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ORIGINAL RESEARCH

Long-term outcomes in dogs with elbow dysplasia, assessed using the canine orthopaedic index

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Abstract

Background: Elbow dysplasia (ED) is an important cause of lameness in dogs. This study aimed to report long-term outcomes in dogs with elbow osteoarthritis.

Methods: Demographic data, medical management, and scores from The American College of Veterinary Surgeons' Canine Orthopaedic Index (COI) were collected from owners of dogs radiographically screened for ED, graded as normal, mild, or moderate. Telephone interviews were performed in 2017 (Q1), followed by an email survey in 2020 (Q2). The association between ED grade and deterioration in COI scores over time was evaluated with logistic regression.

Results: A total of 765 replies were collected for Q1 and 293 for Q2. At Q2, 222 dogs (76%) were alive, with a median age of 8 years (range 5–12 years). No association was found between ED and changes in COI score over time or between ED and survival ($p = 0.071$). Dogs with mild and moderate ED were treated with analgesic medications to a higher degree than dogs without ED ($p < 0.05$).

Limitations: Only owner-assed data were assessed; no clinical orthopaedic examination or follow-up radiographic evaluation was performed.

Conclusions: No association was found between the grade of ED and the worsening of clinical signs in dogs with elbow osteoarthritis.

INTRODUCTION

Elbow dysplasia (ED) is an important cause of thoracic limb lameness (hereafter referred to as lameness) in dogs and denotes a group of developmental conditions affecting the elbow joint.[1] These conditions include medial coronoid process disease (MCPD), ununited anconeal process (UAP), osteochondrosis dissecans of the medial humeral condyle and joint incongruity.[1–5] MCPD is the most frequent form of ED.[6–8] ED causes abnormal development of the elbow joint, leading to degenerative changes and osteoarthritis (OA).[1,9,10] Surgical and medical management have been described, all aiming to reduce the progression of OA.[5,8,11–18] The aetiology of the ED disease complex is not fully understood, but it is regarded as multifactorial with a polygenic mode of inheritance.[1,19,20] Environmental variables also have a role in the development of ED in predisposed individuals.[21,22]

Since ED is considered a hereditary condition, screening schemes have been adopted. The Swedish Kennel Club's (SKC) screening scheme for ED is based on guidelines provided by the International Elbow Working Group (Figure 1).[23] A quantitative scoring scheme is used for dogs over 12 months of age and involves one mediolateral radiograph of the elbow in a flexed position. The radiograph is submitted to the SKC for scrutiny and grading by a panel of veterinary specialists. The ED screening programme aims to record any signs of OA without diagnosing the primary pathology causing the OA.[23,24]

To evaluate larger numbers of dogs over longer periods, validated clinical metrology instruments, or questionnaires, can be used. Questionnaires can be applied to quantify owners' behaviour-based assessment of an animal's perceived pain and how it affects the animal's daily life.[25–28] The American College of Veterinary Surgeons' canine orthopaedic index (COI)

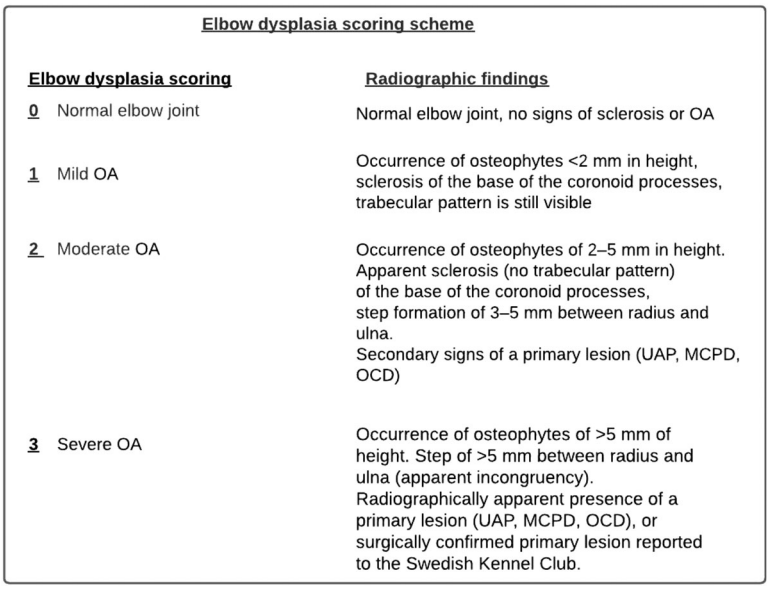

FIGURE 1 The Swedish Kennel Club's elbow dysplasia (ED) scoring system, modified from the International Elbow Working Group guidelines.[23,24] MCPD, medial coronoid process disease; OA, osteoarthrosis; OCD, osteochondrosis dissicans; UAP, ununited anconeal process

was developed to measure owners' perceptions of outcome in dogs with orthopaedic diseases and has been validated in blinded, placebo-controlled studies.[29–31]

