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Original article

Prevalence of lumbosacral transitional vertebrae in dogs in Berlin

H. Gong[1], P. Slunsky[1], L.G. Klass[1], L. Brunnberg[1]

[1] Department of Veterinary Medicine, Small Animal Clinic,
Freie Universitaet Berlin, Oertzenweg 19b, Building 20, 14163 Berlin, Germany

Abstract

Lumbosacral transitional vertebrae (LTV) are abnormally formed vertebrae of congenital origin. Dogs with LTV are predisposed to premature degeneration of the lumbosacral spine and hip dysplasia due to a weakened sacroiliac attachment. Moreover, LTV has been discussed as a cause of cauda equina syndrome. To date, LTV remain poorly understood and a diagnostic standard is yet to be established. This study examines prevalence, types and breed predispositions for LTV in the canine population in Berlin. The diagnostic value of laterolateral radiographs of the lumbosacral region, in addition to ventrodorsal radiographs, was also evaluated. The prevalence of LTV was assessed by reviewing ventrodorsal pelvic radiographs of 1030 dogs. LTV were detected in 95 (9.2%) dogs. The prevalence was higher in Pugs (63.6%) and Jack Russel Terriers (27.6%) than in the other breeds. The most common type of LTV was type II (37.9%), showing separation of the first sacral segment from the sacrum, the presence of a rudimentary intervertebral space between the first sacral segment and the rest of the sacrum, and symmetrically formed transverse processes. Laterolateral radiographs were available for 66 of 95 dogs with LTV and provided evidence of a rudimentary intervertebral disc space between the first and second sacral vertebrae in all cases of LTV type II and III (100%). The results of this study contribute to a better understanding of the condition. Furthermore, they demonstrate that laterolateral radiographs are a valuable addition to standard ventrodorsal radiographs and should be included in routine LTV screening protocols to provide a complete evaluation.

Key words: radiology, congenital disease, breed health, hip dysplasia, cauda equina

Introduction

A lumbosacral transitional vertebra (LTV) is an abnormally formed vertebra between the last normal lumbar vertebra and the first normal sacral vertebra (Morgan 1968). It is a congenital disorder and has morphologic characteristics of both lumbar and sacral vertebrae (Morgan 1968, Morgan 1999). Prevalence reports of LTV in dogs vary from 2.3% to 40.4%, depending on the evaluation criteria and the sample population (Winkler and Loeffler 1986, Morgan 1999, Damur-Djuric et al. 2006, Wigger et al. 2009, Lappalainen et al. 2012). In addition, a hereditary predisposition to LTV has been suggested (Morgan et al. 1993, Morgan et al. 1999, Morgan et al. 2000, Damur-Djuric et al. 2006, Wigger et al. 2009). An LTV can be clinically relevant, since it predisposes to premature degeneration of the lumbosacral junction and cauda equina syndrome, particularly

Correspondence to: H. Gong, e-mail: gonghe_0824@sina.com

Table 1. Lumbosacral transitional vertebrae (LTV) prevalence in dogs of different breeds in Berlin.

Breed	Number of dogs (n)	Dogs with LTV (%)	Type of LTV (n)		
			I	II	III
Pug	11	7 (63.6%)	1	3	3
Jack Russell Terrier	29	8 (27.6%)	2	1	5
Yorkshire Terrier	26	5 (19.2%)	2	2	1
Chihuahua	17	3 (17.6%)	1	1	1
French Bulldog	40	7 (17.5%)	0	6	1
Doberman Pinscher	12	2 (16.7%)	0	1	1
Beagle	19	3 (15.8%)	0	1	2
Australian Shepherd	13	2 (15.4%)	1	1	0
Tibetan Terrier	10	1 (10.0%)	0	1	0
Dachshund	31	3 (9.7%)	1	0	2
Other breeds	309	28 (9.1%)	11	9	8
Labrador Retriever	74	6 (8.1%)	2	3	1
Poodle	14	1 (7.1%)	0	1	0
Golden Retriever	30	2 (6.7%)	0	0	2
German Shepherd	53	3 (5.7%)	1	0	2
Boxer	36	2 (5.6%)	0	1	1
Rottweiler	40	2 (5.0%)	0	0	2
Mixed breed	210	10 (4.8%)	4	5	1
Bernese Mountain Dog	27	0 (0.0%)	0	0	0
Border Collie	10	0 (0.0%)	0	0	0
Bulldog	19	0 (0.0%)	0	0	0
Total	1030	95 (9.2%)	26	36	33

in German Shepherds (Morgan et al. 1993, Flückiger et al. 2006). Moreover, asymmetric LTV types may lead to pelvic misalignment beyond the vertical axis, causing a unilateral load increase on the hip joint, which results in detrimental development of the hip joint (Larsen 1977, Damur-Djuric et al. 2006, Flückiger et al. 2009). The aim of this study was to assess the prevalence of LTV in the canine population in Berlin and the value of laterolateral radiographs of the lumbosacral spine in the diagnosis of LTV.

