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Investigation on the diagnostical value of the dorsal compression index (DCI) in small breed dogs with and without Atlantoaxial Instability

Inaugural-Dissertation

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Zusammenfassung

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Untersuchung des diagnostischen Wertes des dorsalen Komspressionsindex (DCI) bei kleinen Hunderassen mit und ohne atlantoaxiale Instabilität

Dorsal kompressive Läsionen (DCL) am Atlantoaxialgelenk sind bei kleinen Hunderassen beschrieben, ihr Zusammenhang mit atlantoaxialer Instabilität (AAI) ist jedoch unklar. Ziel war, die Häufigkeit von DCL bei Hunden mit und ohne AAI zu prüfen. In einer retrospektiven, nach Rasse/Gewicht, MRT-System und Kopf-Hals-Position angeglichenen Fall-Kontroll-Studie wurden 26 Hunde ausgewertet (13 AAI, 13 Kontrollen). Auf T2-gewichteten sagittalen MRT-Bildern wurden dorsaler Kompressionsindex (DCI) und ventraler Kompressionsindex (VCI) sowie zusätzliche Winkelindizes gemessen und statistisch verglichen. Die Gruppen unterschieden sich nicht in Alter, Geschlecht, Kopf-Hals-Position oder dem dorsalen atlanto-dental Interval (DADI). Der VCI und das ventrale atlanto-dental Interval (VADI) waren bei AAI signifikant höher (VCI $p \leq 0{,}01$; VADI $p=0{,}02$), auch in der Subgruppe der Toy-Rassen (VCI $p=0{,}03$). Der DCI unterschied sich hingegen weder insgesamt noch innerhalb der Toy-Rassen (alle $p>0{,}4$). Hyperintensitäten der dorsalen ligamentären Struktur im STIR traten häufiger auf als Kontrastmittel-Enhancement, waren aber in der Messbarkeit limitiert. Somit sind DCL, quantifiziert über den DCI, nicht mit AAI assoziiert, während der VCI AAI trotz positionsgematchter Erhebung zuverlässig differenziert. Der DCI scheint nicht mit AAI assoziiert zu sein; die Dokumentation dorsaler Läsionen kann jedoch Fallbeschreibung und chirurgische Planung unterstützen.

Schlüsselwörter: atlantoaxiale Instabilität, dorsales Kompressionsband, kraniozervikaler Übergang

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Summary

Vetsuisse-Fakultät Universität Bern 2025

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Investigation on the diagnostical value of the dorsal compression index (DCI) in small breed dogs with and without Atlantoaxial Instability

Dorsal compressive lesions (DCLs) at the atlantoaxial junction are described in toy and small-breed dogs, but their relationship to Atlantoaxial Instability (AAI) remains unclear. This retrospective matched case–control study evaluated 26 dogs (13 AAI, 13 controls) matched for breed/weight, MRI system, and head–neck position (HNP). On sagittal T2-weighted MR images, the dorsal compression index (DCI) and the ventral compression index (VCI) and corresponding angular indices were measured and compared. Groups did not differ in age, sex, HNP, or dorsal atlantodental interval (DADI). VCI and ventral atlantodental interval (VADI) were significantly higher in AAI (VCI $p \leq 0.01$; VADI $p=0.02$), including the toy-breed-only analysis (VCI $p=0.03$). In contrast, the DCI did not differ between AAI and controls overall or within toy breeds (all $p>0.4$). STIR hyperintensity within the posterior ligamentous complex (PLC) was more prevalent than post-contrast enhancement, although measurability was limited. DCLs quantified by DCI are not associated with AAI, whereas VCI robustly discriminates AAI even when positioning is matched; DCI seems not to be associated with AAI, although documenting dorsal lesions may aid case description and surgical planning.

key words: atlantoaxial instability, dorsal compressive band, craniocervical junction

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1. Introduction

Atlantoaxial instability (AAI) in dogs is a pathological condition primarily affecting small and toy breeds. Structural abnormalities—congenital or acquired—of the dens (odontoid process) of the axis, its supporting ligaments (transverse, alar, apical), or the atlas–axis joint geometry lead to excessive motion between C1 and C2. This excessive motion induced by instability can cause spinal cord compression, resulting in clinical manifestations ranging from neck pain to severe neurologic deficits including tetraparesis or paralysis.[1–4] The atlantoaxial joint (AAJ) gains its stability dorsally through ligaments in addition to the posterior ligamentous complex (PLC). The elastic dorsal atlantoaxial ligament runs between the dorsal tubercle of the atlas and the spinous process of the axis. The PLC consists of the supraspinous ligament (SSL), the interspinous ligament (ISL), the ligamentum flavum (LF), the capsules of the facet, and the cervical fascia.[5]
AAI belongs to the craniocervical junction abnormalities (CJAs) complex meaning that several malformations in the craniocervical region of the spine may be concurrent to this disease.[6–10] In case of AAI it is well known that dorsal displacement of the axis and its dens may lead to compression of the spinal cord. Dorsal compressive lesions (DCLs) associated with AAI have received less attention and appear as focal compressions of the dorsal subarachnoid space and the spinal cord. These lesions cause varying degrees of compression and range from superficial indentations of the dorsal subarachnoid space to severe dorsal spinal cord compressions. DCLs have commonly been described as dural/fibrous bands (“AA bands”). Dural/fibrous bands are associated with fibrosis, proliferation, hypertrophy, and ossification of the dura mater or ligamentum flavum. The cause of dural/fibrous bands is unknown, but they may occur secondary to congenital malformations.[1,9,11–14]
Quantifying spinal cord compression at the atlantoaxial region is pivotal for diagnosing the presence and severity of AAI, deciding surgical versus conservative management and standardizing comparisons across studies.
Two metrics that have gained recent prominence in veterinary literature are the ventral compression index (VCI) and the dorsal compression index (DCI) (especially in the context of dorsal compression bands), among related measures of compression of the spinal cord or subarachnoid space. The VCI describes a quantitative ratio measuring ventral compression of the spinal cord by the dens (axis) relative to the dorsal space adjacent to the dens. It is typically measured on CT or T2-weight MRI sagittal images. Images should include the atlantoaxial (C1–C2) junction fully in a flexed or neutral and extended head–neck position (HNP). The DCI measures the severity of dorsal compression either of the spinal cord or subarachnoid space at the AAJ. It is until now particularly relevant when assessing dorsal compressive lesions (“AA bands”) rather than primarily ventral compression from dens subluxation or displacement. Example contexts include Cavalier King Charles Spaniels with dorsal soft tissue bands.[11,12,15–17]
The VCI has emerged as a robust and highly accurate metric for diagnosing AAI in small-breed dogs, with recent studies giving validated cutoff values ($p \geq 0.16$ in extension, ≥ 0.20 in flexion). Planchamp et al. defined cut-off values for the VCI in dogs with AAI, representing statistically derived threshold values used to distinguish between normal and abnormal measurements and to support the diagnostic assessment of atlantoaxial instability.[18] The DCI (or equivalent measures) is increasingly recognized, particularly in cases where dorsal soft-tissue structures (bands, ligaments) compress the dorsal spinal cord or subarachnoid space. Its correlation with syringomyelia and clinical signs offers potential for both diagnostic and prognostic utility.

