Can owners and clinicians assess outcome in dogs with fragmented medial coronoid process?

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Keywords
Elbow dysplasia, gait analysis, fragmented medial coronoid process, inverse dynamics

Summary
Objectives: To investigate the long term reliability of clinician and owner visual analogue score (VAS) for dogs with unilateral forelimb lameness attributable to fragmented medial coronoid process (FMCP) when compared to objective gait analysis.

Methods: Nine dogs with unilateral thoracic limb lameness due to FMCP underwent inverse dynamics gait analysis at initial presentation, and at one, two, six and 12 months following diagnosis. Total support moments were calculated and a total support moment ratio (TSMR) derived as an objective assessment of thoracic limb asymmetry. A VAS questionnaire for lameness was completed by the owner of each dog for each visit. Video footage of each dog walking and trotting at each visit was compiled, assigned to random order and subjected to VAS for lameness by a specialist in small animal surgery. Data from owner and clinician VAS lameness questionnaires were compared to the thoracic limb TSMR.

Results: Statistical analysis demonstrated a significant negative correlation between TSMR and owner VAS at four weeks post treatment but at no other period of evaluation. There was no significant correlation between TSMR and clinician VAS score at any evaluation period.

Clinical Significance: Assessments by owner and clinicians using VAS appear to be of limited use as a long term outcome measure for dogs with unilateral lameness due to FMCP when compared to objective gait analysis. There is a tendency for owners to underestimate forelimb lameness with increasing time which is not supported by quantitative measures of gait.

Introduction
Fragmented medial coronoid process (FMCP) of the ulna is the most common cause of juvenile thoracic limb lameness in large breed dogs such as the Labrador Retriever, Rottweiler and Bernese Mountain dog (1–3). The high prevalence of FMCP in these breeds (4) and its associated lameness has resulted in considerable literature reviewing purported aetio-pathogenesis as well as the most appropriate surgical treatments for this condition. However, the precise mechanisms by which these developmental lesions form are incompletely understood and literature regarding the most appropriate means of treatment for FMCP is poorly defined (5–8). The majority of published studies for the treatment of FMCP are retrospective, fail to employ objective functional outcome measures and lack exact details pertaining to the surgical treatment employed (9–14).

There has been a recent focus in the veterinary literature towards the need to apply validated specific outcome measures and objective quantification in the assessment of disease progression and surgical outcome (15–18). The scientific literature on human beings reveals that subjective patient outcome measures have long been employed for the assessment of chronic musculoskeletal diseases and these have been reviewed (19–21). Adaptation of one such system, the patient visual analogue scale (VAS) has previously been modified from human methodology to the dog as a metrological tool for owner-based assessment of outcome following surgery for canine cranial cruciate insufficiency (22). The authors of this study reported the reliability and responsiveness of VAS as acceptable for owner assessment of lameness attributable to cranial cruciate ligament disease. However, a concurrent objective means of comparison directly evaluating limb function was not employed in this study. In contrast, more recent studies investigating the validity of VAS in the assessment of canine lameness concluded subjective lameness scoring did not accurately reflect lameness as assessed via objective force platform analysis (23, 24).

Subjective assessment of lameness assumes both observational acuity, as well as the ability of the clinician or owner to reliably interpret the signs of pain or disability following treatment for disease. The validity of owner and clinician subjective outcome measures as a reliable indicator of limb function and as a means of quantifying the long term success of treatment for FMCP is currently unknown. Such information would...
indicate whether past or future studies employing subjective outcome measures are of use in assessing the efficacy of either medical or surgical treatment protocols for this disease. Recently, we have described assessment of the gait disruptions of dogs with FMCP using inverse dynamics to quantify the joint angle, moment and power compensations in the dysplastic and contralateral limbs (25). Inverse dynamics analysis is a quantitative method of gait analysis combining morphometric, kinematic and force data to yield patterns of joint angular excursion, net joint moments and net joint powers. Such a methodology permits an objective assessment of limb function and thus is a controlled means by which to assess the validity of owner and clinician VAS for dogs with FMCP.

