Elbow dysplasia: The predictive value of radiographic screening at one year of age

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***Abstract*—**

Elbow dysplasia is a degenerative joint disease that can cause debilitating osteoarthritis that affects the animal well-being in a negative way. The aim of this study was to determine the predictive value of radiographical screening according to NZVA standards. 15 dogs that proved dysplastic at one year of age and 15 that proved non-dysplastic were used in this study. The dogs had second elbow radiographs taken between the ages of 2 and 10 years old. The McNemar test comparing radiographs taken at 1 year of age and 2-10 years of age (p=0.7237) proved there was no statistical differences between the groups. A radiograph taken at one year of age has a good predictive value for the dog developing radiographical signs of ED.

Keywords: Elbow Dysplasia, ED, Dog, screening, radiograph

INTRODUCTION

Elbow dysplasia (ED) in dogs is a degenerative joint disease that affects young medium to large breeds. (Goldhammer et al 2010) Males are more often affected than females. (Hou et al 2013) Four underlying causes have been described: Ununited Anconeal Process (UAP), Fragmentation of the Medial Coronoid Process (FMCP), Elbow Incongruence (EI) and Osteochondrosis Dissecans or Osteochondrosis (OC). (Worth et al 2010)

So far, the aetiology of ED is undetermined. Theories explaining ED are trauma during development, weight gain, high growth rate, genetics, nutrition and ischaemia. (Worth 2010) (Goldhammer 2010)

The genetics of ED are complex. Differences in inheritance between breeds (Lappalainen 2013) and sexes (Hou et al 2013) are described. Because of the complex etiology, no genetic tests are available yet. (Michelsen 2013)

Out of the 4841 dogs that were submitted to the New Zealand Veterinary Association (NZVA) screening program for ED in 2011, only 1532 were accredited as not being dysplastic. (Annex I)

Dogs with ED generally develop elbow osteoarthritis, which is a debilitating condition that affects the animal well-being in a negative way. (Alves-Pimenta 2013) The secondary effects of ED can be treated conservatively with weight loss, restricted exercise and NSAIDs, or surgically. (Michelsen 2013). Surgery can be performed by arthroscopy or arthrotomy and consist of: joint resurfacing, joint replacement, proximal abducting ulna osteotomy or ostectomy, sliding humeral osteotomy, joint denervation and arthrodesis. (Michelsen 2013) These treatments vary greatly in effectiveness in short and long term effect on clinical signs and the evidence provided for their claims differs greatly as well. (Michelsen 2013) Because of the multitude of risk factors and underlying causes, no ideal treatment has been found yet.

The gold standard for detecting cartilage defects and thereby ED is arthroscopy. (Temwichitr 2010) Arthroscopy is not suitable for screening purposes due to its invasiveness. Imaging techniques such as radiographs or CT-scans can be used to diagnose ED non-invasively. Radiographic examination is widely accepted as the method of choice for screening ED in dogs. (Alves-Pimenta 2013)

World wide there are numerous elbow schemes developed for the screening of ED. The radiographic projections required per scheme vary from 1 to 4 per elbow. (Worth 2010)

The International Elbow Working Group (IEWG) recommends using at least 2 radiographs; flexed mediolateral and craniocaudal at at least two years of age. (Worth 2010)

In 1992 The NZVA has developed an ED scheme based on these recommendations. Currently the NZVA ED scheme utilizes a single mediolateral radiograph taken at a 45° angle at a minimum age of 12 months. (Worth 2010) In 2011 only 26% of Labrador Retrievers submitted for scoring to NZVA was accredited as non-dysplastic. FMCP is the most frequently observed primary lesion in ED in Labrador Retrievers, Golden Retrievers and Bernese Mountain Dogs. (Lavrijsen et al 2012) The prevalence of FMCP in Labrador Retrievers varies between studies. In the Netherlands a prevalence of 18% has been reported. (Lavrijsen et al. 2012)

It is widely accepted by veterinarians that dogs with a higher ED score at one year of age have a larger chance of developing clinical signs of ED later in life. According to the authors, so far this correlation has not been documented in veterinary literature.

The aim of the current study is to establish whether there is a correlation between the ED score at one year of age and the ED score later in life. The hypothesis is that there is no difference in ED scores between time points and that screening at one year of age is indicative for the development of ED at a later stage in life.