To the author's knowledge, no published veterinary studies have assessed DCLs in dogs affected by AAI in comparison to non-affected dogs. The purposes of this study are to determine whether DCLs are commonly associated with AAI and to investigate if the DCI might be a useful complementary diagnostic imaging tool in assessing this disease. We hypothesized that dogs affected by AAI show significant differences in DCI values.

2. Materials and methods

Population

Dogs included in the present study were retrospectively selected and related datasets were analyzed. To be included in the study, patients must have undergone MRI of the cranial cervical spine at our institution in a period between June 2015 and April 2024. The study population was divided into two groups of identical sizes: dogs diagnosed with AAI were included in the case group (AAI) and the same number of dogs without AAI were included in the control group (control).The AAI group consisted of dogs that had a clinical diagnosis of AAI, based on neurological and clinical examination, and exhibited subjective imaging features indicative of AAI on MRI scans of the CVJ at the time of presentation. The control group consisted of dogs free of AAI and examined for reasons not primarily related to CJA. Both groups were matched for weight, breed, imaging system and head–neck positioning during imaging. Due to the epidemiological characteristics of our hospital population, matching based on sex or age was not possible.

MRI

MRI was selected since it has been recognized as a valuable tool for assessing soft tissue integrity and ligamentous structures of the AAJ.[3,5,8,19–21] During the defined retrospective study period, the MRI system was replaced by a new one, so imaging data were obtained from two different MRI systems (1- Panorama High Field Open, 1.0 Tesla, Philips AG Healthcare, Switzerland, 2- Magnetom Vida 3.0 Tesla, Siemens Healthineers International AG, Switzerland.)
A single observer, a trained veterinarian, reviewed and measured the images under the supervision of a board-certified radiologist. During measurements, the observer was blinded to group information.

Measurements

Sagittal T2-weighted MRI scans were used for all measurements performed.
The influence of the HNP was taken into consideration for all measurements. Patients were therefore matched according to their HNP during imaging.

Head−neck position

The HNP was measured as described by Upchurch et al.[22] by the intersection and the angle created of a line extending from the sella turcica to the ventral end of the foramen magnum and a second line extending from the craniodorsal to the caudodorsal border of the vertebral body of the axis.(Figure 1)
Based on the head–neck angle, the HNP was defined as follows: ≥ 25° indicates a neutral or flexed head position, while < 25° indicates an extended head position.[18]

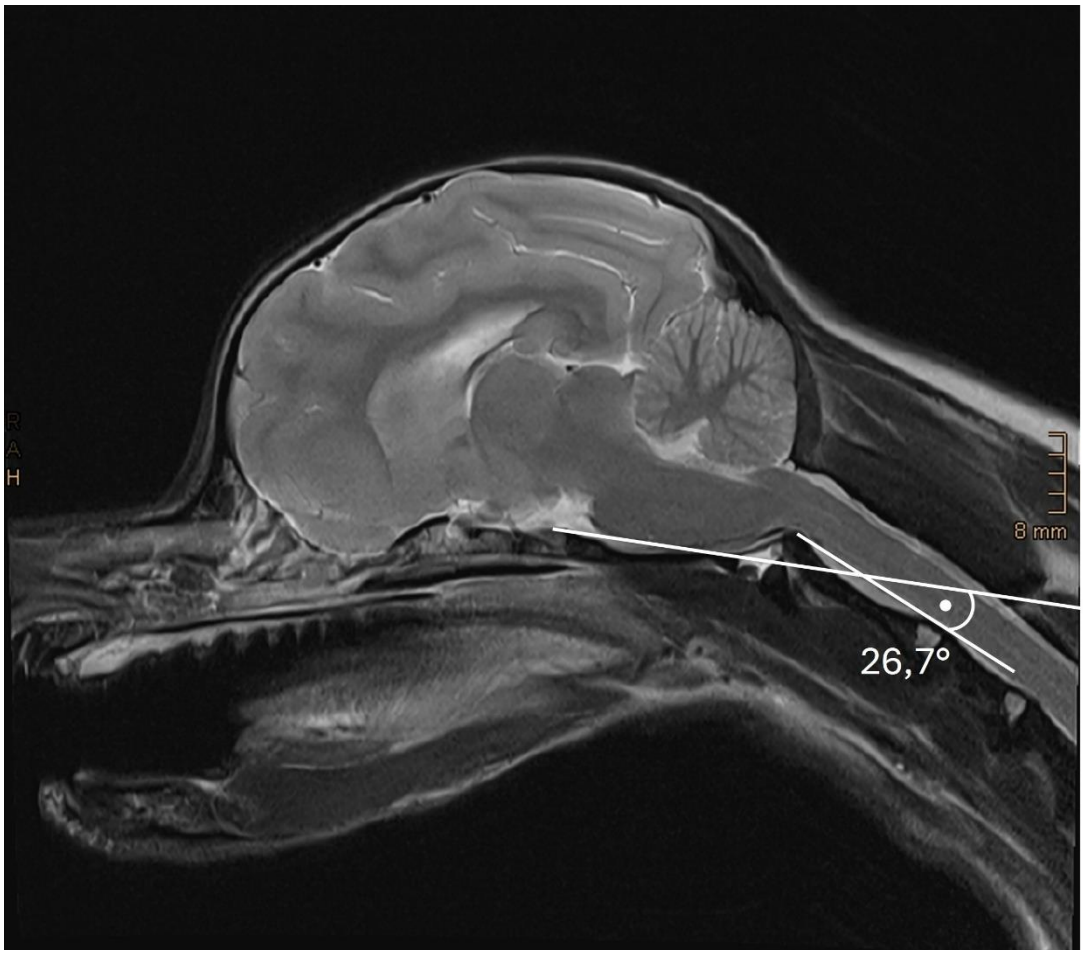


Figure 1: Measurement of the head–neck angle in a Pomeranian from the control group, showing a neutral or flexed HNP (26.7°).