The aim of this study was to investigate the reliability of owner and clinician VAS for lameness for dogs with unilateral lameness due to FMCP over a 12 month period when compared to objective gait analysis using inverse dynamics.

Materials and Methods

Inclusion criteria

Nine dogs referred to the University of Bristol Small Animal Hospital were prospectively recruited for this study. Inclusion criteria were an age of less than two years, and unilateral thoracic limb lameness localised to the elbow joint on clinical examination. All dogs were examined and certified as healthy with the exception of the unilateral lameness and were not receiving any medication at the time of enrollment in the study. Orthogonal radiographs of both elbows were performed for all dogs and the radiological signs, as previously described (26–28) were consistent with unilateral FMCP in all cases. Dogs subsequently underwent elbow arthroscopy confirming the presence of unilateral FMCP and the FMCP was removed arthroscopically in each case as previously described (13). Subjective lameness scores were performed at the time of initial examination by the clinician. Dogs were re-examined at one, two, six and 12 months subsequent to initial presentation. Following enrollment into the study all dogs were prescribed a six week course of the non-steroidal anti-inflammatory drug (NSAID) tepoxalin (Zubrin™) at a dose of 10 mg/kg once daily.

VAS questionnaires

Owners were asked to complete a VAS lameness questionnaire at each visit (Fig. 1). VAS questionnaire results were scored as a percentage of total line length for each dog.

<table>
<thead>
<tr>
<th>Percentage Lameness Score</th>
<th>Percentage of Total Line Length</th>
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<tbody>
<tr>
<td>0</td>
<td>0%</td>
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<tr>
<td>25</td>
<td>25%</td>
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<tr>
<td>50</td>
<td>50%</td>
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<td>75</td>
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<tr>
<td>100</td>
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Data are presented as ‘percentage lameness’ with a score of 100 representing maximal lameness on the affected limb and zero denoting sound limb use with no evidence of lameness. Owners were instructed how to complete the questionnaire at each visit and all questionnaires were completed immediately.

Video footage of the dog walking and trotting was also obtained during gait analysis at each visit. Video footage was obtained using a single camera and dogs were filmed walking and trotting both away and towards the camera as well and in a circle of approximately 10 meters diameter around the camera both clockwise and anti-clockwise. Approximately two minutes of footage was obtained for each dog. Videos of each dog were assigned to random order and VAS for lameness was performed by a specialist in small animal surgery (MRO).

Gait analysis

Flat retro-reflective markers were affixed to the skin of each dog overlying the centres of rotation of the metacarpophalangeal (MCP), carpal, elbow and shoulder joints. Additional markers were placed, one on the distal aspect of the fourth digit to identify the paw segment and one on the spine of the scapula for measuring shoulder joint angle. Dogs were familiarised with the runway used for gait analysis by trotting back and forth on a lead several times such that a constant speed and routine were established prior to data capture. Six stance phases were recorded for each thoracic limb at trotting speed using four infrared cameras and a force platform. Cameras were arranged in a semicircle on one side of the runway such that each retroreflective marker was recorded by at least three cameras. A calibrated volume of space (1.6 m in length x 1.0 m in width x 1.0 m in height) was used to enable marker capture on the force platform throughout the thoracic limb stance phase of gait in either direction.

The kinematic and force data were imported into a custom programme to obtain an inverse solution for net joint moments...
Thoracic limb segment morphology was established from a generic forelimb model for Labrador Retrievers (unpublished data). Net joint moments on the palmar side of the limb were assigned negative values. Data from right and left thoracic limbs were normalised within each dog to 101 data points for creation of ensemble averages across the nine dogs.

