses <550 kg, while 60 ml was used for horses >550 kg. A total of two horses were given 50 ml of contrast agent. This modification resulted in a cessation of post-myelogram seizures without effecting image quality. A single horse developed central blindness without clinical evidence of seizures, which resolved within 12 hours. No other post-myelogram complications were noted.

Reduction of the dorsal myelographic column by more than 50% was identified at C7-T1 by at least three out the four observers in 6/12 horses (3 Thoroughbreds and 3 Warmbloods; Fig. 1). Similarly, > 50% reduction of the dorsal myelographic column at C6-C7 was recognized in 3/12 horses (2 Thoroughbreds and 1 Warmblood). Two of the three horses with > 50% reduction at C6-C7 also had > 50% reduction at C7-T1. For all horses, the intervertebral dorsal myelographic column remained larger than 2 mm throughout the vertebral column.

The dorsal myelographic column reduction at C7-T1 (48±12%) was significantly larger than the dorsal myelographic column reduction at C6-7 (33±17%) (P=0.01) (Fig. 2). No significant differences were observed between the intervertebral dorsal myelographic column (5.5±1.4 mm at C6-C7 and 5.3±1.4 at C7-T1, P=0.53) but intravertebral dorsal myelographic column at C6 (8.4±1.7 mm) was significantly smaller (P=0.0004) than at C7 (10.2±1.6 mm). The intervertebral at C7-T1 (4.4±0.9 mm) was larger (P=0.0002) than at C6-C7 (2.7±1.0 mm) (Fig. 3).

dural diameter reduction of more than 20% was present in 6/12 of the horses at C7-T1 (3 Thoroughbreds and 3 Warmbloods) and in 3/12 of the horses at C6-C7 (1 Thoroughbred and 2 Warmbloods). All three horses with >20% reduction at C6-C7 also had >20% reduction at C7-T1. Two of the six horses with abnormal dural diameter reduction at C7-T1 had a normal dorsal myelographic column reduction at this site. Similarly, two of the three horses with abnormal C6-7 dural diameter had normal C6-7 dorsal myelographic column. The dural diameter reduction at C7-T1 (22.0 ± 6.7%) was significantly larger than the dural diameter reduction at C6-C7 (13.2 ± 9.5%) (P=0.0007) (Fig. 2). The intervertebral dural diameter at C6-C7 (22.6±2.0 mm) and C7-T1 (22.6±1.6 mm) were not significantly different (P=0.9808), however the intravertebral dural diameter at C7 (29.1 ± 2.7 mm) was larger (P<0.0001) than at C6 (26.1 ± 2.3 mm) (Fig. 4).

In summary, four horses were considered abnormal at C7-T1 for both ratio criteria, two were abnormal according to the dural diameter reduction only and two were abnormal according to the dorsal myelographic column reduction only. This leads to a total of eight out of the 12 horses that would be considered abnormal at C7-T1 using at least one criteria.

Discussion

This study confirmed the hypothesis that 50% reduction of the dorsal myelographic column or 20% reduction of the dural diameter, criteria commonly used as a supportive finding for spinal cord compression in the cervical vertebral column, do not apply at C7-T1.[2] Criteria considered positive for cervical stenotic myelopathy was present at C7-T1 in neurologically normal Warmbloods and Thoroughbreds. If currently accepted ratio criteria were used, a

high prevalence of false positive cases would be identified as a total of eight out of 12 horses would be considered positive for cervical stenotic myelopathy based on myelographic results.

Interestingly, the dorsal myelographic column remained larger than 2 mm in all cases. This would suggest that the “2 mm rule” performed better than the other tested criteria. This rule however has significant limitations being based on an absolute measurement, leading to individual variation based on the size of the patient and magnification issues. For these reasons, the use of this rule is typically not recommended. [2]

Narrowing of the dorsal myelographic column by >50% was observed at C6-7 in 3/12 neurologically normal horses. This finding is in accordance with a previous study, reporting a high potential for false positives with specificity of only 76% for detection of spinal cord compression at C6-7 using the reduction of more than 50% of the dorsal contrast column.[2] The intervertebral dorsal myelographic column remained larger than 2 mm in all horses, which may explain lack of clinical signs of spinal cord compression in these cases. Our study suggests that if the 50% reduction of the dorsal myelographic column was applied at C7-T1, the specificity would be 50%. Due to poor specificity, this criterion should not be used at C7-T1 in a clinical situation. Based on our study population, using a 60% reduction of the dorsal myelographic column to consider cervical stenotic myelopathy would have led to only one false positive out of the 12 horses. For the dural diameter ratio, changing the criterion from 20 to 30% reduction would have reduced the number of false positive cases from 6/12 to 2/12.