Dorsal compression index

The DCI was measured as described by Marino et al.[13] The DCI was used to measure the dorsal atlantoaxial band in both groups. The DCI is the quotient of the compressive lesion (CL) and the diameter (D).

$$DCI = \frac{\mathrm{CL}}{\mathrm{D}}$$

The CL–line extends from the dorsal limit of the subarachnoid space (dot line) to the point of greatest neural indentation. The D–line was set between the dorsal and ventral limit of the spinal cord including the subarachnoid space at the cranial level of C2. The lines run parallel to each other and at a 90° angle to the auxiliary lines.(Figure 2)

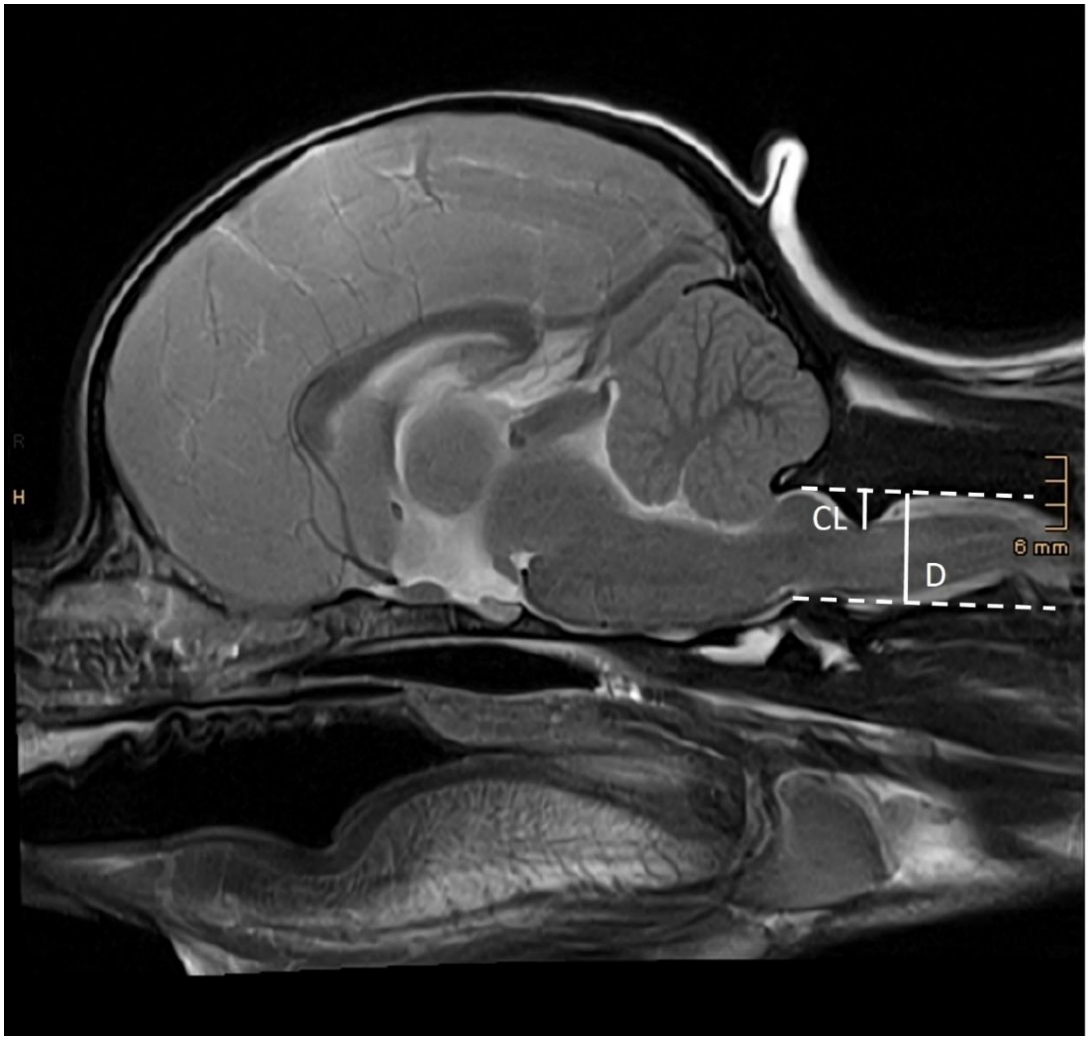


Figure 2. Measurement of the DCI (CL/D) in a Chihuahua from the control group.

Ventral compression index

The VCI was measured as described by Planchamp et al.[18] The VCI is the quotient of the VADI and the DADI.

$$VCI = \frac{VADI}{DADI}$$

The main line connects the midpoint of the ventral atlas and the midpoint of the dorsal atlas (dot line). VADI and DADI are measured along this line. The VADI–line extends from the dorsal contour of the atlas body (ventral arch) to the ventral contour of the dens axis. The DADI–line extends from the dorsal contour of the dens axis to the ventral contour of the dorsal arch of the atlas. The lines run parallel to the auxiliary line.(Figures 3a and 3b)

