Carpal flexural contracture deformity is an uncommon musculotendinous disorder characterized by flexion of the antebrachiocarpal joint and supination of the manus in young animals.1–5 In dogs, carpal flexural deformity, also known as flexor tendon contracture, carpal instability, flexion syndrome, carpal hyperflexion, carpal laxity syndrome, and carpal hyperflexion syndrome, is caused by contracture of the flexor carpi ulnaris muscle and may affect medium-, large-, and giant-breed puppies of various breeds between 6 and 26 weeks of age.1–7 The Doberman Pinscher, Chinese Shar-Pei, and Anatolian Shepherd Dog are the most commonly reported breeds.2,3,5 Flexural deformity has also been reported in kittens.8,9

The cause of carpal flexural contracture deformity is unclear. In one of the first reports, Vaughan2 suggested an asynchrony between skeletal and muscle tendon growth, resulting in a relative shortening of the flexor carpi ulnaris muscle. Another proposed disease mechanism is that the flexor carpi ulnaris muscle in affected dogs contains more type I (antigravitational) fibers, which are active in maintaining posture, than neighboring muscles, predisposing them to develop the condition.7,10 Nutritional causes have also been suggested.3,6 Carpal flexural contracture deformity is usually bilateral, although the 2 forelimbs may be involved at different times and with different grades of severity.1,3,8,5 Affected animals are usually...
well nourished and in good condition and typically have normal skeletal development. Trauma does not appear to play a role. The typical clinical manifestation is a sudden onset of lameness with an initial shift of weight-bearing to the lateral surfaces of the digits and carpal hyperflexion associated with a variable degree of varus deviation of the manus. Overexercise has been speculated to possibly play a role in the development and severity of the deformity.

Owing to its typical presentation and occurrence in young, active medium- to large-breed dogs, carpal flexural contracture deformity is easily diagnosed during an orthopedic examination. A wheelbarrow test is useful in detecting early signs of contracture, particularly in mild or early cases. By lifting the hind limbs and walking the dog with weight-bearing only on the forelimbs, the deformity can become more evident as the puppy struggles to walk and maintain its balance. In severe cases, the clinical signs are much more apparent, causing the dog to stumble when walking. Palpation and manipulation of the antebrachiocarpal joint is not painful, and there is typically no evidence of effusion or crepitus. In most but not all cases, the carpal joint can be extended, although this may require a fair amount of force to accomplish, accompanied by increased tension in the flexor tendons. Radiographic examination does not reveal bone or joint abnormalities, and the distal radial and ulnar growth plates as well as bony mineralization are normal. The disease has been considered self-limiting and responsive to conservative management. In most mild cases, a few days of rest result in resolution of the deformity. Dogs that do not respond to rest alone and dogs that are more severely affected usually respond to rest and the addition of an elbow-to-paw bandage for 1 to 3 weeks. In severe cases, tenotomy of the ulnar and humeral heads of the tendon of the flexor carpi ulnaris muscle has been performed.

There is little objective information available on the outcome of various treatments for carpal flexural contracture deformity. The objective of the study reported here was to review the outcome for a series of dogs with carpal flexural contracture deformities treated with rest alone or with rest combined with bandaging. Our working hypotheses were that conservative management would resolve the deformity and that use of a bandage would contribute positively to this resolution.

Materials and Methods

Medical records of dogs examined between January 2000 and June 2018 at the Clinica Veterinaria Milano Sud or Clinica Veterinaria Villa Felice because of carpal flexural deformities were reviewed. All dogs were evaluated because of a sudden onset of a unilateral or bilateral forelimb deformity or abnormal forelimb gait. Signalment, clinical findings, treatments, and outcome were reviewed. The diagnosis of carpal flexural contracture deformity was made on the basis of clinical presentation and associated history. A detailed orthopedic examination was performed on all dogs, focusing on the forelimb deformity; this included flexion and extension with varus and valgus stress and assessments for joint effusion or laxity and abnormal bone angulation. The presence of any of these findings indicated an alternative diagnosis that was further assessed radiographically, and these dogs were excluded from the study. In the absence of these findings, the diagnosis was confirmed on the basis of the following findings during the orthopedic examination: focal point of the deformity and limited joint extension at the level of the antebrachiocarpal joint; ability to manually extend the joint, revealing normal alignment in the absence of a painful response; and simultaneous increased tension of the flexor tendons during antebrachiocarpal joint extension.