Data regarding long-term outcomes and survival in dogs with ED are relatively sparse. In a previous study, we used Bayesian network analysis to report on the long-term prognosis for quality of life in a cohort of dogs, not primarily seeking veterinary care, diagnosed with mild and moderate OA through an ED screening programme.[32] The present study aimed to report the long-term owner-assessed outcome of ED and survival in the same cohort of dogs. Additionally, risk factors for the worsening of the COI score over time were evaluated.

MATERIALS AND METHODS

Study design and questionnaire

A cohort study was performed using a questionnaire involving the COI.[29–31] An initial questionnaire study was conducted in 2017 (Q1),[32] and a follow-up study was performed in 2020 (Q2). Five breeds frequently diagnosed with ED were selected: American Staffordshire Terrier, Bernese Mountain dog, German Shepherd dog, Labrador Retriever and Rottweiler.[33–36] Dogs from the selected breeds that had been radiologically screened for ED within the SKC's screening programme between January 2011 and January 2015 were eligible for inclusion. The radiological evaluation of the elbow joint was performed by the SKC and was based on signs of OA and/or any primary ED lesion. The minimum score was 0 for a normal joint (ED0), 1 for a mildly affected joint (ED1), 2 for a moderately affected joint (ED2) and the maximum possible score was 3 (ED3) for a severely affected joint (Figure 1). Sixty dogs from each of the five breeds and from each of the following ED groups—ED0, ED1 and ED2—were randomly chosen from the SKC's database. The selection and randomisation were performed using the random number method. The owners of the selected dogs were then invited to participate in the study via mail. Owners who accepted the invitation were contacted by telephone for the Q1 study, and a total of 765 questionnaires were collected between January and December 2017. The results from this study have been published previously.[32] To evaluate the long-term outcome of ED, the participants from the Q1 study were contacted again at least 2 years after the first interview and asked to participate in the web-based Q2 study.

The Q2 study included owner-reported data on lameness, treatment and analgesic medication for the past 4 weeks. Additionally, a validated Swedish translation of the COI was employed.[37] The translated COI survey includes 16 questions separated into five categories: stiffness, function, lameness, quality of life and the owner's perception. Each category contains 1–5 questions with a response scale ranging from 1 to 5, where 1 is the least severe and 5 is the most severe alternative.

Inclusion and exclusion criteria

Inclusion criteria were the completion of Q1 and Q2 questionnaires. Dogs that were euthanased or had changed owners during the period between Q1 and Q2 were excluded from the statistical analyses, except for the survival analysis where euthanased dogs were included. Dogs whose owners did not respond to Q2 were excluded. Dogs with severely affected elbow joints (ED3) were excluded from the study due to their being too few cases for statistical analysis.

Risk factors

The degree of ED was defined as the main exposure and included three groups: ED0, ED1 and ED2. The variables breed, age, sex, lameness, veterinary and/or rehabilitation treatment, analgesic medication due to elbow disease during the last 2 years, hip dysplasia (no—grades A and B and yes—grades C, D and

E), other orthopaedic diseases (yes/no) and surgical treatment of ED were included as potential determinants. The age variable was based on the age at Q2 and was divided into three categories: 5–7 years, 8–9 years and more than 9 years.

Statistical analysis

Associations between variables were evaluated with the chi-squared test and Fisher's exact test (categorical variables), one-way ANOVA (normally distributed continuous variables and categorical variables) or Kruskal–Wallis one-way ANOVA (non-normally distributed continuous variable and categorical variable). The Shapiro–Wilk test was used to evaluate the normal distribution of the continuous variables. Correlations between variables were evaluated by Goodman and Kruskal's gamma.