Material and Methods

Samples

The current project made use of a population of working dogs that consisted solely of Labrador Retrievers, living in regular households in New-Zealand. Only dogs that have had their radiograph taken at one year of age (R-1) according to the NZVA standards were eligible. These standards include sedating the dog with Butorphanol 0.1mg/kg combined with Medetomidine 0.022mg/kg and taking one medio-lateral radiograph per elbow at a 45° flexed position. (Worth 2010)

Out of the dogs that met these standards, all dogs younger than 2 years were excluded because not enough time will have passed between the first and second radiograph to show changes on a radiograph. All dogs older than 10 years were excluded as well due to anesthetic risks involved in this elective procedure. 15 dogs were chosen at random out of the dysplastic group and 15 out of the non-dysplastic group to take part in this study.

All the R-1 were taken by the same veterinarian and all but two radiographs taken later on were taken by the same veterinarian whom took the first one. One of them was caused by logistics (distance), while the other dog was already undergoing surgery elsewhere and the radiographs were taken while it was still sedated.

Radiographic scoring

Multiple sets of radiographs were being used in the current study: the original radiographs taken at one year of life and the ones that were taken later on in life (R-Later).

All the R-Later were scored by A.J. Worth, MANZCVS (radiology), FANZCVS (small animal surgery), New Zealand Registered Specialist SAS, Convener of the New Zealand Hip and Elbow Panel and New Zealand's delegate to the IEWG

Three specialists in New-Zealand are accredited to score radiographs. According to NZVA standards, the radiographs are sent to any 2 scorers from the pool of 3 and if a consensus is made, the score is set.

Seeing as the scorer in this project is but one from the pool of 3, a consensus of 2 scorers cannot be made. In order to investigate if this single scoring system differed from the double scoring system, the single scorer rescored all the R-1. The scorer was unaware of the initial score. The R-1 were rescored 3 times and the median of those 3 scores was the final score. These rescored radiographs (R-Rescore) were then compared with the R-1 to assess the inter-observer reliability. The R-Later were scored in the same way by the same single scorer.

The observer evaluated and graded the radiographs on the presence of a primary lesion (FCP, UAP or ODC) and the presence and size of osteophytes, according to NZVA standards as seen in Figure 1. (Worth, 2010) The scores 0 and B were accredited as non-dysplastic, but only if both elbows had that score. If at least one elbow had a score of 1a-3, they were scored as dysplastic. (NZVA elbow scheme)

Grade	Features
Non-Dysplastic	
0	No evidence of elbow dysplasia
B (borderline)	Subtle changes are seen on radiographs of the elbow, that are suggestive of elbow dysplasia but are of insufficient severity to be conclusive
Dysplastic	
1a	Mild arthrosis (osteophytes 0-1mm)
1b	Mild arthrosis (osteophytes >1 but <2 mm)
2	Medium arthrosis (osteophytes 2-5 mm)
3	Severe arthrosis (osteophytes >5 mm) or primary lesion

Figure 1. This table shows the features that belong to each ED score according to NZVA standards. (Worth 2010)

Statistical analyses

To test if the rescored data differed from R-1, a kappa test was performed. This test is used to assess agreement between observers for a categorical variable. (Petrie 2008) Because of that, the data had to be converted. We relabeled the "0" and "b" scores as not having the disease ("N") and "1a", "1b", "2", and "3" as having the disease ("Y"), for both the rescored results and the original results.

The R-Rescore results were compared with the R-Later using a McNemar and had to be renamed in the same way as for the Kappa test in a "Y" and an "N". A McNemar test is used to compare paired results on a binary variable. (Petrie 2008) The α has been set at 0.05 to make the probability of a type 1 error low. (Petrie 2008)

As not all dogs were rescored at the same age, varying from 2-10 years, a logistic regression model was done to determine if the factor "Time" in days had any influence on the results.

Results

The entire population consisted of 216 dogs that had had their radiograph taken at one year of age. After limiting the population according to our age restrictions only 80 dogs remained. Of those 80 dogs, 44 were scored as dysplastic and

36 as non-dysplastic. Out of both the dysplastic and non-dysplastic group 15 dogs were chosen to participate at random.

The results of the accuracy of the rescoring are seen in Table 2. This table shows what the score was in R-1 compared to the rescored one in R-Rescore. The results for the kappa test were 21 "Y" results, 37 "N" in R-1, and 14 " Y" results and 40 "N" in R-Rescore. The κ-value was 0.745. A κ-value of 0.745 states there is a substantial agreement between the observers. (Petrie 2008)

The results for comparing R-Rescore and R-later are seen in table 3. The McNemar test comparing these results gave a P-value of 0.7237. The null hypothesis in a McNemar test states that the results per group differ. (Petrie 2008) This null hypothesis was rejected; the groups did not differ significantly.

At one year of age 17 out of the 30 dogs had the same score on both elbows. Only 3 of those dogs had the same score and were dysplastic. The results of the R-Later group showed that 21 dogs had the same score on both elbows, with only 2 dogs scored as dysplastic.