Materials and Methods

This study is based on the retrospective analysis of pelvic radiographs in dogs, taken at the Small Animal Clinic, Department of Veterinary Medicine at the Freie Universität Berlin (Berlin, Germany) between 2012 and 2016. Cases with poor radiographic technique, unacceptable projection of the pelvis and the vertebrae, failure to project L6 and L7, or superimposition due to a dense fecal mass or a dense penis bone, were excluded from the study. For all dogs that met the inclusion criteria for evaluating LTV, at least one standard ventrodorsal pelvic radiograph with extended pelvic limbs was available and evaluated. In some dogs, laterolateral radiographs of the lumbosacral spine were also available and evaluated regarding the intervertebral disc space between the first and second sacral vertebra, based on the visibility of a radiolucent line.

All radiographs were evaluated by two of the authors (HG; LB). LB is a board certificated radiologist and HG is a doctor of veterinary medicine. The diagnosis of LTV was based on consensus. An LTV seen on a ventrodorsal projection was diagnosed and classified as one of four types, based on the morphology of the lumbosacral spine, according to the scheme described by Flückiger et al. (2009). In type 0, the lumbosacral spine is shaped normally. In type 1, the spinous process of the first sacral vertebra is separated from the median sacral crest without signs of rudimental intervertebral disc space between the first sacral segment and the remaining sacrum. In type 2, the LTV is completely separated from the sacrum, transverse processes are symmetrical, but their attachments to the pelvis can vary. In type 3, the transverse processes of the LTV are asymmetrical.

The prevalence of LTV was determined individually for 20 different breeds, each of which was represented

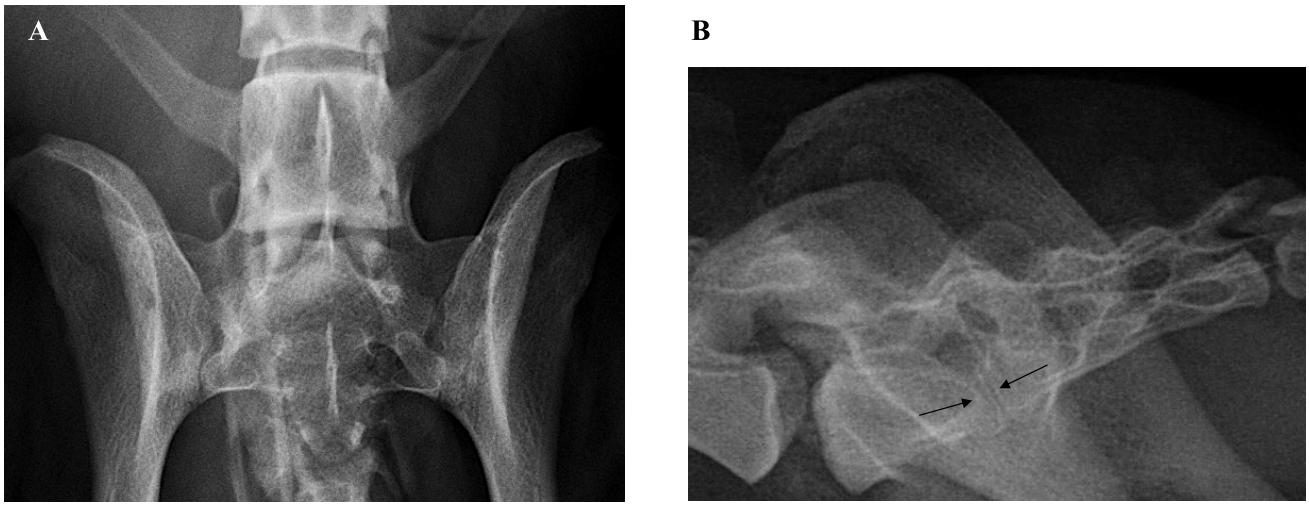

Fig. 1. Ventrodorsal (A) and laterolateral (B) projections of a 12-year-old male Fox Terrier with LTV type II. This type is characterized by a separated spinous process of the first sacral vertebra from the median sacral crest seen in (A), and a rudimentary intervertebral disc space between the first and second sacral segment appearing as a slit-like, radiolucent line (black arrows) seen in (B). In this case, a rudimentary intervertebral disc space is easily overlooked in a ventrodorsal projection.

by at least 10 dogs in the total sample. Less common breeds were combined as "other breeds".