A standardised score was calculated for each COI category by dividing the raw score by the maximum score, which resulted in a standardised score ranging between 0.2 and 1. The standardised scores were dichotomised as follows: a score of 0.2 was considered good, and a score greater than 0.2 was considered poor.[32] The standardised score for Q1 was subtracted from the standardised score for Q2 for each category to evaluate deterioration during the follow-up period. The resulting difference was dichotomised as 'same/better' (same standardised score or improvement from Q1 to Q2) or 'worse' (deterioration from Q1 to Q2).

Logistic regression models were used to estimate the effect of ED grade and other determinants on the change in standardised score from Q1 to Q2 for each COI category. A causal diagram was constructed to identify possible confounders. In addition, a 20% coefficient change with the potential confounder included in the model was used to assess confounding. All variables with p-values less than 0.2 in the univariable analysis were considered for inclusion in the multivariable model. The variable for ED was forced into the models since it was the main exposure under investigation. Manual stepwise backwards elimination was used for variable selection, and p-values less than 0.05 were considered to indicate statistically significant differences. The models were compared using the likelihood ratio test, and the significance of individual predictors was evaluated using the Wald test. Biologically plausible interactions were included in the model-building process. Influential observations were examined by visualising the Cook's distance values, and the variance inflation factor was used to evaluate multicollinearity in the final models. A coefficient, an odds ratio with a 95% confidence interval and a p-value were calculated for each variable. Kaplan–Meier survival curves were used to assess differences in survival time for the ED groups, and the log-rank test was used to compare the survival curves. If it was alive at that point, a dog was considered censored in the analysis at the time of follow-up (Q2). All statistical analyses were conducted in R.[38]

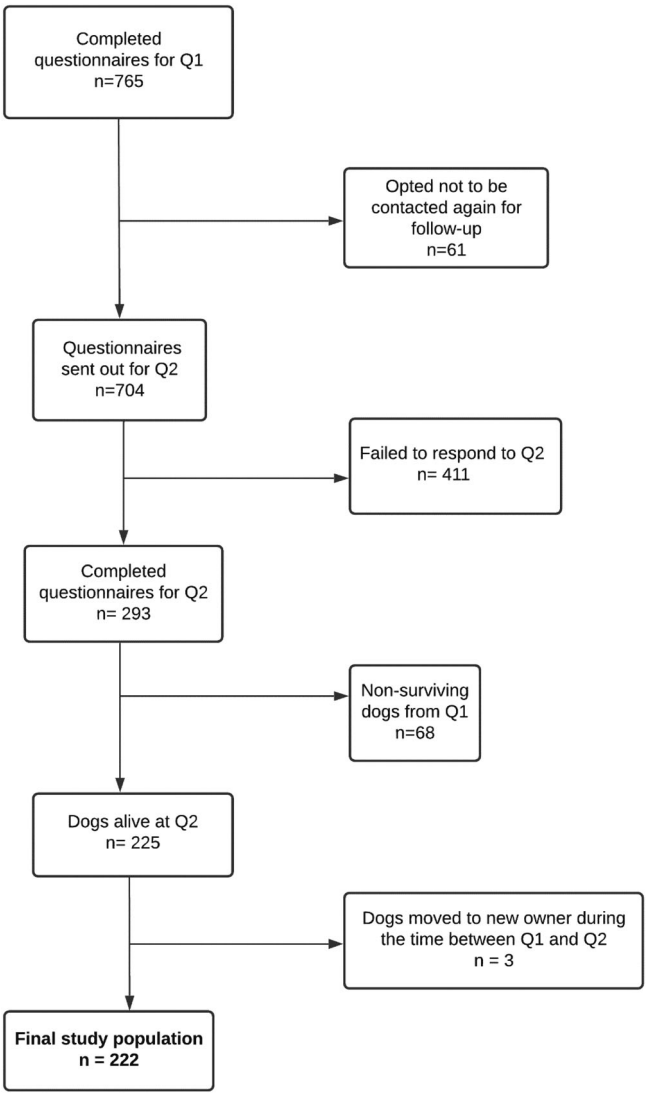

FIGURE 2 Flowchart for the participants in this study evaluating long-term outcomes in dogs with elbow dysplasia

RESULTS

Animals

A total of 704 owners from the Q1 study were contacted again for the Q2 study (61 owners from the Q1 study opted not to be contacted again). Out of the 704 owners contacted, 411 were excluded due to failure to return the Q2 questionnaire. Altogether, 293 owners responded to the Q2 questionnaire. Three dogs had changed owners and 68 had been euthanased since Q1, leaving a total of 222 dogs. The Q2 questionnaire was completed online between January and February 2020, and the median time between Q1 and Q2 was 2.8 years (range 2.2–3.1 years). A flowchart of participants is shown in Figure 2.