When comparing the elbows of R-Rescore with R-Later, 39 results stayed the same, 12 changed for the better and 3 changed for the worse.

The logistic regression model showed that the factor "time" had a p-value of 0.054, so is verging on it being a significant factor. If a dog was rescored 8 years later than any other dog it had a 1% higher chance of being scored as dysplastic. This model also showed that if a dog was scored dysplastic at R-1 it had a 22 odds ratio of being scored dysplastic in R-Later.

R-1\R-Rescore	0	b	1a	1b
0	**18**	0	2	0
b	12	**1**	1	0
1a	3	6	**9**	2

Table 2. This table compares the results of the original radiographs (R-1) with the rescored radiographs at one year of age (R-Rescore). The bold underlined numbers represent results that retained their original score.

R-Later	0	b	1a	1b	2	3
R-Rescore						
0	**28**	0	1	0	1	1
b	6	**1**	0	0	0	0
1a	5	0	**7**	0	0	0
1b	0	0	1	**1**	0	0

Table 3. This table compares the results of the rescored radiographs (R-Rescore) and the radiographs taken later on in life during this study (R-Later). The bold underlined scores represent results that retained their original score.

DISCUSSION

Initially, multiple ED sub groups would have been created based on the elbow score. Unfortunately, this was not possible as only two elbows had the score of 1b, no elbow had the score of 2 and only one elbow had the score of 3. Because that would not yield a significant result, this research instead focussed on mild ED with a maximum initial score of 1a.

As this paper used a specific group of Labrador Retrievers with mild ED that have been selected for breeding for years on not having joint diseases, it is unclear how well these results translate to higher radiographic scores, other breeds or even other Labrador Retrievers.

Some sort of pre-selection has occurred because all potential working dogs that showed signs of ED before the mandatory radiograph at one year of age were excluded from the program. This group consisted of XX dogs that could have skewed the results one way or the other, had they been scored. Unfortunately, it was not possible to have the radiographs scored double blindly. The R-1 were analogue whereas the R-Later were digital. So as the scorer could tell which radiographs were the older radiographs, there might have been some bias in the scoring and rescoring.

Two of the dogs did not have their radiographs taken by the same veterinarian. But, according to the NZVA standards, any veterinarian can make the radiographs and have them scored by the official NZVA panel. The scorer in this project has scored many radiographs from many veterinarians for multiple years, so the effects this has on the results should be minimal.

Most studies done on ED make use of voluntary owner participation in order to get the results needed. This means that owners could preselect which dogs they would let participate in the study in order to get a more desirable result. The present research worked with a foundation of working dogs that still owned the dogs even though they were working. Thanks to the foundation this research had a 100% participation rate of the selected dogs and because of that there was no pre-selection done by owners.

The logistic regression model showed that Time in days is close to being a significant factor. Even though it is close to being significant, the biological significance is very low. According to the same model, if a dog was rescored 8 years later than any other dog, it only had a 1% higher chance of being scored as dysplastic.

This study made use of results of a binary value and thus, unweighted results. No distinctions were made between the mild ED score of 1a and the severe ED score of 3.

This research made use of the NZVA scheme for scoring ED. Only one radiograph was taken per elbow and because of that primary defects could have been missed in the interpretation of the radiographs.

CONCLUSION

The kappa test comparing R-1 with R-Rescore showed that the rescoring was in substantial agreement with the original scoring. This either means they have the same scoring bias, or that there was no scoring bias to begin with. It was justified to use a single observer for all results instead of two observers who had to reach a consensus and the different groups in this study can be compared safely.

The McNemar test used to compare the scores of the R-Rescore and R-Later resulted in a high p-value (0.7237). This means the two sets of radiographs did not differ significantly

from each other. As the original results were transcribed into a "y" for being dysplastic and an "n" for not being dysplastic two different conclusions can be made. A radiograph taken at one year of age accrediting the dog as not having ED, has a good predictive value for the dog not showing radiographical signs of ED later on in life.

Dogs that were scored as dysplastic at one year of age were 22 times more likely to be scored as dysplastic later on in life. This is in agreement with our previous statements. So a radiograph taken at one year of age that does give the dog a dysplastic score, has a good predictive value for the dog getting a dysplastic score later on in life.

Even though time is close to having a significant effect ($p=0.054$) for the rescoring of the results, it holds little to no biological significance. This means that even though time could well prove to be a significant factor if more dogs had been entered, the results in this research would differ minimally and the research is justified in taking the R-Later with a wide variation in age.

Though no statistical analysis has been performed, the data suggests that ED is not often a bilateral disease.