Severity of the deformity was graded on a scale of 1 (weight-bearing on lateral surfaces of the digits; antebrachiocarpal varus and carpal procurvatum absent), 2 (antebrachiocarpal varus with slight flexion; no obvious carpal procurvatum), or 3 (antebrachiocarpal varus with moderate or severe flexion; obvious carpal procurvatum; Figures 1–3). In dogs that were bilaterally affected, a severity grade was assigned to each limb. Dogs were grouped on the basis of severity score for the most severely affected limb.

Dogs were treated with rest alone or with rest and bandaging. Selection of treatment was at the discretion of the attending veterinarian at the initial visit. Most often, treatment was subjectively chosen on the basis of the assessment of the deformity severity. Rest was defined as limited activity (no running, jumping, or playing with other dogs; in-house confinement with multiple short leash walks daily; and crate restriction when other measures failed to control an active puppy). Rest and bandaging involved applying a modified Robert-Jones bandage and providing identical rest recommendations. The modified Robert-Jones bandage was relatively thinner than a typical Robert-Jones bandage and extended proximal to the elbow joint.

Dogs were reexamined weekly (within a range of 6 to 8 days to allow for weekends and holidays)
by the same individual who made the initial diagnosis, and bandages were replaced or removed on the basis of results of repeated orthopedic examinations performed as described for the initial diagnosis. In addition, all dogs were observed unrestricted either in the exam room or outdoors in a confined space to evaluate their ability to ambulate and run appropriately without lameness. Recovery was defined as resolution of the deformity and lameness. Dogs lost to weekly follow-up prior to recovery were excluded.

Statistical analysis

The Shapiro-Wilk test was used to determine whether data for severity score, age at the time of diagnosis, age at the time of recovery, and recovery time were normally distributed. Because data were not normally distributed, the Spearman rank correlation test was used to determine whether severity score was associated with age at the time of diagnosis, age at the time of recovery, or recovery time and whether age at the time of diagnosis was associated with age at the time of recovery or recovery time. All analyses were performed for all dogs as a single group and for each treatment group (rest alone vs rest and bandaging) separately. If a significant correlation was identified, linear regression was performed to verify the finding. For linear regression, data were first normalized by converting them to percentiles, with the lowest value in each data set considered the 0th percentile, the median considered the 50th percentile, and the highest value considered the 100th percentile. Finally, the Mann-Whitney test was used to determine whether time to recovery differed between dogs treated with rest alone versus dogs treated with rest and bandaging for all dogs and for dogs in each severity score group.

All analyses were performed with standard software (GraphPad Prism version 6.07; GraphPad Software). Values of \( P < 0.05 \) were considered significant.

Results

Fifty-nine dogs were initially included in the study. However, 12 dogs were lost to weekly follow-up and excluded. The remaining 47 dogs were included in the study.

All 47 dogs responded successfully to conservative management, with all dogs regaining full extension of the antebrachialcarpal joint and ambulating normally at the time of the final visit. No abnormal findings were present at the time of the final visit, except that 2 dogs had mild joint hyperextension (standing joint angle ≤ approx 135°). Both dogs recovered from hyperextension within 48 hours. No other complications were observed or reported by the owners. None of the dogs had a recurrence of the deformity through the age of skeletal maturity, as reported by the owners.

All dogs were initially examined within 1 week of the onset of clinical signs. Twenty-four of the 47 dogs were sexually intact males, and 23 were sexually intact females. Mean ± SD age at the time of diagnosis was 9.4 ± 1.8 weeks (median, 9 weeks; range, 6

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**Figure 2**—Photograph of an 8-week-old sexually intact female Afghan Hound with a unilateral grade 2 left carpal flexural contracture deformity. Notice the slight antebrachialcarpal varus and flexion.

**Figure 3**—Photograph of a 12-week-old sexually intact male mixed-breed dog with bilateral grade 3 carpal flexural contracture deformities. Notice the moderate antebrachialcarpal varus and severe carpal procurvatum.
to 13 weeks). Twenty-eight of the 47 dogs had bilateral flexural contracture deformities, and 19 had unilateral deformities (left forelimb, 13; right forelimb, 6). Four litters with multiple affected dogs in each litter accounted for 18 of the dogs. This consisted of a litter of Afghan Hounds (10 affected puppies), a litter of American Staffordshire Terriers (2 affected puppies), a litter of Doberman Pinschers (4 affected puppies), and a litter of Dogue de Bordeaux (2 affected puppies). For the litter of Afghan Hounds, all puppies in the litter were affected; the numbers of affected puppies in the remaining 3 litters were not recorded.