An overview of the demographics and treatment variables is presented in Table 1. Pairwise comparisons revealed that dogs with ED2 had a higher frequency of lameness during the preceding month than dogs with ED0 and ED1 ($p < 0.05$ for both comparisons). In addition, compared with dogs in the ED0 group, more dogs in the ED1 and ED2 groups

TABLE 1 Overview of the demographics and treatment variables in a cohort of dogs with elbow dysplasia (ED) scores ranging from 0 (normal joint) to 2 (moderately affected joint)

	ED0	ED1	ED2	Total	*p*-Value
Overall number of dogs	75	82	65	222	0.373
Time Q1 to Q2 (years)					0.732
Mean	2.8	2.8	2.8	2.8	
Median	2.7	2.8	2.7	2.8	
Range (minimum–maximum)	2.4–3.1	2.3–3.1	2.1–3.1	2.2–3.1	
Breed					0.939
American Staffordshire Terrier	8 (38.1%)	8 (38.1%)	5 (23.8%)	21	
Bernese Mountain dog	15 (36.6%)	15 (36.6%)	11 (26.8%)	41	
German Shepherd dog	19 (31.7%)	20 (33.3%)	21 (35.0%)	60	
Labrador Retriever	20 (30.8%)	28 (43.1%)	17 (26.2%)	65	
Rottweiler	13 (37.2%)	11 (31.4%)	11 (31.4%)	35	
Sex					0.753
Female	41 (34.8%)	45 (38.1%)	32 (27.1%)	118	
Male	34 (32.7%)	37 (35.6%)	33 (31.7%)	104	
Age (years, at Q2)					0.359
Mean	8.1	8.3	8.4	8.3	
Median	7.9	8.3	8.5	8.1	
Range (minimum–maximum)	5.4–11.5	5.6–11.1	5.7–11.2	5.4–11.5	
Not available	0	0	1		
HD					<0.001
A	44 (41.1%)	37 (34.6%)	26 (24.3%)	107	
B	21 (35.0%)	17 (28.3%)	22 (36.7%)	60	
C	3 (12.5%)	17 (70.8%)	4 (16.7%)	24	
D	3 (15.0%)	5 (25.0%)	12 (60.0%)	20	
E	0 (0.0%)	1 (50.0%)	1 (50.0%)	2	
Not available	4 (44.4%)	5 (55.6%)	0 (0.0%)	9	
Thoracic limb lameness in the last month					0.020
Yes	18 (27.7%)	19 (29.2%)	28 (43.1%)	65	
No	56 (36.6%)	60 (39.2%)	37 (24.2%)	153	
Not available	1 (25.0%)	3 (75.0%)	0 (0.0%)	4	
Analgesic medication during the last 2 years[a]					<0.001
Yes, elbow	5 (10.0%)	23 (46.0%)	22 (44.0%)	50	
Yes, other joint	9 (29.0%)	12 (38.7%)	10 (32.3%)	31	
No	59 (42.7%)	47 (34.1%)	32 (23.2%)	138	
Not available	2 (66.7%)	0	1 (33.3%)	3	
Elbow surgery during the last 2 years					1
Yes	1 (33.3%)	1 (33.3%)	1 (33.3%)	3	
No	74 (34.3%)	81 (37.5%)	61 (28.2%)	216	
Not available	0 (0.0%)	0 (0.0%)	3 (100%)	3	
Rehabilitation treatment during the last 2 years[a]					0.023
Yes, elbow	2 (11.8%)	7 (41.2%)	8 (47.0%)	17	
Yes, other joint	11 (50%)	3 (13.6%)	8 (36.4%)	22	
No	62 (33.9%)	72 (39.3%)	49 (26.8%)	183	
Sought veterinary care due to elbow disease during the last 2 years					0.005
Yes	9 (19.6%)	15 (32.6%)	22 (47.8%)	46	
No	66 (37.5%)	67 (38.1%)	43 (24.4%)	176	
Other orthopaedic disease					0.210
Yes	13 (24.1%)	22 (40.7%)	19 (35.2%)	54	
No	62 (36.9%)	60 (35.7%)	46 (37.4%)	168	