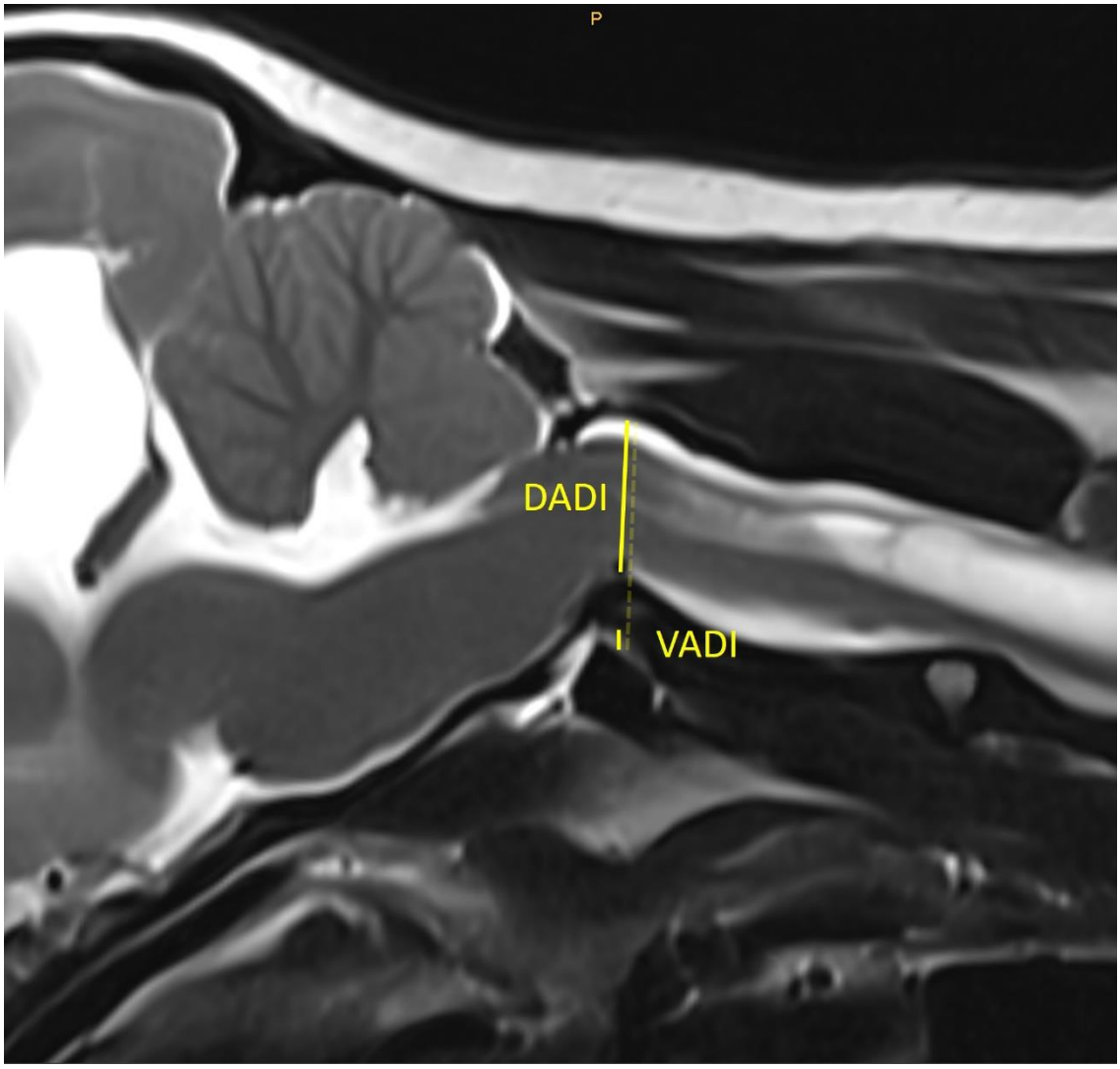


Figure 3a. Measurement of the VCI (VADI/DADI) in a Pomeranian from the control group.

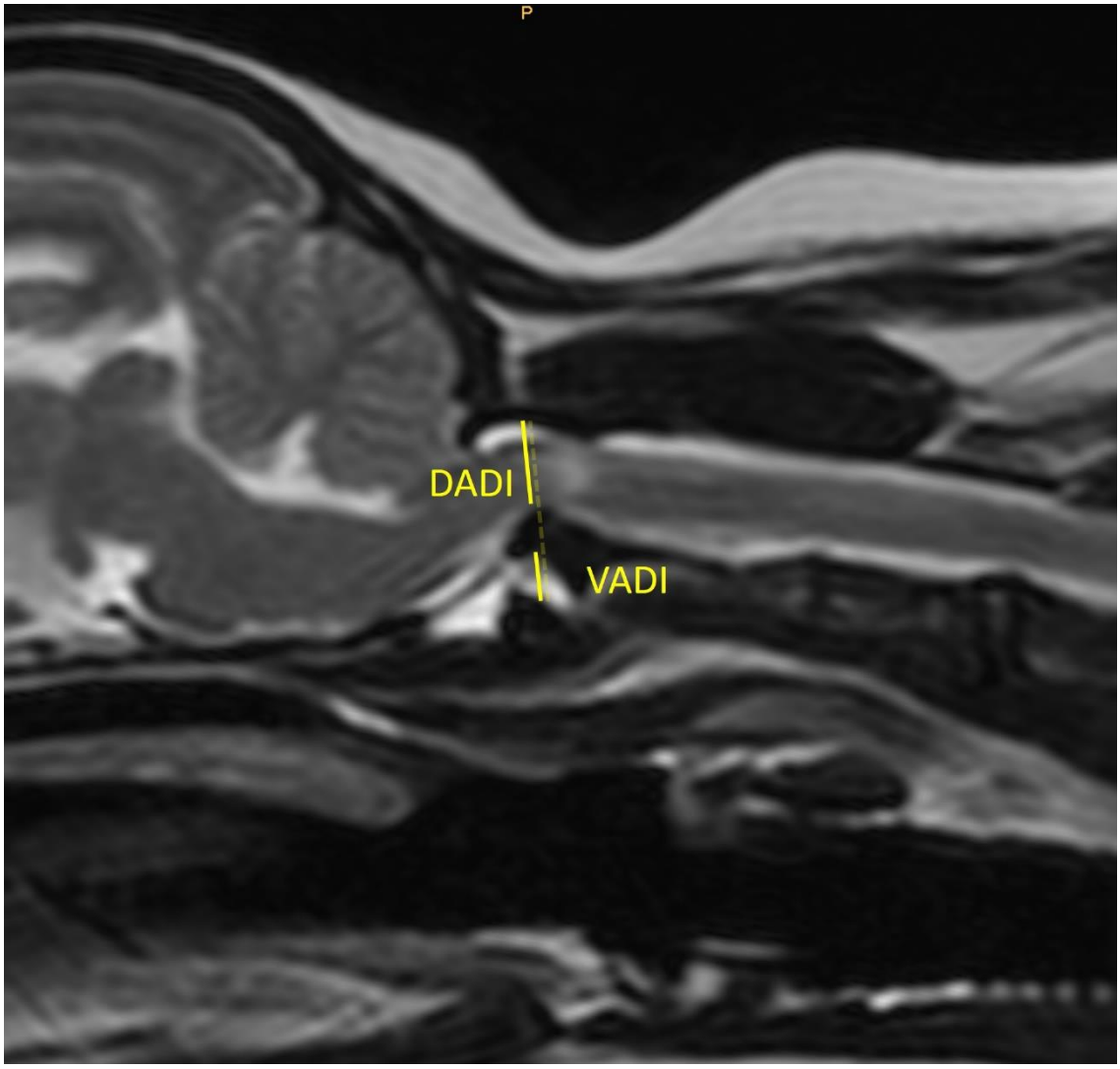


Figure 3b. Measurement of the VCI (VADI/DADI) in a Chihuahua with AAI.

