ORIGINAL ARTICLE

Investigation of neutering status and age of neutering in female Dachshunds with thoracolumbar intervertebral disc extrusion

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Objectives: To evaluate neutering status and age of neutering in female Dachshunds with thoracolumbar intervertebral disc extrusion. We hypothesised that neutered Dachshunds presented with intervertebral disc extrusion at an earlier age, with a higher grade of neurological deficits and with more extensive extrusion of disc material compared with intact females.

Materials and Methods: Retrospective multi-centre study of client-owned female Dachshunds with surgically confirmed thoracolumbar intervertebral disc extrusion. Dogs were classified as early, late or not neutered (intact). Age, body condition score, duration of clinical signs before presentation, modified Frankel score at presentation, length of extruded disc material, maximum spinal cord compression and whether dogs presented for a subsequent intervertebral disc extrusion were recorded.

Results: One hundred and fifty-four dogs were included: 36 early neutered, 69 late neutered and 49 intact. No significant difference was found between early neutered, late neutered and entire female Dachshunds in any of the variables studied.

Clinical Significance: In this cohort of female dogs, neuter status and age of neutering were not found to affect age at onset nor severity of thoracolumbar intervertebral disc extrusion.

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INTRODUCTION

The intervertebral disc is composed of the nucleus pulposus, anulus fibrosus, the cartilaginous endplates and a transition zone (Evans & de Lahunta, 2013). In chondrodystrophic dog breeds such as the dachshund, degeneration of the intervertebral disc occurs relatively early in life resulting in a decreased ability to resist compressive and torsional forces. This can ultimately progress to an intervertebral disc extrusion (IVDE), in which the degenerated nucleus pulposus extrudes dorsally into the vertebral canal resulting in spinal cord compression and/or contusion (Smolders et al., 2013). The clinical severity of IVDE can be graded using a modified Frankel score (MFS). The original Frankel score was described in 1969 for people with traumatic myelopathy (Frankel et al., 1969). Alternative scoring systems that have been used in dogs incorporate ability to ambulate and presence of nociception (Davies & Sharp, 1983; Levine et al., 2006; Olby et al., 2014; Scott, 1997). Surgical treatment of thoracolumbar IVDE has been associated with a functional recovery in 93% to 98.5% of dogs that retain nociception in the pelvic limbs, compared with 60% to 80% of dogs treated medically (Baumhardt et al., 2020; Davies & Sharp, 1983; Funkquist, 1962a, 1962b; Langerhuus & Miles, 2017; Levine et al., 2007).

Studies suggest that 15.9% to 19% of Dachshunds are affected by IVDE (Ball et al., 1982; Packer et al., 2016), and up to 31% in a study of Finnish Dachshunds (Lappalainen et al., 2014). Identifying risk factors for the development of IVDE could help improve welfare, management, breeding practices and clinical outcomes in the breed. To date, various studies have evaluated potential risk factors for IVDE in Dachshunds. Taller dogs and those with a larger pelvic circumference were found to be more frequently affected

in one study, while taller height at the withers and smaller pelvic circumference were associated with more severe spinal cord injury (Levine et al., 2006). In another study, Dachshunds that were skeletally smaller, had a higher body condition score (BCS) or a body length to height at withers ratio of more than 1.5 were found to have an increased risk of IVDE (Packer et al., 2013). Additionally, an increased incidence reported in two families of Dachshunds suggests a genetic risk factor (Ball et al., 1982), while insertion of a fibroblast growth factor (FGF4) retrogene on CFA12 has been associated with the risk of developing intervertebral disc disease in chondrodystrophic breeds (Brown et al., 2017).