Note: HD (A–E): no—grades A (no signs of hip dysplasia) and B (near normal hip joints); yes—grades C (mild dysplasia), D (moderate dysplasia) and E (severe dysplasia) (Fédération Cynologique Internationale).
Abbreviations: HD, hip dysplasia; Q1, initial questionnaire; Q2, follow-up questionnaire.
[a]Analgesic medication and rehabilitation treatment during the last 2 years. 'Yes, elbow' refers to the treatment being given specifically for elbow-related causes, and 'Yes, other joint' refers to the treatment being given for treatment of other joints than the elbow joint.

TABLE 2 Overview of the score of the second questionnaire (Q2) and the change in questionnaire score from the first (Q1) to the second survey in a cohort of dogs monitored for progression of elbow dysplasia (ED)

	ED0	ED1	ED2	Total	*p*-Value
Stiffness score, Q2					0.008
Good	42 (56%)	32 (39%)	20 (30.8%)	94 (42.3%)	
Poor	33 (44%)	50 (61%)	45 (69.2%)	128 (57.7%)	
Stiffness score, change					0.028
Same/better	46 (61.3%)	37 (45.1%)	26 (40%)	109 (49.1%)	
Worse	29 (38.7%)	45 (54.9%)	39 (60%)	113 (50.9%)	
Function score, Q2					0.013
Good	57 (76.0%)	51 (62.2%)	34 (52.3%)	142 (64.0%)	
Poor	18 (24.0%)	31 (37.8%)	31 (47.7%)	80 (36.0%)	
Function score, change					0.031
Same/better	59 (78.7%)	55 (67.1%)	37 (56.9%)	151 (68.0%)	
Worse	16 (21.3%)	25 (30.5%)	27 (41.5%)	68 (30.6%)	
Not available	0 (0.0%)	2 (2.4%)	1 (1.6%)	3 (1.4%)	
Lameness score, Q2					0.028
Good	42 (56.0%)	32 (39.0%)	23 (35.4%)	97 (43.7%)	
Poor	33 (44.0%)	50 (61.0%)	42 (64.6%)	125 (56.3%)	
Lameness score, change					0.477
Same/better	48 (64.0%)	47 (57.3%)	35 (53.8%)	130 (58.6%)	
Worse	27 (36.0%)	34 (41.5%)	30 (46.2%)	91 (41.0%)	
Not available	0 (0.0%)	1 (1.2%)	0 (0.0%)	1 (0.4%)	
Quality of life score, Q2					0.053
Good	52 (69.3%)	49 (59.8%)	32 (49.2%)	133 (59.9%)	
Poor	23 (30.7%)	33 (40.2%)	33 (50.8%)	89 (40.1%)	
Quality of life score, change					0.836
Same/better	55 (73.3%)	56 (68.3%)	45 (69.2%)	156 (70.3%)	
Worse	20 (26.7%)	25 (30.5%)	20 (30.8%)	65 (29.3%)	
Not available	0 (0.0%)	1 (1.2%)	0 (0.0%)	1 (0.4%)	
Owner's perception score, Q2					0.023
Good	51 (68.0%)	52 (63.4%)	30 (46.2%)	133 (59.9%)	
Poor	24 (32.0%)	30 (36.6%)	35 (53.8%)	89 (40.1%)	
Owner's perception score, change					0.074
Same/better	47 (62.6%)	54 (65.8%)	34 (52.3%)	135 (60.8%)	
Worse	14 (18.7%)	18 (22.0%)	23 (35.4%)	55 (24.8%)	
Not available	14 (18.7%)	10 (12.2%)	8 (12.3%)	32 (14.4%)	

Note: A good outcome is defined as a weighted score of 0.2, while a poor outcome is a weighted score greater than 0.2. Same/better is defined as a better or decreased score in Q2, compared to Q1. Worse is defined as an increased score in Q2, compared to Q1. The ED grade reported here represent the initial grouping (ED0-ED2) at Q1. The non-available results are due to missing values on Q1.

were treated with analgesic medication ($p < 0.05$ for both comparisons). A comparison of the demographics and results of responders and non-responders for Q2 is presented in datasheet 1 in Supporting Information S1.