All but 2 dogs were purebred (Supplementary Table S1). Clinical severity was assessed as grade 1 in 16 of the 47 dogs, grade 2 in 12, and grade 3 in 19.

For all dogs considered together, mean ± SD time from the time of initial diagnosis to recovery (ie, resolution of the deformity and lameness) was 2.9 ± 2.2 weeks (median, 2 weeks; range, 1 to 9 weeks). Thirty of the 47 dogs were treated with rest alone, and 17 were treated with rest and bandaging. Mean time to recovery for dogs treated with rest alone (3.4 ± 2.4 weeks; median, 2 weeks; range, 1 to 9 weeks) was significantly (all \(P \leq 0.001\)) different. However, for dogs with grade 3 severity, mean time to recovery did not differ significantly between dogs treated with rest alone and dogs treated with rest and bandaging. However, for dogs with grade 3 severity, mean time to recovery was significantly \((P < 0.001)\) longer for dogs treated with rest alone than for dogs treated with rest and bandaging.

When all dogs were considered as a single group, severity score was not significantly correlated with age at the time of diagnosis \((P = 0.126; P = 0.399)\), and age at the time of diagnosis was not significantly correlated with recovery time \((P = -0.064; P = 0.670)\). However, severity score was significantly correlated with age at the time of recovery \((P = 0.561; P < 0.001)\) and with recovery time \((P = 0.554; P < 0.001)\), and age at the time of diagnosis was significantly correlated with age at the time of recovery \((P = 0.509; P < 0.001)\). Results of linear regression of the normalized data for all 3 significant correlations were also significant \((P < 0.001; Figure 4)\).

For dogs treated with rest alone, severity score was significantly correlated with age at the time of recovery \((P = 0.761; P < 0.001)\) and with recovery time \((P = 0.897; P < 0.001)\), and age at the time of diagnosis was significantly correlated with age at the time of recovery \((P = 0.418; P = 0.022)\); however, age at the time of diagnosis was not significantly correlated with recovery time \((P = -0.030; P = 0.877)\). For dogs treated with rest and bandaging, age at the time of diagnosis

### Table 1—Age at the time of diagnosis and time to recovery for 47 puppies with carpal flexural contracture deformities treated with rest and bandaging (n = 17) or with rest alone (30); all dogs recovered (ie, resolution of the deformity and lameness).

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of dogs</th>
<th>Mean ± SD (range)</th>
<th>Median (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at diagnosis (wk)</td>
<td>All dogs</td>
<td>16</td>
<td>9.4 ± 1.9 (8-12)</td>
</tr>
<tr>
<td></td>
<td>Rest alone</td>
<td>14</td>
<td>9.2 ± 1.8 (8-12)</td>
</tr>
<tr>
<td></td>
<td>Rest and bandaging</td>
<td>2</td>
<td>11.0 ± 1.4 (10-12)</td>
</tr>
<tr>
<td>Time to recovery (wk)</td>
<td>All dogs</td>
<td>16</td>
<td>1.4 ± 0.5 (1-2)</td>
</tr>
<tr>
<td></td>
<td>Rest alone</td>
<td>14</td>
<td>1.4 ± 0.5 (1-2)</td>
</tr>
<tr>
<td></td>
<td>Rest and bandaging</td>
<td>2</td>
<td>1.0 ± 0.0 (1)</td>
</tr>
</tbody>
</table>

- Values were significantly \((P < 0.001)\) different.