Though it might seem counterintuitive that different diagnostic criteria should be applied at C6-C7 and C7-T1, the morphometric analysis performed in this study provides an explanation. Although both the dorsal myelographic column and the dural diameter reductions are greater at C7-T1 than at C6-C7, the intervertebral dorsal myelographic column and dural diameter are not significantly different between the two sites. The ratios are significantly different due to the dorsal myelographic column and the dural diameter being larger within C7 than within C6. Another interesting observation is that the ventral contrast column is larger at C7-T1 than at C6-C7. This suggests that the spinal cord sits further dorsally in the vertebral canal at C7-T1 than at C6-C7. This is likely due to the natural curvature of the cervicothoracic junction.

The improved visualization of the C7-T1 region is in large part due to the higher sensitivity of modern digital radiology system compared with the screen-film systems used for the initial myelographic studies. To improve the visualization of the contrast column in the caudal cervical spine, the horse’s head was elevated at an angle of approximately 60°, not only after the initial contrast injection, but between each view. Additionally, the caudal cervical radiographs were obtained first. Using collimation of the C7-T1 region also helped to better define the contrast column by decreasing scatter. These modifications in the standard contrast myelogram technique greatly improved visualization of the contrast column, even in well-muscled horses.

The quality of images now achievable in the C7-T1 region suggests that other parameters, such as the intra- and intervertebral minimum sagittal diameters, that have not been previously reported caudal to C7, could now be investigated. This was not performed in the current study as the design was focused on myelographic measurements. Validation of plain radiograph parameters could be better performed on a larger population of horses.

Study limitations included a fairly small sample population size. Additionally, though these horses were ascertained to be neurologically normal prior to the study, necropsy to definitively confirm the lack of spinal cord compression was not performed. The measurements were only obtained on the initial neutral position myelographic projection. Although flexed and extended views were also obtained, the conspicuity of the contrast column was not as good on these views and the measurements were not considered reliable enough for proper comparison. Subjectively, no major change could be appreciated in the appearance of the myelographic columns between the different positions.

In conclusion, this study revealed that narrowing of the dorsal myelographic column by >50% and of the dural diameter by >20% are observed at the cervicothoracic junction in horses without any clinical evidence of spinal cord compression. To avoid high numbers of false positive myelograms, diagnostic criteria of 60% narrowing of the dorsal myelographic column and 30% narrowing of the dural diameter as evidence of spinal cord compression might be indicated at C7-T1. However, the design of the current study did not allow assessment of the sensitivity of such ratios. Additional studies including horses with confirmed cervical compressive myelopathy at C7-T1 is necessary to validate the new proposed criteria.

Acknowledgments

This work was supported by a grant from the Center for Equine Health, University of California, Davis. Support for CF was provided by the National Institutes of Health (NIH) (1K01OD015134 and L40 TR001136) The authors would like to thank radiology technicians Vanessa Covarrubias and Becky Lopes for their expert contribution to the acquisition of the myelographic studies. The authors are also thankful to the staff at the Center for Equine Health and the Veterinary Medical Teaching Hospital for their compassionate care of all research horses.

References

1. Papageorges M, Gavin PR, Sande RD, Barbee DD, Grant BD. Radiographic and Myelographic Examination of the Cervical Vertebral Column in 306 Ataxic Horses. Vet Radiology. 1987; 28:53–59.
2. van Biervliet J, Scrivani PV, Divers TJ, Erb HN, de Lahunta A, Nixon A. Evaluation of decision criteria for detection of spinal cord compression based on cervical myelography in horses: 38 cases (1981–2001). Equine Vet J. 2004; 36:14–20. [PubMed: 14756366]
3. Mayhew IG, Delahunta A, Whitlock RH, Krook L, Tasker JB. Spinal cord disease in the horse. Cornell Vet. 1978; 68:44–71.
4. Nyland TG, Blythe LL, Pool RR, Helphrey MG, Obrien TR. Metrizamide Myelography in the Horse - Clinical, Radiographic, and Pathologic-Changes. American Journal of Veterinary Research. 1980; 41:204–211. [PubMed: 7369592]
5. Nixon AJ, Stashak TS, Ingram JT. Diagnosis of cervical vertebral malformation in the horse. P Annu Conv Am Equin. 1982; 28:253–266.
6. Levine JM, Adam E, MacKay RJ, Walker MA, Frederick JD, Cohen ND. Confirmed and presumptive cervical vertebral compressive myelopathy in older horses: a retrospective study (1992–2004). J Vet Intern Med. 2007; 21:812–819. [PubMed: 17708404]