A large retrospective study of 8117 dogs with intervertebral disc herniation found that, across all breeds included, neutered females had a small increase in risk of intervertebral disc herniation (relative risk of 1.2) compared with intact females (Priester, 1976). Neutering status and age of neutering have also been studied as potential risk factors for the development of IVDE in Dachshunds (Dorn & Seath, 2018; Packer et al., 2016). One study found that early neutered female dogs had a risk ratio of 2.12 for the development of IVDE and late neutered females of 1.55 compared to intact females (Dorn & Seath, 2018). Another study assessed the neuter status of affected dogs, but not the age of neutering, and found that intact dogs were at significantly decreased odds of developing intervertebral disc disease (odds ratio: 0.38) (Packer et al., 2016). Both these studies obtained data on intervertebral disc disease via owner questionnaires and hence are subject to recall bias as well as likely variations in type/severity of disc disease and means of diagnosis. A recent study of 99 female intact and 212 female neutered Dachshunds reported that 38% of the intact females had intervertebral disc disorders, compared with 61% of females neutered at <6 months and 59% of females neutered at 6 to 11 months (Hart et al., 2020). In clinical veterinary practice, advice is frequently sought by owners on choice to neuter their pets and the optimum time to do so. This study aimed to retrospectively investigate both neuter status and age of neutering in female Dachshunds with thoracolumbar IVDE (TL-IVDE). We specifically investigated if neutering influences IVDE severity and recruited only dogs that underwent surgical treatment of TL-IVDE to ensure a confirmed diagnosis. Given existing data supporting an increased incidence of TL-IVDE in neutered dogs, we questioned if this was reflective of an earlier onset and/or increased severity of IVDE so resulting in more neutered dogs developing clinically detectable IVDE within their lifetime. We hypothesised that neutered female Dachshunds were affected at a younger age with TL-IVDE, with more severe neurological deficits and more extensive extrusion of disc material compared with intact females.

MATERIALS AND METHODS

Study design and inclusion criteria

Data were collected retrospectively from the Queen Mother Hospital for Animals electronic records from January 2009 to July 2021, and Cave Veterinary Specialists electronic records from January 2020 to December 2022. Search terms were "female," "dachshund" and "hemilaminectomy." Inclusion criteria were the availability of a clinical history that documented the date of neutering or listed the dog as intact, a documented date of birth and surgical management of a TL-IVDE via hemilaminectomy. Dogs were excluded if medical records were incomplete or unavailable. Where available, BCS was noted at the time of hemilaminectomy; dogs were not excluded if a BCS was not available.

Data collected

Cases were classified as "early neutered" if they were neutered before 12 months of age, "late neutered" if they were neutered at or over 12 months of age, and "intact" if they were listed on the referral hospital's database as intact and there was no history of neutering in the clinical records from the referring veterinary surgeon.

Data collated from each dog included age at presentation, BCS, duration of clinical signs before presentation (days), neurological examination findings at presentation, length of extradural material relative to length of L2, maximum spinal cord compression and if the dog represented for a surgical TL-IVDE. The clinical severity of the neurological deficits on presentation was graded retrospectively using the MFS shown in Table 1. Using EUnity (by Mach 7, v.7.3.2-334) length of extradural material was measured on CT sagittal reconstruction (bone window) or T2W sagittal high field (1.5 T) MR images and reported relative to sagittal length of the second lumbar vertebra (mm). Percentage spinal cord compression was calculated by dividing the cross-sectional area of the spinal cord on transverse CT or magnetic resonance imaging (MRI) at the level of maximum compression by the cross-sectional area measured immediately cranial to the compression (Gomes et al., 2016). Follow-up information was obtained from re-examination appointments at the referral hospitals; dogs presenting with surgically confirmed recurrent TL-IVDE at each institution were recorded as a repeat case.

Statistical analysis

Data were analysed using IBM SPSS Statistics (version 29.0.1.0). Descriptive statistics were calculated for each parameter assessed. Data were assessed for normality using the Shapiro–Wilk test, and presented as median and range where not normally distributed. The variable under study was neuter status. With the exception of BCS, all other evaluated variables were measures of disease. As BCS could feasibly influence both neuter status and disease variables, BCS was considered a potential confounder. Data were analysed using a general linear model or binary logistic

Table 1. Grades of intervertebral disc extrusion clinical severity based on modified Frankel score (Scott, 1997)

Modified Frankel score	Presentation
Grade 0	No clinical signs of neurological dysfunction
Grade 1	Spinal hyperaesthesia, no neurological dysfunction
Grade 2	Ambulatory paraparesis
Grade 3	Non-ambulatory paraparesis
Grade 4	Paraplegic with intact nociception in pelvic limbs
Grade 5	Paraplegic with absent nociception in pelvic limbs and tail

regression with parameter estimates. A P value of <0.05 was considered statistically significant.