Moments for the MCP, carpus, elbow and shoulder joints of both thoracic limbs for each dog for each visit were derived and these were summed to yield a total support moment for each thoracic limb. Net joint moments for an animal on the caudal/palmar side of the limb were assigned negative values and moments on the cranial/dorsal aspect of the limb were assigned positive values. The total support moment of the lame limb was divided by that of the normal limb yielding a total support moment ratio (TSMR). A TSMR value of 1.0 denoted complete forelimb symmetry (i.e. the dog demonstrated no lameness) and a value of zero denoted maximal asymmetry or lameness on the FMCP affected limb. It was envisaged that any statistically significant correlation between VAS and TSMR would be negative as a high VAS for lameness would correspond with a low TSMR.

### Statistical analysis

Pearson correlation coefficient analysis was performed on the TSMR, owner VAS and clinician VAS at zero, one, two, six and 12 months subsequent to initial presentation using commercially available software. Analysis was similarly performed on the change in TSMR and change in VAS scores (calculated as the ratio of values between successive periods of clinical evaluation) to assess for a correlation in the rate of change in lameness as a function of time. To assess whether the mean observer score of the clinician and owners were statistically different, a paired t-test was used to compare the responses at each time point using commercially available software. Statistical significance was defined as p<0.05 for all statistical comparisons.

### Results

Nine dogs were prospectively enrolled in the study. Seven were lame on the right thoracic limb and two were lame on the left thoracic limb. Five dogs were male (two neutered) and four were female (one neutered). Their ages ranged from five to 24 months, with a mean age of 12.3 months (Standard deviation [SD] ± 7.3). They comprised five Labrador Retrievers, one German Shepherd dog, one Airdale Terrier, one Border Collie and one Staffordshire Bull Terrier. The body mass of the dogs ranged from 15.0 to 30.6 kg, with a mean of 25.0 kg (SD ± 5.33), and the dogs had been lame prior to referral for between one and 12 months (mean: 3.64 months, SD ± 3.9). The onset of lameness had manifested at between
five and 23 months of age (mean 10.0 months, SD ± 5.6). Subjective lameness scores using the scale of Bennett et al (29) at presentation ranged from 6/10th (one dog), 5/10th (two dogs), 4/10th (three dogs), 3/10th (one dog), 2/10th, 1/10th (two dogs). The mean TSMR, owner VAS and clinician VAS are illustrated in ►Figures 2 and 4.

**Total support moment ratio**

Analysis of the mean TSMR throughout the 12 month period of evaluation revealed seven of nine dogs had improved symmetry for at least one period of evaluation compared to that at the time of initial presentation. Six of nine dogs had improved thoracic limb symmetry at 12 months relative to initial presentation, however only one dog regained a TSMR of 1.0 by this time, denoting a symmetrical gait and ‘soundness’ to have returned. Interestingly, this dog appeared to develop a transient lameness in the contralateral limb (denoted by a TSMR >1.0) at the six month period of evaluation prior to return to soundness.

► Figure 2 shows the average TSMR across the nine dogs at each time point, and identifies that the symmetry ratio was smallest at two months after treatment. ► Figure 3 illustrates the actual peak elbow moments contributing to the total support moment in the FMCP affected and compensating limbs and reveals that the FMCP affected elbow only showed evidence of bearing more weight at the six and 12 month time points. In contrast, the compensating elbow increased its moment contribution from baseline to two months, and then reduced this at the six and 12 month time points. This pattern indicates the greatest elbow mechanical asymmetry at two months, and the least at 12 months, which corroborates the data shown in ►Figure 2 and identifies the elbow as likely having a major influence on the overall TSMR.

**Owner VAS scores**

The analysis of the mean owner VAS throughout the 12 month period of evaluation (►Fig. 4) reveals a general trend towards perceived improvement of lameness with time. Seven of nine owners believed their dog’s lameness had improved at the 12 month period. However, only five of nine dogs were improved as assessed via the TSMR. One owner scored their dog’s lameness as worse at 12 months compared with the time of initial presentation when the dog’s symmetry and hence lameness was improved. Owners were questioned two months postoperatively whether their dog’s lameness had worsened subsequent to completing the six week treatment using tepoxalin. None of the owners reported their dog’s lameness was worsened on cessation of the six week course of tepoxalin and thus no further NSAID’s were prescribed for any dog for the remainder of the study period.