Figure 4—Scatterplots of severity score versus recovery time and age at the time of recovery (A); age at the time of diagnosis versus age at the time of recovery for all dogs (B), for dogs treated with rest and bandaging (C), and for dogs treated with rest alone (D); severity score versus recovery time for dogs treated with rest and bandaging (E); and severity score versus age at the time of recovery for dogs treated with rest alone (F) for 47 puppies with carpal flexural contracture deformities treated with rest and bandaging \((n = 17)\) or with rest alone \((n = 30)\); all dogs recovered (ie, resolution of the deformity and lameness). In each graph, the line represents the results of linear regression analysis of data normalized by conversion to percentiles. Linear regression analysis was performed only when a significant correlation was found in initial analyses with the Spearman rank correlation test. Dx = Diagnosis.
was significantly correlated with age at the time of recovery ($\rho = 0.783; P < 0.001$); however, severity score was not significantly correlated with age at the time of recovery ($\rho = 0.150; P = 0.563$) or with recovery time ($\rho = -0.019; P = 0.943$), and age at the time of diagnosis was not significantly correlated with recovery time ($\rho = 0.064; P = 0.806$). Results of linear regression of normalized data for all 4 significant correlations were also significant (all $P < 0.001$, except $P = 0.013$ for age at the time of diagnosis vs age at the time of recovery for dogs treated with rest alone; Figure 4).

**Discussion**

Results of the present study suggested that conservative management (rest alone or rest and bandaging) was a successful treatment option for puppies with carpal flexural contracture deformity and that bandaging resulted in a shorter time to recovery for dogs that were severely affected. In addition, linear regression analysis indicated that as the severity of the deformity increased, both the recovery time and the age at the time of recovery increased; as the age at the time of diagnosis increased, age at the time of recovery also increased, regardless of treatment; and, for dogs treated with rest alone, as the severity of the deformity increased, both the recovery time and the age at the time of recovery increased. Most importantly, for the most severely affected dogs (ie, dogs with grade 3 severity), rest alone was associated with a significantly longer recovery time than was rest and bandaging. Significant differences in recovery times were not found between treatment groups for dogs with grade 1 or grade 2 severity. However, this could have been due at least in part to the fact that only 2 dogs with grade 1 severity underwent bandaging. Also, when all dogs were considered together, recovery time was significantly longer for dogs treated with rest alone than for dogs treated with rest and bandaging. However, this may have reflected the significant difference between treatment groups for dogs with grade 3 severity.

None of the dogs in the present study required surgical transection of the flexor tendons. Therefore, we cannot comment on outcomes for dogs undergoing surgical treatment. However, on the basis of our findings, we believe that surgical treatment would rarely be required and that, even in the most refractory cases, simply prolonging the duration of bandaging would be successful.

For dogs included in the present study, a thorough orthopedic examination was sufficient to diagnose carpal flexural contracture deformity, as has been reported previously. Age at the time of diagnosis has been reported to range from 5 to 8 weeks and from 6 to 13 weeks in 3 previous reports, and this was consistent with findings for our dogs, which ranged from 6 to 13 weeks old. In dogs suspected to have carpal flexural contracture deformity, it may be prudent to perform screening radiography of the forelimb or antebrachium to rule out other skeletal deformities. However, this was not consistently done for dogs in the present report because findings were unremarkable for the first few dogs in which screening radiography was performed. Also, all dogs fully recovered within 1 to 9 weeks of the onset of treatment, making other skeletal deformities unlikely. Similarly, previous reports have suggested that radiographic examination was uninformative.

Deformity of the distal radius and ulna is one of the most commonly diagnosed forms of angular limb deformity in dogs, and premature closure of the distal ulnar growth plate is the most common cause of this growth disturbance. However, at the age of the puppies in the present report, there is unlikely to be any observable radiographic changes even in the presence of a physeal injury. Furthermore, valgus deviation, a procurvatum deformity, and external torsion of the distal radius are the clinical and radiographic signs associated with premature closure of the distal ulnar growth plate. In contrast, carpal flexural contracture deformity results in a slight or moderate varus deviation, most notably at the joint level, without procurvatum and with hyperflexion at the level of the joint. Additionally, there is no torsional component. Because none of the dogs in the present study had an angular limb deformity after treatment, we can be confident in our diagnostic approach because an angular limb deformity would not be expected to resolve but would continue to worsen in growing puppies.

Serum biochemical analyses were not performed in any of the dogs in the present study, again because of the absence of any clinical signs of other problems. All of our cases involved medium- to large-breed puppies that were happy, eating well, and growing rapidly; had no signs of pain; and had an abrupt onset and progression of their deformity over a short time frame. It is not known whether performing serum biochemical analyses would have altered the diagnosis, treatment, or outcome in any clinically meaningful way in these dogs. A previous report described slightly high serum calcium, phosphorus, and magnesium concentrations in 21 of 31 (68%) puppies with carpal flexural contracture deformities. However, actual values were not reported or compared with values for unaffected puppies or healthy adult dogs. Our approach to forego serum biochemical testing can be supported by the full recovery of all dogs with conservative treatment. Nevertheless, such testing might provide further insight into this disease process.