Evaluation of posterior ligamentous complex lesions

The MRI scans were also analyzed to determine the presence of PLC lesions. Pre-contrast dorsal T2W STIR sequences were evaluated for abnormal hyperintense signals in the PLC area. Post-contrast transverse or sagittal T1W fat-suppressed sequences were evaluated for abnormal contrast enhancement in the PLC area. Subjective findings were classified as present, absent, or undetermined.

3. Statistical analysis

All statistical analyses were performed with NCSS 10 Statistical Software (NCSS, LCC. Kaysville, Utah, United States). Descriptive statistics were calculated for all variables. A Shapiro–Wilk test was applied to assess the normality of each variable. The level of significance was set at $p \leq 0.05$. The Mann–Whitney U test was used to compare key variables between both groups adjusting for age, sex, castration status, breed group, weight, and imaging system. Quantitative variables were first compared between toy

breed dogs and other breeds within each group. Subsequently, only the toy breeds from both groups were analyzed.

4. Results

MRIs of 26 dogs were retrospectively analyzed. Thirteen dogs were included in the AAI group, and 13 matched dogs were included in the control group. Before, six dogs were excluded from the study due to poor image quality or confounding conditions (e.g., ganglioneuritis, AA overriding, or fragmented dens).

In the AAI group the mean age ± standard deviation (SD) was 4.18 ± 3.36 years, ranging from 0.5 to 11.5 years. The group consisted of three males and 10 females, of which one male and four females were castrated. The mean weight ± SD was 7.0k ± 7.5kg, ranging from 1.4kg to 20kg. Ten of the 13 dogs were classified as toy breeds. Imaging was performed using a Philips System in seven dogs and a Siemens System in six dogs.(Table1) The mean HNP ± SD was 12.9° ± 20.7°, ranging from -22.9° to 50.3°. Ten dogs were in an extended HNP and 3 dogs in a flexed or neutral HNP.(Table 1) The mean DCI ± SD was 0.14cm ± 0.06cm ranging from 0cm to 0.25cm. The mean VCI ± SD was 0.58cm ± 0.71cm ranging from 0.11cm to 2.68cm.(Table 2, Figures 4 and 5)

The control group had a mean age ± SD of 5.04 ± 3.17 years ranging from 0.6 to 10.7 years. The group consisted of five males and eight females, of which three males and two females were castrated. The mean weight ± SD was 6.0kg ± 5.7kg, ranging from 1.9kg to 16.5kg. Nine of the 13 dogs were classified as toy breeds. Imaging was performed with a Philips System in six dogs and a Siemens System in seven dogs.(Table 1) The mean HNP ± SD was 9.5° ± 18.1°, ranging from -28.9° to 28.4°. Nine dogs were examined with an extended HNP and four dogs with a flexed or neutral HNP.(Table 1) The mean DCI ± SD was 0.11cm ± 0.1cm ranging from 0.01cm to 0.29cm. The mean VCI ± SD was 0.22cm ± 0.7cm ranging from 0.09cm to 0.35cm.(Table 2, Figures 4 and 5)

Table 1. Details on the study population: group (AAI, C=control), breed, breed classification (T=toy breed, O=others), weight, sex, MRI System, HNP, HNP classification (NF=neutral or flexed, E=extended) and results of the measurements

Dog	Group	Breed	Breed class	Weight (KG)	Sex	MRI System	HNP (°)	HNP class	CL	D	DCI	VADI	DADI	VCI
1	AAI	Chihuahua	T	1.5	F	P	6.9	E	0.80	6.40	0.13	2.80	6.20	0.45
2	AAI	Yorkshire Terrier	T	3.3	F	P	9.4	E	1.04	8.17	0.13	2.32	7.63	0.30
3	AAI	Chihuahua	T	1.4	F	P	37.1	NF	0.70	4.50	0.16	1.70	7.90	0.22
4	AAI	Epagneul Japonais	T	2.2	F	P	50.3	NF	1.00	6.60	0.15	3.10	9.00	0.34
5	AAI	Chihuahua	T	2.5	M	P	28	NF	1.40	7.80	0.18	2.70	8.80	0.31
6	AAI	Collie	O	18.7	F	P	-12.9	E	1.00	9.60	0.10	1.40	12.60	0.11
7	AAI	Pug	T	9.3	M	S	19	E	1.50	6.50	0.23	3.40	8.80	0.39
8	AAI	Spitz Nain	T	2.4	F	S	24.3	E	1.35	6.61	0.20	1.77	7.13	0.25
9	AAI	Bichon Maltais	T	2.1	M	S	21.2	E	0.86	6.62	0.13	1.98	7.72	0.26
10	AAI	Australian Shepherd	O	20	F	S	-12.4	E	0.00	12.70	0.00	9.92	6.64	1.49
11	AAI	Boxer	O	20	F	S	14.1	E	2.00	7.90	0.25	5.90	2.20	2.68
12	AAI	Biewer Yorkshire Terrier	T	1.6	F	P	5	E	0.90	7.88	0.11	2.53	7.42	0.34
13	AAI	Jack Russell Terrier	T	5.6	F	S	-22.9	E	0.70	8.70	0.08	3.70	8.30	0.45