**Clinician VAS scores**

The analysis of the mean clinician VAS throughout the period of evaluation (►Fig. 4) reveals a perceived improvement in five of
nine dogs by 12 months. However, only two of these five dogs were improved as assessed via the TSMR. Mean clinician VAS scores at the start of the study were lower and fluctuated less throughout the 12 month period than the owner VAS.

Statistical analysis

Pearson correlation coefficient statistical analysis performed on the TSMR, owner and clinician VAS is presented in Table 1 and 2. This revealed a significant negative correlation between the TSMR and owner VAS at the one month post-treatment evaluation only. Statistical significance was not evident between the TSMR and clinician VAS throughout the 12 month period.

Paired t-test analysis comparing the mean owner and clinician VAS only revealed a significant difference in score at initial presentation (p = 0.03) and at the six month period of evaluation (p = 0.04).

Discussion

The results of this study suggest that owner VAS for lameness following treatment for FMCP is only a reliable predictor of limb function in the immediate post treatment period. Pre-treatment owner VAS scores and those of four weeks post-treatment did not provide a reliable assessment of limb function when compared to quantitative measures of gait. Clinician VAS for lameness was similarly deemed unreliable throughout the 12 month period of evaluation.

Our results appear to support those of recent force platform studies evaluating the reliability of VAS scoring in surgically induced pelvic limb lameness in dogs (23, 24). These authors concluded that agreement between VAS and force platform analysis was poor unless lameness was severe. The mean total support moment ratio (Fig. 2) throughout our study was greater than 0.5 and mean clinician VAS score was less than 25% (Fig. 4). Whilst the correlation between clinician VAS and TSMR was poor, the magnitude of both TSMR and clinician VAS data suggests the chronic lameness exhibited by dogs with unilateral FMCP was similarly mild to moderate and thus, may have been of insufficient severity to facilitate accurate VAS scoring. Our observations and those of Quinn and others (23) are in conflict with those of an earlier study which found VAS was a repeatable and valid means for assessing mild to moderate lameness in dogs (30). It appears that the reliability of VAS for the accurate assessment of canine lameness is inconsistent. The reliability of VAS may be influenced by multiple factors such as the cause of lameness, its chronicity, severity and the specific gait compensations that different orthopaedic diseases may produce.

Figure 4 demonstrates that the mean owner and clinician VAS differed throughout the period of evaluation with owners scoring greater initial and lower 12 month lameness scores. The difference between owner and clinician VAS was statistically significant at the time of initial presentation and at the six month period of evaluation. Multiple factors could account for these differences in perceived outcome; however, of these the evaluation period for lameness may be an important variable. Owners most likely score their dog’s lameness based on their overall ‘impression’ of limb function. Whilst owner assessment of their dog’s lameness is professionally uninformed, VAS may be influenced by multiple observational variants of the owner such as how lameness varies with the time of day, ambient temperature, floor surface, interaction with other dogs, activity levels, exercise tolerance and performance. These variables do not influence clinician VAS for lameness which, in contrast, is often restricted to a limited ‘window’ of visual assessment of gait and clinical examination which may not be an accurate reflection of ‘average’ limb function. Such limitations for the accurate assessment of limb function also hold true for objective kinetic and kinematic assessments of gait.

Over the past decade, kinetic and kinematic analysis techniques have been used increasingly to quantify the gait of clinically normal dogs (31, 32) as well as those with experimentally induced lameness (33, 34). More recently, assessment of the compensations specific orthopaedic diseases produce (25, 35, 36), as well as the use of inverse dynamics analysis in the assessment of intra-breed mechanics have been described (37). Inverse dynamics analysis utilises ground reaction forces, kinematics and limb segment morphometry to yield force, moment and powers for limb moment. The accuracy of the constituent joint moments, and thus the total support moment are limited by the accuracy of marker placement over the limb joints, and therefore calculated moment arm distances, so there is potential for the total support moment to be less accurate than simply comparing raw forces. However, a benefit of total support moment is the ability to identify relative contribution of individual joint moments within the overall support moment, and to account for varying segment or limb angles. If the limb is more protracted, for instance, in early stance, the vertical ground reaction forces may be lower, but the segmental moment arms may be increased, thus increasing the joint moments and total support moment. In this way, assessment of symmetry via summation of joint moments provides a more comprehensive assessment of limb loading than that of joint kinematics or peak vertical force in isolation (38), and thus total support moment was used as an objective assessment of thoracic limb symmetry in our study.