This paper focused on the radiographic score and the predictive value of radiographs. It in no means tries to predict the onset of clinical ED in the dogs. More research is needed to establish the correct age of scoring, how many radiographs should be taken and how the radiographic scores correlate with clinical signs of ED.

CONFLICTS OF INTEREST

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ANNEX I

ELBOW DYSPLASIA RESULTS FOR 2011 AS SCORED BY THE NZVA.

Elbow Dysplasia - Totals by Breed

Breed	No. of Dogs	Accredited	Dysplastic		
			Grade 1	Grade 2	Grade 3
Airedale Terrier	17	4	13	0	0
Akita	3	2	1	0	0
Alaskan Malamute	135	35	84	11	5
American Bulldog	29	4	14	9	2
American Staffordshire Terrier	9	2	1	5	1
Anatolian Shepherd Dog	2	1	1	0	0
Australian Cattle Dog	7	3	3	1	0
Australian Shepherd	18	7	10	1	0
Beagle	1	1	0	0	0
Bearded Collie	3	2	1	0	0
Belgian Shepherd (Groenendael)	7	5	2	0	0
Belgian Shepherd (Malinois)	1	0	1	0	0
Belgian Shepherd (Tervueren)	6	4	2	0	0
Bernese Mountain Dog	184	77	64	35	8
Bichon Frise	1	1	0	0	0
Bloodhound	3	1	2	0	0
Border Collie	64	36	26	2	0
Bouvier Des Flandres	18	11	3	3	1
Boxer	15	6	9	0	0
Briard	1	1	0	0	0
Bulldog	2	0	0	2	0
Bullmastiff	121	27	54	28	12
Chesapeake Bay Retriever	5	2	2	1	0
Chow Chow	16	1	5	8	2
Cocker Spaniel	5	5	0	0	0
Curly Coated Retriever	27	6	21	0	0
Dalmatian	20	11	9	0	0
Dobermann	7	2	5	0	0
Dogue De Bordeaux	60	21	23	13	3
English Bull Mastiff	3	1	1	1	0
English Setter	1	1	0	0	0
English Springer Spaniel	6	5	0	0	1
Fila Brasileiro	2	1	1	0	0
Flat-Coated Retriever	14	6	8	0	0
French Bulldog	2	2	0	0	0
German Pinscher	5	5	0	0	0
German Shepherd Dog	986	444	411	86	45
German Shorthaired Pointer	22	10	12	0	0
German Wirehaired Pointer	6	2	4	0	0
Golden Retriever	715	168	450	76	21
Gordon Setter	7	1	4	2	0
Great Dane	16	8	6	2	0

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Elbow Dysplasia - Totals by Breed

Breed	No. of Dogs	Accredited	Dysplastic		
			Grade 1	Grade 2	Grade 3
Heading Dog	1	1	0	0	0
Hungarian Vizsla	44	6	38	0	0
Huntaway	2	2	0	0	0
Irish Red & White Setter	7	2	5	0	0
Irish Setter	1	1	0	0	0
Irish Water Spaniel	1	0	0	1	0
Irish Wolfhound	1	1	0	0	0
labradoodle	34	19	15	0	0
Labrador Retriever	1346	354	830	128	34
Lagotto	4	2	1	1	0
Large Munsterlander	3	1	2	0	0
Leonberger	57	25	29	3	0
Maremma Sheepdog	2	1	1	0	0
Mastiff	73	16	40	12	5
Neapolitan Mastiff	5	0	2	3	0
Newfoundland	82	27	41	12	2
Nova Scotia Duck Tolling Retriever	1	0	1	0	0
Old English Sheepdog	9	4	5	0	0
Polish Lowland Sheepdog	1	0	1	0	0
Poodle (Miniature)	11	7	4	0	0
Poodle (Standard)	39	21	18	0	0
Poodle X Cavalier King Charles	1	1	0	0	0
Pyrenean Mountain Dog	2	2	0	0	0
Rhodesian Ridgeback	22	7	15	0	0
Rottweiler	359	20	169	143	27
Samoyed	64	35	24	5	0
Schnauzer (Giant)	6	2	4	0	0
Shar Pei	2	0	0	1	1
Shetland Sheepdog	7	5	2	0	0
Siberian Husky	29	12	17	0	0
Spoodle	2	2	0	0	0
St Bernard	33	10	18	3	2
Staffordshire Bull Terrier	5	2	2	1	0
Swedish Vallhund	1	1	0	0	0
Tibetan Mastiff	2	0	2	0	0
Tibetan Terrier	2	1	1	0	0
Weimaraner	4	4	0	0	0
Welsh Corgi (Pembroke)	1	1	0	0	0
Welsh Springer Spaniel	11	4	7	0	0
working sheep dog	1	1	0	0	0