Data analysis was then repeated but with a reduced data set in which only dogs neutered at 9 months old or less were included in the early neuter group, and only those neutered at 14 months or older in the late neutered group.

RESULTS

Of 227 dogs initially identified, 73 dogs were excluded due to lack of data on neuter status or time of neutering, leaving 154 dogs that met the study inclusion criteria. Of these, 36 of 154 (23.3%) were early neutered, 69 of 154 (44.8%) were late neutered and 49 of 154 (31.8%) were intact. The median age of neutering was 0.58 years (range 0.17 to 0.92) for early neutered dogs and 1.50 years (range 1.00 to 6.17) for the late neutered dogs. Data are summarised in Table 2 and Figs S1 to S3.

The median age at presentation was 4.79 years for all dogs, 4.7 years (range 2.0 to 8.0) for early neutered dogs, 5.0 years (range 2.2 to 11.3) for late neutered dogs and 4.4 years (range 2.9 to 10.3) for intact dogs (P=0.18).

The BCS at presentation was available for 92 dogs; 21 early neutered, 44 late neutered and 27 intact dogs. The median BCS for all dogs was 5. There was no difference in BCS between early neutered (median, 5; range 4 to 8), late neutered (median, 5; range 4 to 8) and intact dogs (median, 5; range 3 to 8) (P=0.47). BCS was excluded as a potential confounder in this study given the lack of significant difference between neuter status groups and hence it was not taken forward to multi-variable statistical analysis.

There was no difference in duration of clinical signs between early neutered (median, 1 day: range 0 to 14), late neutered (median, 2: range 0 to 32) and intact dogs (median, 3: range 0 to 50) (P=0.59).

The median MFS at presentation was 3 for all dogs. There was no difference in MFS between early neutered (median, 3; range, 2 to 5), late neutered (median, 3; range, 2 to 5) and intact dogs (median, 3; range, 1 to 5) (P=0. 58).

Advanced imaging was available for review in 118 dogs. There was no difference in sagittal length of extradural material between early neutered (median, 1.2×L2; range 0.4 to 3.6), late neutered (median, 1.1; range 0.4 to 4.8) and intact dogs (median, 1.0; range 0.3 to 4.1) (P=0.49), nor in maximum spinal cord compression (median, 46%; range; 28 to 78, median, 44%; range 24 to 89, median, 50%; range 26 to 80 for early, late neutered and intact dogs respectively) (P=0.81).

Twenty-two dogs (14.3%) were re-presented for surgical management of a repeat TL-IVDE. Of these, seven were early neutered dogs (7/36, 19.4%), six were late neutered dogs (6/69, 8.7%) and nine were intact dogs (9/49, 18.4%), with no detected difference between groups (P=0.22).

Grouping dogs into those neutered at <12 months old *versus* those neutered at 12 months or older was selected based on protocols used in previous studies (Dorn & Seath, 2018; Hart et al., 2020). However, such grouping could compare dogs

Table 2. Summarised clinical variables for early neutered (<12 months), late neutered (≥12 months) and intact female Dachshunds with TL-IVDE and treated surgically

Neuter status	No. of dogs	Age at neutering (years)		Age at presentation		Body condition score		Duration of clinical signs before presentation (days)	
		Median	Range	Median (range)	Estimated coefficient (95% CI)	Median (range)	Estimated coefficient (95% CI)	Median (range)	Estimated coefficient (95% CI)
Early: <12 months	36	0.6	0.2 to 0.9	4.7 (2.0 to 8.0)	0.05 (−0.61 to 0.71)	5 (4 to 8)	0.35 (−0.16 to 0.87)	1 (0 to 14)	−1.42 (−4.37 to 1.54)
Late: ≥12 months	69	1.5	1.0 to 6.2	5.0 (2.2 to 11.3)	0.48 (−0.08 to 1.05)	5 (4 to 8)	0.40 (−0.03 to 0.83)	2 (0 to 32)	−0.17 (−2.69 to 2.36)
Intact	49	NA	NA	4.4 (2.9 to 10.3)	0	5 (3 to 8)	0	3 (0 to 50)	0
P value					0.18		0.47		0.59