Dog	Group	Breed	Breed class	Weight (KG)	Sex	MRI System	HNP (°)	HNP class	CL	D	DCI	VADI	DADI	VCI
14	C	Chihuahua	T	2.8	M	P	9.7	E	2.10	7.15	0.29	1.28	7.66	0.17
15	C	Pomeranian	T	1.9	F	P	18.3	E	0.85	6.14	0.14	1.25	6.63	0.19
16	C	French Bulldog	O	15.3	M	P	-11.5	E	1.00	11.30	0.09	0.80	8.60	0.09
17	C	Chihuahua	T	2.2	M	S	-11.9	E	2.48	8.67	0.29	2.45	8.46	0.29
18	C	Pug	T	4.3	M	P	23.7	E	0.70	9.50	0.07	2.50	10.50	0.24
19	C	Crossbreed	O	16.5	F	S	-28.9	NF	1.00	9.30	0.11	2.30	9.50	0.24
20	C	French Bulldog	O	15.3	M	S	-3	E	0.36	9.69	0.04	0.78	7.84	0.10
21	C	Chihuahua	T	3.0	F	S	13.8	E	0.24	6.05	0.04	1.46	5.99	0.24
22	C	Papillon	T	2.1	F	P	10.2	E	0.50	8.50	0.06	2.90	10.00	0.29
23	C	French Bulldog	O	7.1	F	P	20.6	E	0.10	8.71	0.01	2.07	9.93	0.21
24	C	Pomeranian	T	2.7	F	S	27.5	NF	1.07	7.62	0.14	1.80	7.90	0.23
25	C	Pomeranian	T	2.1	F	S	28.4	NF	0.91	6.46	0.14	2.01	7.46	0.27
26	C	Pomeranian	T	2.4	F	S	26.7	NF	0.40	6.74	0.06	2.18	6.30	0.35

Mean, median, SD, and range of D, CL, and DCI in AAI (case) and control dogs are illustrated in Figure 4, with outliers shown as individual points. Figure 5 shows the same for VADI, DADI, and VCI.

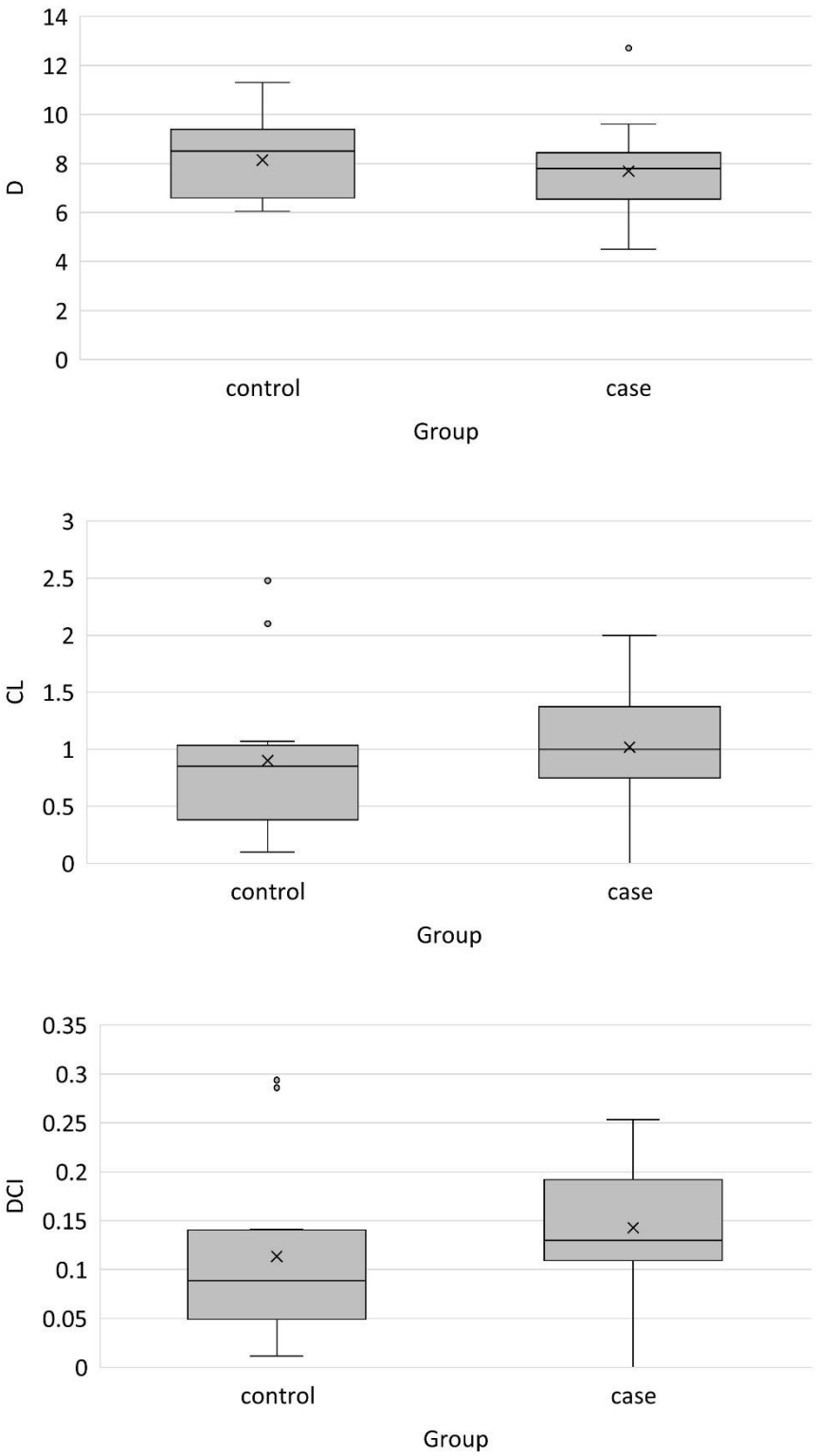
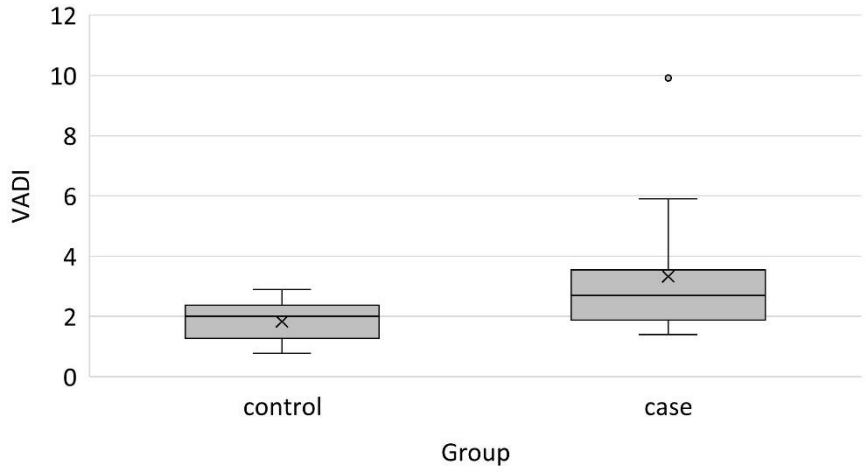
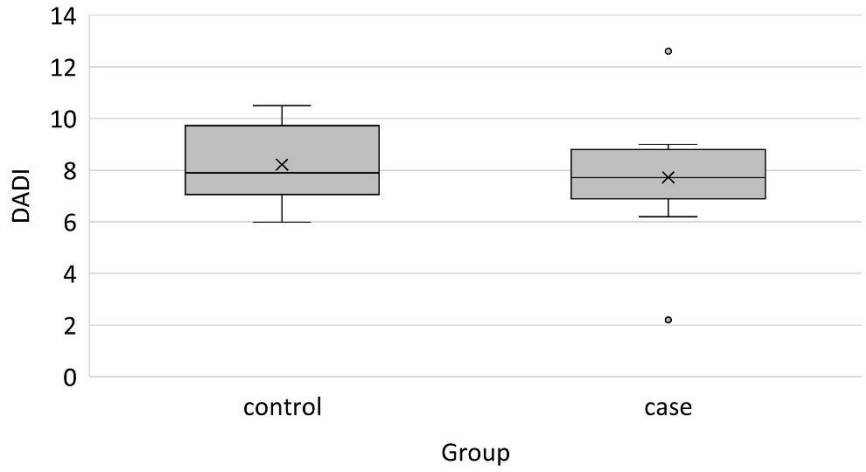