Ten Afghan Hounds, 4 Doberman Pinschers, 2 Dogue de Bordeaux, and 2 American Staffordshire Terriers from 4 litters were included in the present study, suggesting that genetic factors could potentially be involved in the etiology of the disorder. In addition, the Afghan Hound (10/47) and Doberman Pinscher (7/47) were the 2 breeds represented by the highest numbers of dogs. Vaughan previously suggested a possible genetic predisposition in Doberman Pinschers. However, the high number of Afghan Hounds in our study simply may have been a result of regional predominance of this breed or may have been purely coincidental, as was suggested by Vaughan for Doberman Pinschers and by Altunatmaz and Ozsoy for Anatolian Shepherd Dogs. We did not identify a sex predisposition in the present study, although a previous study identified a predisposition in male dogs.

Some limitations of the present study must be considered, and most of those limitations related
to the study’s retrospective nature. First and foremost, dogs were not randomly assigned to treatment groups and treatment was determined by the attending veterinarian, introducing a potential treatment bias, and the criteria used to select a particular treatment were not specified in the medical records. It was also not possible to eliminate treatment bias, as it was quite clear which dogs had bandages and which did not. Finally, grouping the dogs by severity resulted in low numbers for some groups, which may have affected our statistical analyses. For example, only 2 of 16 dogs with grade 1 severity underwent bandaging. On the other hand, dogs with grade 2 or 3 severity were more evenly split between treatment groups. It can be debated whether a grade 1 carpal flexural deformity contracture might be an incidental finding; however, we believe it is prudent to limit activity in a growing puppy with any evidence of a deformity. Notably, combining dogs with grades 1 and 2 deformities did not change our findings. It is reasonable to assume that grade 3 deformities are the most problematic, and our findings showed the clear advantage of bandaging in these dogs.

Another potential limitation of the present study was the proposed severity scoring system we used. This scoring system was based on visual and orthopedic findings and has not been validated. The Brighton scoring system is a validated goniometric method of measuring joint mobility in children that is based on evaluations of joint hypo- or hypermobility. A similar scoring system for puppies may provide a more objective measure of severity in puppies with carpal flexural contracture deformities. However, such a scoring method may prove problematic in puppies owing to the variability in size and conformation of affected dogs.

In the present study, rest alone was more likely to be selected for puppies with grade 1 severity, most likely because of the mild degree of deformity present, whereas rest alone and rest with bandaging were about equally likely to be selected for puppies with grade 2 or 3 severity. This treatment approach appeared to be reasonable, given our finding that bandaging provided a definitive advantage only for puppies with grade 3 severity.

Notably, adjunctive treatments were not investigated in the present study. A previous report included general comments recommending various modes of physiotherapy, but information was not given as to whether physiotherapy was recommended on the basis of severity of the deformity. No specific physiotherapy has been documented for carpal flexural contracture deformity in dogs, and this may be a useful area of investigation. Certainly, some veterinarians prefer to avoid using bandages in puppies because of potential negative effects, such as local bandage-related issues (eg, dermatitis) and alterations in muscle and tendon development due to the lack of stress associated with normal activity. The dogs reported here were frequently evaluated, and no local bandage-related issues were observed. Because relaxation of the flexor tendons is the goal with bandaging, the attendant risk is hyperextension. However, hyperextension was uncommon, occurring in only 2 dogs in the present study, and resolved quickly (< 48 hours) after the bandage was removed. This was consistent with our overall anecdotal experience, but it does illustrate that prolonged bandaging, especially with the use of splints, may result in hyperextension in puppies. Therefore, it is prudent to frequently reevaluate these cases during treatment and to monitor standing joint angles. Our recommendation is to remove the bandage and reevaluate these dogs on at least a weekly basis. No long-term dysfunction was reported by any owner, and all dogs returned to normal function and activity.

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References


Supplementary Materials

Supplementary materials are available online at the journal website: avmajournals.avma.org