Table 2 Pearson correlation coefficient and p values for change in Total Support Moment Ratio (TSMR), owner and clinician Visual Analogue Score (VAS).

<table>
<thead>
<tr>
<th>Period of evaluation (Months)</th>
<th>Change in TSMR &amp; Owner VAS</th>
<th>Change in TSMR &amp; Clinician VAS</th>
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<tbody>
<tr>
<td></td>
<td>Correlation coefficient</td>
<td>p Value</td>
</tr>
<tr>
<td>0–1</td>
<td>−0.16</td>
<td>0.71</td>
</tr>
<tr>
<td>1–2</td>
<td>−0.25</td>
<td>0.56</td>
</tr>
<tr>
<td>2–6</td>
<td>−0.08</td>
<td>0.83</td>
</tr>
<tr>
<td>6–12</td>
<td>0.26</td>
<td>0.51</td>
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Similarly, dogs were evaluated in our study at a trotting gait as this has been demonstrated to be more sensitive and accurate than a walking gait for the differentiation of dogs with low grade lameness (39). That TSMR (Fig. 2) largely agreed with the elbow moment asymmetry (Fig. 3) is an indication that overall limb function was mainly affected by the discrete unilateral elbow lesion. The largest changes in elbow moment occurred in the compensating elbow where the moment was largest at two-months post arthroscopy, and although the differences were small, the FMCP affected elbow moment was smallest at this time yielding the largest degree of asymmetry. As elbow moment increased in the dysplastic elbow at six and 12 months, the moment in the compensating elbow decreased, yielding TSMR’s that were greatest at these time points.

A statistically significant negative correlation was identified between the TSMR and owner VAS at four weeks of treatment. Figure 4 reveals that the mean owner VAS of lameness decreased over time in the first six months post-treatment and that the greatest rate of owner perceived improvement, as defined by the slope of the line, was within the first month following institution of treatment. This period of evaluation coincided with the six week course of oral tepoxalin prescribed to all dogs and examination of the mean TSMR (Fig. 2) reveals a mild improvement in thoracic limb symmetry at this time (increased TSMR and therefore symmetry). It is likely that the initial transient improvement and the statistically significant negative correlation at the one month post-treatment assessment are due to the non-steroidal anti-inflammatory medication administered. The mean TSMR then decreased from the one to two month period of evaluation denoting a greater degree of asymmetry than at initial presentation. Previous studies have assessed the efficacy of NSAID administration peri-operatively in dogs using gait analysis (40) and our data appears to suggest efficacy of oral tepoxalin in improving lameness attributable to FMCP. The authors’ are not aware of any previously published objective measures of the most suitable duration of NSAID treatment for dogs diagnosed with FMCP. However, based on our gait analysis, a treatment period of at least two months duration would appear appropriate as it was not until between two to six months post-arthroscopic treatment that mean TSMR improved above that of pre-treatment levels.

In conclusion, owner assessment of outcome using VAS following treatment for unilateral lameness caused by FMCP is only reliable in the immediate post-treatment period. Pre-treatment scores and those of four weeks post-treatment do not provide a reliable assessment of thoracic limb function as assessed via gait analysis. Clinician assessment of outcome using VAS similarly appears unreliable as a means by which to assess thoracic limb symmetry. There appears to be a tendency for owners to underestimate forelimb asymmetry with increasing time, which is not supported by quantitative measures of gait.

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References