7. Levine JM, Scrivani PV, Divers TJ, et al. Multicenter case-control study of signalment, diagnostic features, and outcome associated with cervical vertebral malformation-malarticulation in horses. J Am Vet Med Assoc. 2010; 237:812–822. [PubMed: 20919847]

8. Finno CJ, Higgins RJ, Aleman M, et al. Equine degenerative myeloencephalopathy in Lusitano horses. J Vet Intern Med. 2011; 25:1439–1446. [PubMed: 22092640]

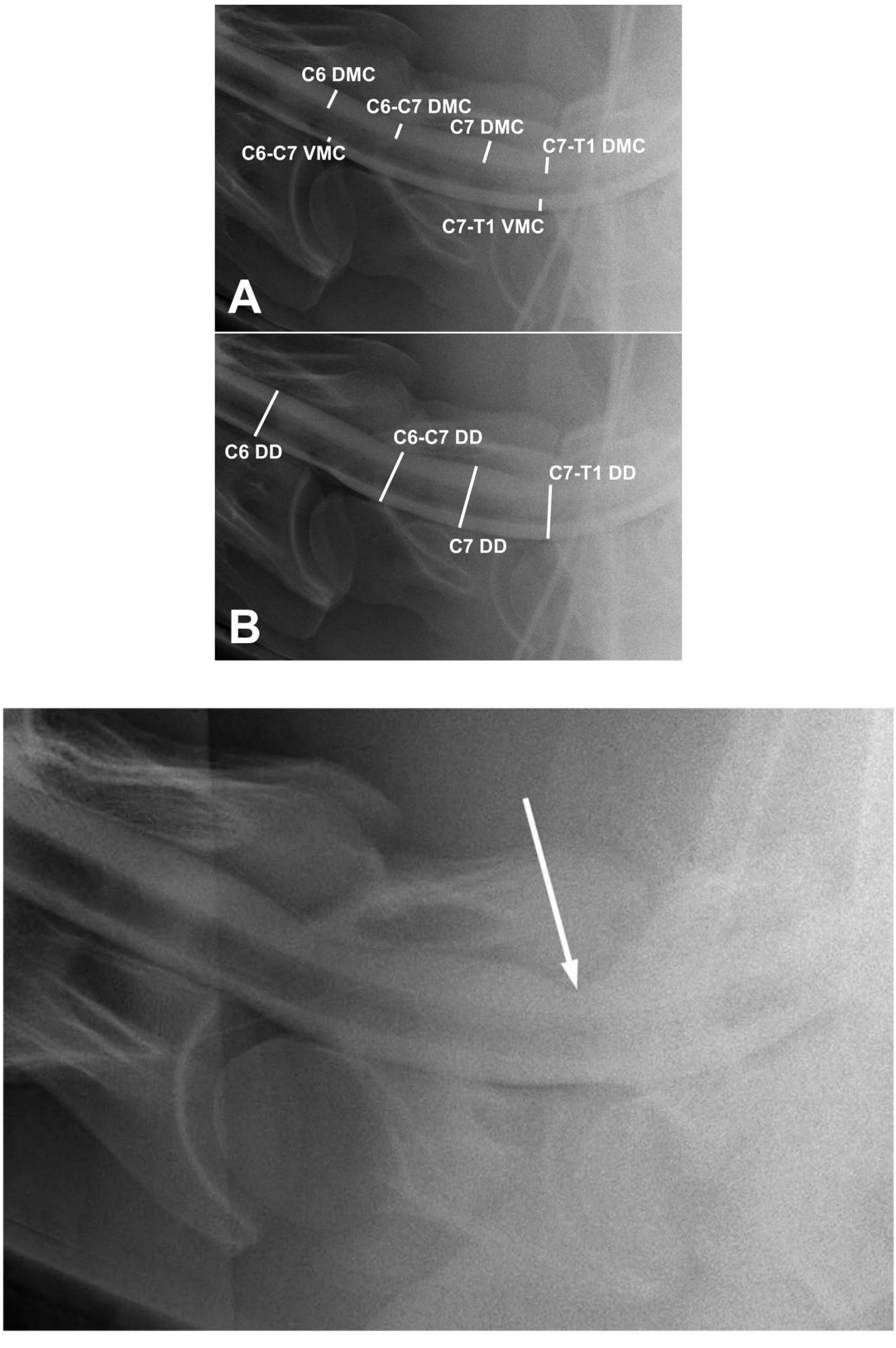

Figure 1.

Lateral myelographic projection of the caudal cervical spine demonstrating narrowing of the dorsal myelographic column at C7-T1 in a neurologically normal nine year-old Warmblood mare.