The statistical analysis was conducted using SPSS (Version 24, IBM, USA) and included descriptive statistics. The $\chi 2$- test was used to assess associations between LTV occurrence and the patient's sex and breed. Significance was determined as $p<0.05$.

Results

From all 1076 dogs, 1030 dogs (497 males and 533 females) fulfilled the inclusion criteria and were evaluated for the presence of LTV. Their age ranged from 4 months to 16 years (median 6.3 years). An LTV was diagnosed in 95 dogs (9.2%); 48 (50.5%) males and 47 (49.5%) females. There was no association between the patient's sex and LTV ($p>0.05$).

The breed predisposition for LTV in this study population varied between 0% to 63.6% (Table 1). It was significantly higher in Pugs (63.6%; $p<0.01$) and Jack Russel Terriers (27.6%; $p<0.01$) on comparing each of these breeds to the total sample. In mixed breed dogs, which accounted for about one-fifth of the sample (20.4%), only 10 dogs (4.8%) were diagnosed with LTV, which was significantly lower ($p<0.05$) compared to the total sample.

Among the 95 dogs diagnosed with LTV, the most common type was type II (37.9%) (Fig.1). Type I was detected in 26 dogs (27.4%), while the asymmetric type (Type III) was found in 33 dogs (34.7%). LTV was diagnosed using both ventrodorsal and laterolateral projections in 66 dogs (69.5%), of which 16 dogs (24.2%) presented with type I, 26 dogs (39.4%) with type II and 24 dogs (36.4%) with type III. Of the 26 dogs with a separated spinous process on the ventrodorsal projection, more than half of the dogs (61.5%) were accompanied by laterolateral views, in which no rudimentary intervertebral disc space was detected. A rudimentary intervertebral disc space was evident in 26 of the type II dogs and confirmed through laterolateral projections (100%) (Fig.1).

Discussion

In the present study, the overall prevalence of LTV was 9.2%. Some data, however, were obtained from dogs that presented for diagnosis of hip dysplasia and cauda equina syndrome, which could have resulted in an increased prevalence of LTV, as LTV is suspected to contribute to the development of hip dysplasia and cauda equina syndrome. Previous studies have documented prevalences of LTV between 2.3% and 40.4% (Winkler and Loeffler 1986, Morgan 1999, Damur-Djuric et al. 2006, Wigger et al. 2009, Lappalainen et al. 2012). This discrepancy may reflect natural fluctuations of different study populations and, more importantly, the difference in classification schemes. LTV classification schemes differ in their morphological evaluation criteria, the number of grades, and in the type of radiograph used to classify LTV types.

Our findings closely match those of a study conducted in the Czech Republic (Fialová et al. 2014) that found LTV prevalence at 10% using the same classification scheme as described in this study. An alternative classification scheme proposed by Damur-Djuric et al. (2006) focused exclusively on morphological variations of transverse processes on the ventrodorsal views. This method can be useful in assessing LTV symmetry

and the clinical relevance for individual cases, but has limited suitability for prevalence assessments, since it is does not include LTV cases that show spinous process separation between the first sacral vertebra and the median sacral crest or a rudimentary intervertebral disc space. Studies that did not classify a sacrum with a separated spinous process of the first sacral vertebra as an LTV generally found lower prevalences. A study conducted in the USA found an LTV prevalence of 2.5% (Morgan 1999), while a study from Switzerland found 3.5% (Flückiger et al. 2006) and a German study described 5% (Winkler and Loeffler 1986). Furthermore, a study (Lappalainen et al. 2012) that classified a normally developed eighth lumbar vertebra as an LTV found a much higher prevalence (40.4%) compared to this study. However, whether an eighth lumbar vertebra can be considered an LTV remains disputed. The classification scheme used in this study is based on Flückiger et al. (2009) and does not include normally developed additional lumbar or sacral vertebrae as LTV. Moreover, it identifies separation of the spinous process of the first sacral vertebra as an independent feature, rather than a morphological variation of the transverse process.

Unlike previous studies, German Shepherds had a lower LTV prevalence (5.7%) compared to the total sample in this study. Many studies have suggested a genetic predisposition of German Shepherds for LTV (Morgan et al. 1993, Damur-Djuric et al. 2006, Flückiger et al. 2006, Wigger et al. 2009). However, these studies used a different classification scheme and generally had higher numbers of German Shepherds in their study samples. To the best of our knowledge, this is the first report of a below-average LTV prevalence in German Shepherds.