Figure 4. Boxplots showing the mean, median, SD, and range of D, CL, and DCI in both groups.





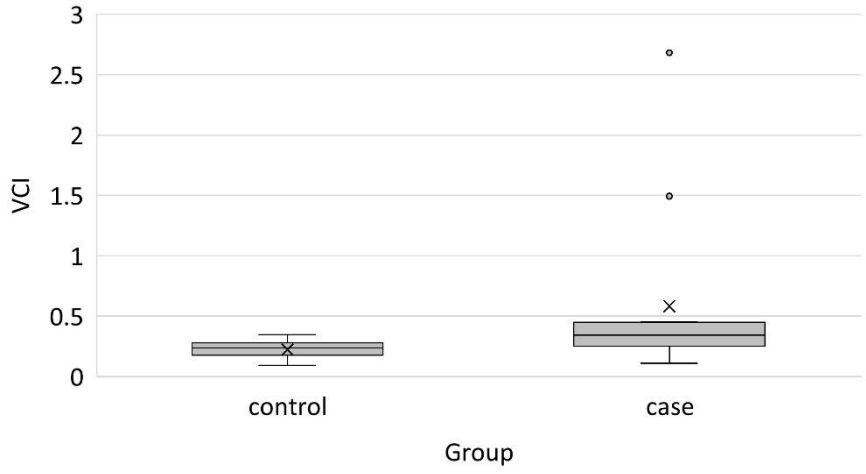


Figure 5. Boxplots showing the mean, median, SD, and range of VADI, DADI, and VCI in both groups.

Using the Shapiro–Wilk test, the variables age, HNP, CL, D, DCI, and DADI followed a normal distribution in the AAI group, whereas VADI and VCI did not. In the control group, age, HNP, D, VADI, DADI, and VCI followed a normal distribution, whereas CL and DCI did not. In the combined analysis of both groups, HNP, D, and DADI were normally distributed, in contrast to VADI and VCI.

No statistically significant differences were found between the two groups for age (p=0.42), sex (p=0.40), castration status (p=1.0), breed class (p=0.66), weight (p=0.82), imaging system (p=0.44), HNP (p=0.90), and DADI (p=0.54). Statistically significant differences were observed only for VADI (p=0.02) and VCI (p=0.01).
To further investigate our hypothesis, we compared the CL, D, and DCI variables between toy breed to non-toy breed dogs within each group. A significant difference in the variable D was found in both groups (control: p=0.014 and AAI: p=0.028). No statistically significant differences were found for CL (control: p=0.44 and AAI: p=0.93) or DCI (control: p=0.12 and AAI: p=0.50).
Since D was significantly different between the two groups, we subsequently focused on comparing only toy breeds from both groups. No significant differences were observed for CL (p=0.46), D (p=0.68), DCI (p=0.41), VADI (p=0.072), and DADI (p=0.78). A statistically significant difference was found for the VCI (p=0.03).(Table 2)

Table 2. Mean, SD and p-values for differences between groups

Group	**Control (all)**	**AAI (all)**	**Control (toy breed only)**	**AAI (toy breed only)**	**AAI (all) vs control (all)**	**AAI (toy breed only) vs AAI (others)**	**Control (toy breed only) vs control (others)**	**AAI (toy breed only) vs control (toy breed only)**
Statistical measure	mean ±SD	mean ± SD	mean ± SD	mean ± SD	p-value	p-value	p-value	p-value
HNP	9.5 ± 18.1	12.9 ± 20.7	16.27 ± 12.12	17.83 ± 18.97	Not significant	Not significant	Not significant	Not significant
CL	0.9 ± 0.7	1.0 ± 0.5	1.03 ± 0.72	1.03 ± 0.28	Not significant	Not significant	Not significant	Not significant
D	8.1 ± 1.6	7.7 ± 2.0	7.43 ± 1.16	6.98 ± 1.14	Not significant	0.028	0.014	Not significant
DCI	0.1 ± 0.1	0.1 ± 0.1	0.14 ± 0.09	0.15 ± 0.04	Not significant	Not significant	Not significant	Not significant
VADI	1.8 ± 0.7	3.3 ± 2.3	1.98 ± 0.55	2.60 ± 0.64	0.017	Not significant	Not significant	Not significant
DADI	8.2 ± 1.5	7.7 ± 2.3	7.88 ± 1.47	7.89 ± 0.83	Not significant	Not significant	Not significant	Not significant
VCI	0.22 ± 0.1	0.6 ± 0.7	0.25 ± 0.05	0.33 ± 0.08	0.006	Not significant	Not significant	0.034

In the present study, PLC lesions were assessed as follows: hyperintensity in STIR was evaluated in 18 individuals, being present in 10 and absent in 8. Contrast enhancement in T1w was evaluated in 21 individuals, being present in 4 and absent in 17. PLC lesions were not identified in 10 individuals, which may indicate technical limitations in the imaging assessment.