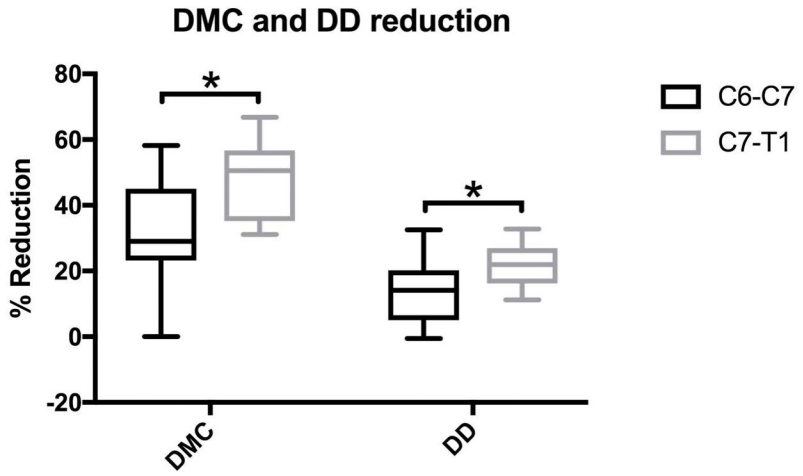

Figure 2.

Percent reduction of the dorsal myelographic column (DMC) and the dural diameter (DD) at C6-C7 and C7-T1. (whiskers indicate minimal and maximal values, n=12, student's T test, *P<0.05)

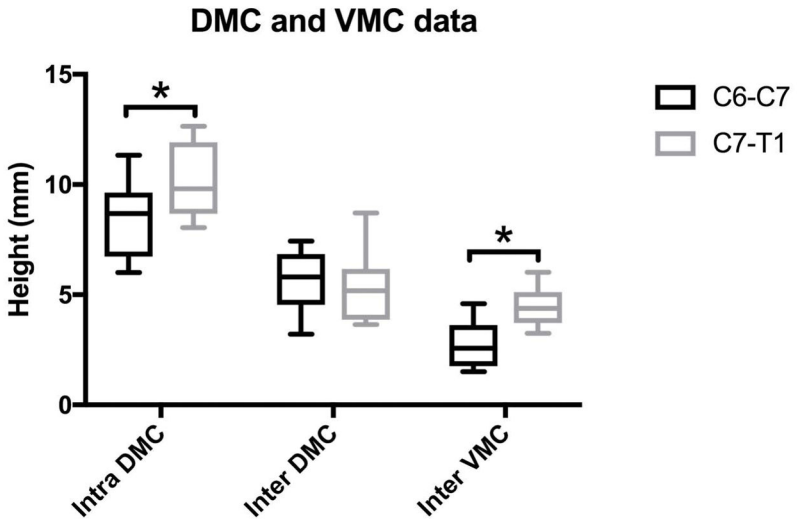

Figure 3.

Height measurements of the intravertebral dorsal myelographic column (intra DMC), intervertebral dorsal myelographic column (Inter DMC) and intervertebral ventral myelographic column (inter VMC) at C6-C7 and C7-T1. (whiskers indicate minimal and maximal values, n=12, student's T test, *P<0.05)

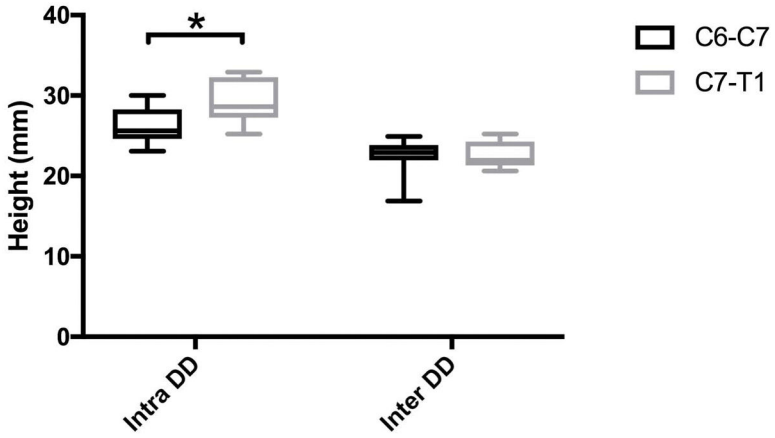

Figure 4.

Height measurements of the intravertebral dural diameter (intra DD) and intervertebral dural diameter (Inter DD) at C6-C7 and C7-T1. (whiskers indicate minimal and maximal values, n=12, student's T test, *P<0.05)