Neuter status	Modified Frankel score		Sagittal length of extradural material relative to the length of L2		Maximum spinal cord compression (%)		No. of dogs presenting with repeat surgical TL-IVDE	
	Median (range)	Estimated coefficient (95% CI)	Median (range)	Estimated coefficient (95% CI)	Median (range)	Estimated coefficient (95% CI)	Number (%)	Odds ratio (95% CI)
Early: <12 months	3 (2 to 5)	0.23 (−0.20 to 0.66)	1.2 (0.4 to 3.6)	0.16 (−0.30 to 0.63)	46 (28 to 78)	0.02 (−0.05 to 0.09)	7 (19.4)	1.1 (0.4 to 3.2)
Late: ≥12 months	3 (2 to 5)	0.11 (−0.26 to 0.47)	1.1 (0.4 to 4.8)	0.23 (−0.16 to 0.63)	44 (24 to 89)	−.004 (−0.07 to 0.06)	6 (8.7)	0.4 (0.1 to 1.3)
Intact	3 (1 to 5)	0	1.0 (0.3 to 4.1)	0	50 (26 to 80)	0	9 (18.4)	1
P value	0.58		0.49		0.81		0.22	

CI Confidence interval, TL-IVDE Thoracolumbar intervertebral disc extrusion

differing in neutering age by as little as 1 day and is dependent on accurate recording of the date of birth and of neutering. To attempt to reduce the potential impact of this, data analysis was repeated using more disparate groupings: dogs neutered at 9 months old or less in the early neuter group, and at 14 months old or more in the late neutered group. This cohort consisted of 135 dogs in total; 29 early neutered, 57 late neutered and 49 intact dogs. The summarised clinical variables for this cohort are shown in Table S1. There was no difference in studied variables between early neutered, late neutered and intact dogs.

DISCUSSION

This study aimed to determine if neutering of female Dachshunds, and in particular early neutering before 12 months of age, was associated with a more severe clinical presentation of TL-IVDE. In our study population, there was no detected difference in age at onset, duration of clinical signs, severity of neurological deficits, extent of extradural material, maximum spinal cord compression nor recurrence of TL-IVDE between early neutered, late neutered and intact female Dachshunds.

Previous studies have documented an increased risk of IVDE in neutered Dachshunds, and that risk is further elevated in early neutered dogs (Dorn & Seath, 2018; Hart et al., 2020; Packer et al., 2016). We then hypothesised that neutering was associated with a more severe phenotype of TL-IVDE, specifically earlier onset, more severe neurological deficits and more extensive extruded disc material. However, within our study population, we found no significant difference in these variables suggesting that, while neutering appears to increase the risk of developing IVDE, it does not significantly alter the severity of the IVDE in affected individuals. That being said, the range in age at presentation, sagittal extent of extruded disc material and severity of associated spinal cord compression was considerable across all three groups, suggesting that this condition is highly heterogenous. As such, our relatively small group sizes might have failed to detect differences in the studied variables. A post-hoc sample size calculation using the mean age at presentation for early neutered dogs (5.03, standard deviation 1.31) compared to the mean of intact dogs (4.77), assuming a power of 80% and type 1 error rate of 0.05, estimates a required sample size of 200 dogs. A similar calculation but comparing late neutered and intact dogs (mean age of presentation 5.34, standard deviation 1.83) estimates a required sample size of 81. While it is important to acknowledge that post-hoc power calculations can have limited value (Zhang et al., 2019), future studies could consider enrolling a larger study population to ensure sufficient power across all evaluated variables.

A higher BCS has been documented in neutered dogs compared with intact dogs (Colliard et al., 2006; Edney & Smith, 1986). Furthermore, higher BCS has been identified as a risk factor for the development of IVDE in Dachshunds (Packer et al., 2016), as well as a contributor to other diseases, such as cranial cruciate ligament rupture (Adams et al., 2011). Interestingly, one study reported that an increase in BCS did not influence the rate of recovery in Dachshunds undergoing hemilaminectomy for the management of TL-IVDE (Gordon-Evans et al., 2018). In our study, there was no difference in median BCS between early neutered, late neutered and intact dogs, and hence BCS was not considered as confounder for further statistical analysis.