5. Discussion

This retrospective study determined the presence of DCLs in dogs with and without AAI. Significant differences in D between toy breed dogs and other breeds in both groups suggested that weight differences may influence the outcomes. However, DCLs quantified by the DCI were not associated with AAI in toy and non-toy breed dogs, whereas the VCI reliably discriminates AAI even when the HNP is matched. Therefore, our working hypothesis could not be confirmed in the present study.

The VCI is considered an important measurement for diagnosing AAI. The VCI is reportedly independent of confounding factors such as breed and weight.[14] Planchamp et al. demonstrated high sensitivity and specificity of the VCI in both flexed and extended head positions for AAI and established diagnostic cutoff values.[18] The VCI can be used to objectively diagnose AAI. Our study confirmed these results and showed a significantly higher mean VCI in dogs with AAI.(Table 2) These results are consistent with findings from Cummings et al., who reported elevated VCI values in dogs affected by AAI compared to unaffected dogs. The study showed no correlation between the VCI and weight or breed. However, an association between the VADI and body weight was reported.[23] Planchamp et al.[14] observed higher VCI values in female dogs, though this was not confirmed by another study.[18] In our data, females had a higher mean VCI than males; however, this may be confounded by a higher prevalence of AAI in females, as gender was not a matching variable.

Abnormal ligamentous structures and dorsal compressive bands have been observed in dogs with CJAs.[8,9,11–13,15,24,25] Various degrees of spinal cord compression, dural band formations, and their clinical relevance have been documented, particularly in Cavalier King Charles Spaniels (CKCS) with Chiari-like malformations.[11,12,16,17] Gonzales et al. reported an association between AA bands and syringomyelia in CKCS, which was related to multiple abnormalities of the craniocervical junction (CCJ) rather than solely to Chiari-like malformations. It is known that dural/fibrous bands may cause varying degrees of spinal cord compression. Excessive cervical motion may contribute to the development of AA bands.[9] This observation led us to evaluate the diagnostical value of the DCI in cases of AAI. Cloquel et al. associated the AA band with ligamentous hypertrophy. Hypertrophy may occur as a consequence of chronic mechanical irritation, due to subclinical instability, and subsequent thickening of ligamentous structures.[26] However, the exact pathogenesis of dural band formations remains unclear and does not exclude even mild forms of AAI as potential catalysator for their development. Histopathological studies by Marion et al. revealed fibrosis, inflammation, and osseous metaplasia in the dural bands.[13] Similar findings have been reported in other studies, including fibrosis and hypertrophy of the ligamentum flavum or dura associated with vertebral malformations.[9,11,12,27–29]

In alignment with these pathophysiological hypotheses, the aim of the present study was to determine whether dorsal compressive bands occur more frequently in dogs with AAI. The DCI quantifies the severity of dorsal spinal cord compression caused by AA bands. In our analysis, the DCI did not differ significantly between dogs with and without AAI.(Table 2) Similarly to our results, Takahashi et al. found no significant differences in dorsal compression between dogs with and without occipitoatlantoaxial overlap (AOO).[30] Furthermore, Gonzales et al. assumed that age-related progression may influence the development of dorsal compressive lesions.[12] This finding might also influence the results sampled in various studies.

Importantly, the HNP during imaging may affect the prominence and diagnosis of AA bands. Head–neck positioning affects interarticular measurement outcomes. Depending on the specific CJA, different head positions have been investigated for diagnostic imaging. Extension of the head brings the atlas and axis closer together, potentially exaggerating spinal cord compression and enhancing band visibility. In contrast, flexed positions may underestimate or obscure band visibility.[12,14,16,22] One study showed that the HNP significantly influences the VCI and the VADI only in maximal flexion.[14] Consequently, both flexion and extension views may indeed be recommended for optimal imaging of the AAJ. Furthermore, lateral bending may also influence the degree of spinal cord compression in dogs with AAI.[2] To overcome this potential bias in the present study, control dogs were matched with AAI-affected dogs based on their HNPs. This might allow a more accurate comparison of relative measurements such as the DCI and the VCI.

Lesions of the PLC are well-recognized contributors to spinal disorders, including injury and instability, in human medicine, but remain largely uncharacterized in veterinary practice.[5,31] In this study, the evaluation of PLC lesions was limited, likely due to the absence of the most sensitive imaging sequences—specifically, fat-suppressed T2-weighted pre-contrast and T1-weighted post-contrast sagittal sequences—which are not part of standard head and neck MRI protocols in dogs. Hyperintensity on dorsal STIR images within the dorsal ligamentous complex was more commonly observed than post-contrast enhancement; however, histopathological confirmation was not available. Future studies employing optimized imaging sequences and, ideally, histopathological validation are warranted to better evaluate and characterize these lesions in dogs.

The main limitations of the present study are the small sample size and the inclusion of non-toy breed dogs. Although attempts were made to balance body weight across groups, true size-matched sampling remains a challenge when studying AAI. Anatomical proportions differ among breeds, which can affect absolute measurements. Some relative indices (e.g. ratios VCI, DCI) potentially overcome this, but residual variation remains. Furthermore, the retrospective study design did not allow imaging adjustment or detailed information on patient positioning (e.g data on lateral bending). Flexion vs extension of the CCJ significantly alters measurements. While cutoff values (e.g., VCI≥0.16 or ≥0.20)[18] are highly useful, some cases may still fall near the threshold or be affected by confounding factors (e.g. hypoplastic dens, angled dens, positional variation). Some dogs classified as “potentially unstable” may fall into intermediate ranges. Gender and age were not used as matching criteria, limiting conclusions regarding their influence. These features could be of high interest, as gender specific differences and age-related disease progression for AAI need further investigation. The study emphasizes the importance of

future research including DCLs in dogs with AAI. Furthermore, some dogs may show clinical signs of instability despite appearing stable on static imaging. Hypertrophy of ligaments and dorsal compressive tissues may develop over time in response to subclinical instability. Dynamic studies (e.g. flexion-extension radiographs or MRI) may capture aspects missed in static images.

6. Conclusion

In conclusion, no statistically significant association was detected between AAI and the presence of DCLs. The VCI was confirmed to be a useful imaging index to discriminate between dogs with and without AAI. Indices like VCI and DCI provide reproducible numeric values rather than purely descriptive assessments when studying AAI. Knowing the magnitude/direction of compression—ventral, dorsal, or both—can inform whether ventral fixation, dorsal decompression, or combination approaches are necessary.

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