Results from the canine orthopaedic index

The dichotomised scores at Q2 as well as the change from Q1 to Q2 for each ED group are presented in Table 2.

High correlations (0.74–1) were identified between lameness during the preceding month, veterinary consultations, analgesic medication and rehabilitation treatment due to elbow disease during the last 2 years and between rehabilitation treatment due to elbow disease during the last 2 years and prior surgical treatment of ED (0.77). Thus, only the variables for lameness during the preceding month and prior surgery for ED were included in the model-building process.

The presence of owner-reported lameness was associated with higher odds for deterioration in all five COI categories. Owner-reported 'other orthopaedic diseases' was associated with worsening in all COI categories except quality of life. Increasing age at the time of questionnaire completion was associated with

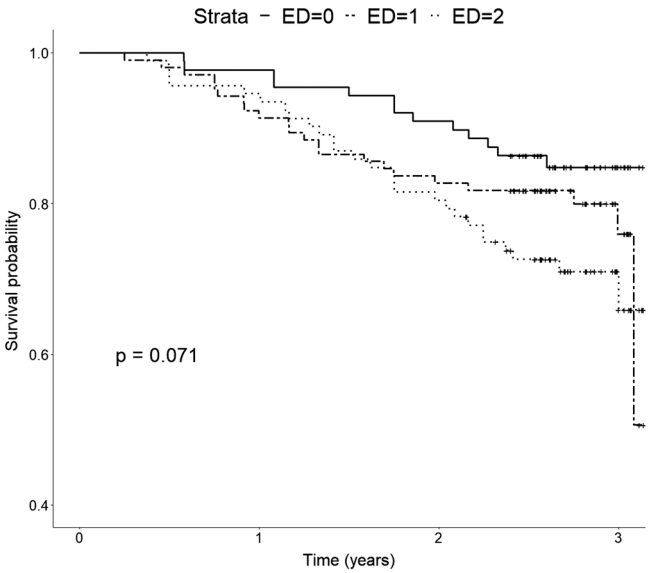

FIGURE 3 Kaplan–Meier curves describing survival in a cohort of 222 dogs with elbow dysplasia (ED) scores ranging from 0 (normal joint) to 2 (moderately affected joint)

higher odds of worsened function. Table 3 presents the results from the final multivariable models for each COI category. The model validation did not reveal any influential observations or multicollinearity in the final models. None of the tested interactions was significant.

Survival

Sixty-eight dogs died between Q1 and Q2. Twenty of these dogs were euthanased due to 'elbow-related causes' and 48 due to 'other causes'. There was no significant association between ED status and overall survival ($p = 0.071$). Kaplan–Meier survival curves for overall survival in the different ED groups are presented in Figure 3.

DISCUSSION

In this study, the long-term outcome of dogs with mild and moderate elbow OA, diagnosed through an ED screening programme, was evaluated using the COI. A strength of this study is the availability of data for a large number of dogs with relatively high age that are not primarily seeking veterinary care. Data regarding the long-term impact of ED/OA in dogs are sparse and have focused on the outcome of various treatment options and predominantly regarding MCPD.[17,18,39] In our study, there was no association found between ED grade and deterioration of the COI in the multivariable models. A high correlation was seen between lameness and all treatment variables as well as between previous surgery and rehabilitation treatment.

The clinical presentation of dogs with ED is usually characterised by stiffness and/or lameness,[1] and regardless of treatment, ED will lead to some degree of OA.[40–42] Approximately one-third (29.3%) of the responders in our study reported the occurrence of lameness in their dog during the preceding month. Dogs in the ED2 group had a significantly higher frequency of lameness than dogs in the ED0 and ED1 groups. The presence of lameness, regardless of ED grade, was a more important determinant for deterioration over time. Moreover, dogs in the ED1 and ED2 groups were more likely to receive analgesic medication than dogs in the ED0 group, indicating that owners of ED1 and ED2 dogs perceived their dogs as requiring treatment to a larger extent than ED0 dogs. Objective measurements such as gait analysis are regarded as the gold standard for the evaluation of lameness in dogs and can also be used for outcome assessment.[43–45] However, it is a time-consuming method and only assesses weight bearing at a given moment in time.[46] Owner-based questionnaires measure changes in the animal's daily life rather than only evaluating lameness or pain.[26] Previous studies have demonstrated a correlation between the Canine Brief Pain Inventory and the Liverpool Osteoarthritis in Dogs questionnaires and objective gait analysis measurements.[26,27]