The MFS was used to grade severity of neurological deficits on presentation. A higher MFS at presentation has been associated with longer recovery times and poorer functional outcomes (Baumhardt et al., 2020; Ingram et al., 2013; Langerhuus & Miles, 2017). No difference in median MFS was detected between the three groups in this study, suggesting that neuter status and age of neutering do not affect the severity of clinical presentation in female Dachshunds with TL-IVDE. However, this result could be influenced by the small group sizes, limited discrimination affording by the ordinal nature of the MFS and/or inaccuracies inherent in deriving a MFS retrospectively from clinical records (Van Wie et al., 2013). Continuous scoring systems, such as the open field score (OFS) have improved discrimination and could be considered in future prospective studies (Olby et al., 2014).

This retrospective study has several important limitations. Only female Dachshunds were evaluated, data was collected from only two referral hospitals and the group sizes were small, which might have resulted in underpowering of the study. Dogs were categorised into early or late neutered groups but future studies could evaluate age of neutering as a continuous variable or consider alternative age cut offs for dichotomized analysis. While the duration of clinical signs before presentation was recorded, the nature and duration of prior medical management were not evaluated given the highly heterogenous treatments administered (and duration of those treatments) before referral. Two variables were recorded on advanced imaging: sagittal length of extradural material relative to the length of L2 and maximum spinal cord compression. Both variables have inherent limitations, including the inability to distinguish extradural haemorrhage from extruded nucleus pulposus, and the subjectivity of identifying the adjacent "non-compressed" spinal cord for comparison. Furthermore, both CT and MRI were used to calculate these variables with inevitable discrepancies in the precise sensitivities for bone and soft tissue discrimination between these imaging modalities. Intrinsic spinal cord changes (*e.g.* severity of contusive injury) were not evaluated in this study. Only female Dachshunds requiring surgical intervention were included to ensure a definitive diagnosis was reached, and there was no control population of female Dachshunds without IVDE. Follow-up information was limited to dogs that were re-presented to the referral hospital and required repeat surgical management, and hence is likely to underestimate the true number of dogs with recurrent TL-IVDE. Additionally, details of the recurrent extrusion (such as severity of neurological deficits, affected intervertebral disc) were not evaluated, nor was the rate and extent of recovery following surgical treatment.

In summary, there was no difference in age at presentation, duration of clinical signs, MFS, extent of extruded disc material, maximum spinal cord compression and recurrence of surgically

managed TL-IVDE between early neutered, late neutered and intact female Dachshunds. Future prospective studies to investigate the consequences of neutering on degeneration of the intervertebral discs (potentially via advanced imaging monitoring and histopathological evaluation) and subsequent development of IVDE would be worthwhile, alongside efforts to determine if there is an identifiable age of neutering at which the risk of IVDE decreases.

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Author contributions

Laura Doeven: Conceptualization (equal); data curation (lead); writing – original draft (lead). **Thomas Cardy:** Data curation (equal); writing – review and editing (supporting). **Abbe Harper Crawford:** Conceptualization (equal); data curation (equal); formal analysis (lead); supervision (lead); writing – review and editing (lead).

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Age at presentation (rounded to nearest year) of 154 female dachshunds presented with surgically treated TL-IVDE. Dogs were separated into early neutered (neutered at less than 12 months of age), late neutered (neutered at more than 12 months of age) and not neutered groups.

Figure S2. Comparison between age of neutering and age of presentation in 105 female dachshunds with surgically treated TL-IVDE. There was no statistically significant difference between the two groups in age at presentation for hemilaminectomy.

Figure S3. Body condition score (BCS) at presentation of 154 female dachshunds with surgically treated TL-IVDE. Dogs were separated into early neutered (neutered at less than 12 months of age), late neutered (neutered at more than 12 months of age) and not neutered groups.

Table S1. Summarised clinical variables for female dachshunds neutered at 9 months or less (early neutered group), 14 months or older (late neutered group) and intact dogs with surgically managed thoracolumbar intervertebral disc extrusion.