Few studies have analyzed LTV occurrence in mixed breed dogs as an independent group. In this study, the prevalence of LTV in mixed breed dogs (4.8%) was below average. This is in agreement with one study (Ziegler 1990), in which the prevalence in mixed breed was reported to be 7%, suggesting a predisposition of purebred dogs for LTV.

To date, studies on LTV prevalence have mostly focused on medium and large breed dogs, since pelvic radiographs of these dog types are more frequently available due to routine hip screening (Larsen 1977, Winkler and Loeffler 1986, Damur-Djuric et al. 2006, Fialová et al. 2014). Interestingly, our study found that small breed dogs, such as Pugs (63.6%) and Jack Russel Terriers (27.6%) had significantly higher prevalences of LTV than other breeds. Since the radiographs included in this study were taken for a variety of diagnostic purposes, this could account for some of the differences in breed representation compared to other studies. Our findings suggest a breed predisposition for LTV in Pugs and Jack Russel Terriers. However, they are limited by the modest sample size. Future studies are warranted and, ideally, should assess LTV prevalence in a larger study sample.

Although this study includes the separation of the spinous process of the first sacral vertebra from the median sacral crest as a mild LTV type, the overall LTV prevalence (9.2%) was not markedly higher compared to studies that did not include this feature. Moreover, these studies have suggested that this feature is often unidentified and contributes to much higher LTV prevalences of 29% and 40.4% (Wigger et al. 2009, Lappalainen et al. 2012), which is contrary to the findings in this study.

Contrary to previous reports, our study found that symmetric LTV was more frequent than asymmetric LTV (Damur-Djuric et al. 2006, Flückiger et al. 2006, Wigger et al. 2009). However, the classification scheme differences between previous reports and this study must be considered with this finding. Firstly, the symmetric LTV type that presents as a sacrum with a separated spinous process of the first sacral vertebra was not included in previous reports. According to the Rosenberg hypothesis (Rosenberg 1907), this LTV type is facilitated by the presence of contact points between the pelvis and the vertebrae at the same level on both sides during the development of the animal. Hence, it represents a symmetric LTV. Secondly, the asymmetry of an LTV was based on the iliac attachment of the transverse processes in the present study, which differs from Wigger et al. (2009), who defined LTV with different appearances of the transverse processes on both sides without iliac contact as asymmetric, without assessing LTV angulation, asymmetric sacroiliac attachments and pelvic obliquity.

In the present study, an LTV was routinely observed on ventrodorsal radiographs that were taken with pelvic limbs in extension. However, a rudimentary intervertebral disc space between an LTV and the sacrum was difficult to evaluate on ventrodorsal views only, due to the diagonal placement of the rudimentary space towards the radiographic surface. One study demonstrated that intervertebral disc space was easier to visualize on ventrodorsal views with abducted pelvic limbs rather than extended, which resulted in better LTV identification (Damur-Djuric et al. 2006). Due to its retrospective nature, advantages of different radiographic positioning for ventrodorsal radiographs could not be evaluated in this study. Nevertheless, our study demonstrates that the presence of rudimentary intervertebral space can be evaluated correctly through laterolateral projections, which is in agreement with other studies (Breit and Künzel 1998, Morgan 1999, Morgan et al. 2000), but can easily be overlooked in ventrodorsal projections. Identi-

fication of a separated spinous process of the first sacral segment from ventrodorsal radiographs is sufficient, and laterolateral radiographs are more reliable for evaluation of the presence of rudimentary intervertebral space. Moreover, misinterpretation could occur in cases where the changes of an LTV are minimal and symmetrical or when the penis bone overlaps the lumbosacral connection (Larsen 1977, Morgen et al. 1993). With laterolateral radiographs, the differentiation between LTV type I and II can be identified correctly. Consequently, routine LTV screening protocols should include ventrodorsal and laterolateral radiographs.

An LTV is often identified as a secondary finding during routine hip dysplasia screening. Since a significant correlation between the two pathologies has been described (Damur-Djuric et al. 2006, Komsta et al. 2015, Flückiger et al. 2017) and genetic predispositions have been suggested for some breeds (Morgan et al. 1993, Morgan et al. 1999, Damur-Djuric et al. 2006, Wigger et al. 2009), the clinical interest in LTV has increased. Due to the close relationship between the pathologies and their clinical relevance, LTV diagnosis and classification should be included in standard hip dysplasia screening to aid breed health.