When using questionnaires, it is essential to consider the study design and what consequence the mode of questionnaire distribution (such as telephone-based or web-based) can have on the results. There is evidence that responders answering questions being read out loud will give more positive responses.[47] Converting from a telephone to a web-based survey might have affected the trends in the questionnaires.[48,49] Moreover, a responder's reply might change over time, and the answer will depend on when and how the question was asked. This is important to note here since the interview was only conducted at one point in time and with no clinical examination or objective measurements. Numerous other factors influence an owner's opinion of their dog's overall function, such as owner expectation, the dog's activity level and the presence of co-morbidities.[50] However, using a validated owner-based questionnaire seems reasonable to answer the question regarding the long-term impact of ED/OA on the daily life of dogs.

ED was not significantly associated with overall survival. This agrees with a previous study evaluating the effect of radiological hip and ED status on overall survival in a cohort of large-breed dogs in Norway.[51] Conversely, a more recent study of elbow-related diseases in the UK stated that elbow joint diseases were an important contributing factor in the decision for euthanasia.[52] It could be speculated that dogs suffering from severe clinical signs due to an elbow-related disease might have been euthanased earlier, even before the first interview for the Q1 study, or that these owners did not reply to the follow-up Q2 study; hence, our results conflict with those of the aforementioned study.

The limitations of our study include the diagnosis of ED, since it is based on an official screening programme using only one mediolateral view of the

TABLE 3 Results from a multivariable logistic regression assessing deterioration in the canine orthopaedic index (COI) in a cohort of 222 dogs radiographically screened for elbow dysplasia (ED)

	Estimate	OR (95% CI)	*p*-Value
Stiffness			
Intercept	–1.19	–	–
ED			0.234[a]
ED0		1.00	
ED1	0.61	1.85 (0.89–3.88)	0.101
ED2	0.50	1.64 (0.75–3.62)	0.218
Lameness	1.88	6.56 (3.19–14.4)	<0.001
Other orthopaedic diseases	1.64	5.15 (2.39–12.0)	<0.001
Function			
Intercept	–2.69	–	
ED			0.428[a]
ED0		1.00	
ED1	0.29	1.33 (0.57–3.14)	0.506
ED2	0.58	1.78 (0.75–4.27)	0.192
Lameness	1.85	6.35 (3.16–13.2)	<0.001
Other orthopaedic diseases	1.08	2.93 (1.37–6.32)	0.006
Age (years)			0.013[a]
5–7		1.00	
8–9	0.98	2.66 (1.16–6.19)	0.022
>9	1.18	3.25 (1.42–7.70)	0.006
Lameness			
Intercept	–1.26	–	
ED			0.837[a]
ED0		1	
ED1	0.16	1.17 (0.56–2.48)	0.672
ED2	–0.06	0.94 (0.42–2.07)	0.876
Lameness	2.09	8.08 (4.11–16.6)	<0.001
Other orthopaedic diseases	0.87	2.39 (1.16–4.97)	0.018
Quality of life			
Intercept	–1.63		
ED			0.633[a]
ED0		1	
ED1	0.15	1.16 (0.53–2.55)	0.712
ED2	–0.25	0.78 (0.33–1.78)	0.554
Lameness	2.04	7.68 (3.95–15.4)	<0.001
Owner's perception			
Intercept	–2.15		
ED			0.366[a]
ED0		1	
ED1	0.02	1.02 (0.41–2.59)	0.962
ED2	0.56	1.75 (0.71–4.37)	0.225
Lameness	1.47	4.34 (2.10–9.16)	<0.001
Other orthopaedic diseases	1.53	4.60 (2.15–10.0)	<0.001

Note: Missing values for the different parts of the COI—stiffness, four observations; function, eight observations; lameness and quality of life, five observations; owner's perception, 36 observations.
Abbreviations: CI, confidence interval; OR, odds ratio.
[a]Wald test.

elbow joint in a flexed position. This is expected to lead to an underestimation of elbow pathologies.[34,53] It is also important to note that the animals included are a heterogenic group, with different primary elbow pathologies all categorised as 'ED'. In addition, dogs with ED3 were not included due to there being too few cases, meaning that dogs with visible primary disease (e.g., UAP) were excluded. It is possible that dogs with ED3 either underwent euthanasia prior to screening or that the long-standing screening programmes in Sweden have resulted in a decrease in the prevalence of ED3 among dogs enrolled in these programmes. Consequently, the outcome and quality of life in more severely affected dogs are not assessed. Complementing data from other outcome assessment methods, such as gait analysis, clinical examination and follow-up imaging, would have been helpful, but a study design including on-site clinical examinations would most likely have led to an increased non-response bias. Non-responder bias is a type of bias that occurs when individuals who participate in a study are not representative of the studied population.[54] Certain groups of people could be more or less likely to participate in a study. For example, individuals who have a strong opinion about a specific problem could be more likely to respond to a survey on that matter, while individuals who are uninterested may not respond. Consequently, the responders may not accurately reflect the larger population, which could lead to biased or inaccurate results.[55,56] The response rate for the current study was 41.6%. Despite the potential for non-responder bias[54] being one of the drawbacks of questionnaires, evidence suggests that a low response rate does not necessarily lead to bias.[55] Observation of the demographic data of responders and non-responders for Q2 showed that the main difference was related to breed, with owners of American Staffordshire Terriers and Rottweilers having a significantly higher non-response rate than owners of other breeds (Supporting Information S1). Whether this is linked to elbow joint problems manifesting differently in these breeds or is due to other owner-related explanations remains unclear. Furthermore, establishing accurate conclusions based solely on owner assessment can be challenging since owners may not be able to correctly evaluate lameness in their dogs.[43,44]

Another potential drawback of owner assessments is the possibility of recall bias.[54] Recall bias can occur when participants are asked to recall information about past events. The accuracy of this can be influenced by several factors, such as the time elapsed since the event and if the event being recalled is important to the participant. Consequently, it can result in an over- or underestimation of the true association between an exposure and an outcome, leading to incorrect conclusions.[56] For example, it could be theorised that owners of dogs with ED2 might expect more clinical signs such as lameness and thus be more meticulous in recording and remembering events such as veterinary appointments and treatment with analgesic medication compared to owners of dogs with ED0 or ED1.

It is also critical to note that other orthopaedic problems may affect the owner's assessment of their dog's elbow joint. Nearly one-quarter of the dogs in the Q2 study were reported to have additional orthopaedic diseases; however, there was no significant difference between the different ED groups. Furthermore, bodyweight or the more appropriate measurement of obesity, body condition score, was not obtained for this study. However, a previous study implied that calorie restriction could slow down the progression of OA in the canine elbow.[57] It would therefore have been of interest to assess any association between obesity and long-term outcome for dogs with ED/OA.

In summary, no association was found between the grade of ED and the worsening of clinical signs assessed by the COI over time. Most dogs with mild and moderate OA at the time of ED screening did not demonstrate clinical problems detected by their owners later in life (at a median age of 8 years). Dogs with moderate OA were more likely to have owner-reported lameness compared to dogs with mild or no OA, which is associated with deterioration in owner-reported clinical signs and quality of life over time. Furthermore, dogs with mild and moderate OA were more likely than dogs without OA to receive treatments such as analgesic medication, veterinary consultations and rehabilitation. ED was not associated with overall survival in this cohort of dogs. Understanding the impact of ED on dogs' daily life can aid veterinarians in advising owners on what to expect in the long-term in affected dogs and guide them regarding the prognosis and treatment options for mild and moderate ED.

AUTHOR CONTRIBUTIONS

Christina Obel contributed to the conception of the study, study design, acquisition of data, data analysis and interpretation and drafting of the manuscript. Annika Bergström contributed to the conception of the study, study design and interpretation and drafting of the manuscript. Arianna Comin contributed to the conception of the study, study design, data analysis and interpretation and drafting of the manuscript. Karolina Engdahl contributed to the conception of the study, study design, data analysis and interpretation and drafting of the manuscript. All authors have edited, read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

All the data supporting the findings of this study are available from the corresponding author upon request.

ETHICS STATEMENT

All owners received written information before inclusion in the first study. The study was approved at the University of Agricultural Sciences monthly meeting regarding planned animal experiments in February 2016. The study has a GDPR acceptance from the legal office at the university. Since no animals were involved ethical animal approval was not required in Sweden.

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SUPPORTING INFORMATION

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

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