References

Breit S, Künzel W (**1998**) Osteologische Besonderheiten an Wirbelsäulen von Rassehunden: eine röntgenologische und morphologische Studie [Special osteological features in the spine of pure-bred dogs: a radiograohic and morphologic study]. Wien Tierärztl Mschr 85: 340-350.

Damur-Djuric N, Steffen F, Hassig M, Morgan JP, Flückiger MA (**2006**) Lumbosacral transitional vertebrae in dogs: classification, prevalence, and association with sacroiliac morphology. Vet Radiol Ultrasound 47: 32-38.

Fialová I, Paninárová M, Nečas A, Stehlík L, Proks P (**2014**) Prevalence of lumbosacral transitional vertebrae in dogs in the Czech Republic. Acta Vet Brno 83: 399-403.

Flückiger MA, Damur-Djuric N, Hassig M, Morgan JP, Steffen F (**2006**) A lumbosacral transitional vertebra in the dog predisposes to cauda equina syndrome. Vet Radiol Ultrasound 47: 39-44.

Flückiger MA, Geissbühler U, Lang L (**2009**) Lumbosakrale Übergangswirbel: Welche Bedeutung haben sie für die Gesundheit von betroffenen Hunden? [Lumbosacral transitional vertebrae: what is their impact on the health of affected dogs?]. Schweiz Arch Tierheilkd 151: 133-135.

Flückiger MA, Steffen F, Hassig M, Morgan JP (**2017**) Asymmetrical lumbosacral transitional vertebrae in dogs may promote asymmetrical hip joint development. Vet Comp Orthop Traumatol 30: 137-142.

Komsta R, Łojszczyk-Szczepaniak A, Dębiak P (**2015**) Lumbosacral Transitional Vertebrae, Canine Hip Dysplasia, and Sacroiliac Joint Degenerative Changes on Ventrodorsal Radiographs of the Pelvis in Police Working German Shepherd Dogs. Top Companion Anim Med 30: 10-15.

Lappalainen AK, Salomaa R, Junnila J, Snellman M, Laitinen-Vapaavuori O (**2012**) Alternative classification and screening protocol for transitional lumbosacral vertebra in German shepherd dogs. Acta Vet Scand 54: 27.

Larsen JS (**1977**) Lumbosacral Transitional Vertebrae in the Dog. Vet Radiol Ultrasound 18: 76-79.

Morgan JP (**1968**) Congenital anomalies of the vertebral column of the dog: a study of the incidence and significance based on a radiographic and morphologic study. Vet Radiol Ultrasound 9: 21-29.

Morgan JP (**1999**) Transitional lumbosacral vertebral anomaly in the dog: a radiographic study. J Small Anim Pract 40: 167-172.

Morgan JP, Bahr A, Franti CE, Bailey CS (**1993**) Lumbosacral transitional vertebrae as a predisposing cause of cauda equina syndrome in German shepherd dogs: 161 cases (1987-1990). J Am Vet Med Assoc 202: 1877-1882.

Morgan JP, Wind A, Davidson AP (**1999**) Bone dysplasias in the labrador retriever: a radiographic study. J Am Anim Hosp Assoc 35: 332-340.

Morgan JP, Wind A, Davidson AP (**2000**) Transitional lumbosacral vertebrae. In: Morgen JP, Wind A, Davidson AP (eds) Hereditary bone and joint diseases in the dog: osteochondroses, hip dysplasia, elbow dysplasia. Schlütersche, Hannover, pp 223-229.

Rosenberg E (**1907**) Bemerkungen über den Modus des Zustandekommens der Regionen an der Wirbesäule des Menschen [Comments on the mode of formation of spnial regions in humans]. Morph Jahrb 36: 609-659.

Wigger A, Julier-Franz C, Tellhelm B, Kramer M (**2009**) Lumbosakraler Übergangswirbel beim Deutschen Schäferhund: Häufigkeit, Formen, Genetik und Korrelation zur Hüftgelenksdysplasie [Lumbosacral transitional vertebrae in the German shepherd dog: prevalence, classification, genetics, and association with canine hip dysplasia]. Tierärztl Prax K: Kleintiere/Heimtiere 37: 7-13.

Winkler W, Loeffler K (**1986**) Lumbosakrale Übergangswirbel beim Hund [Lumbosacral transitional vertebrae in the dog]. Berl Münch Tierärztl Wochenschr 99: 343-346.

Ziegler G **(1990)** Assimilationsstörungen im lumbosakralen Übergangsbereich der Wirbelsäule bei Hund und Katze [Assimilation disorders in the lumbosacral transition area of the spine in the dog and cat]. Doctoral thesis, Freie Universitaet Berlin, Berlin.