Evaluation of application of a carpal brace as a treatment for carpal ligament instability in dogs: 14 cases (2008–2011)

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Objective—To determine whether carpal brace application is a viable treatment for dogs with unilateral carpal ligament instability.

Design—Retrospective case series.

Animals—14 client-owned athletic dogs.

Procedures—Medical records were reviewed to identify dogs treated with a brace for unilateral carpal valgus or varus instability between August 2008 and August 2011. Treatment included passive motion and isometric strengthening exercises during brace application.

Results—Of the 14 dogs, 11 were considered to have returned to normal function; 11 of 12 dogs returned to agility competition. Carpal measurements before treatment indicated the affected limb had significantly greater valgus measurements (median, 30º; range, 30º to 35º), significantly greater varus measurements (median, 15º; range, 15º to 25º), and significantly less flexion (median, 37.5º; range, 30º to 45º), compared with results for the contralateral carpus. Long-term monitoring revealed no differences in measurements between affected and contralateral limbs. Valgus measurements of the affected carpus at brace removal (median, 15º; range, 15º to 20º) and at the end of long-term monitoring (median, 15º; range, 15º to 20º) were significantly lower than measurements before treatment (median, 30º; range, 30º to 35º). Dogs had significantly lower lameness scores (assessed on a scale of 0 to 5) at brace removal (median, 0; range, 0 to 2), compared with scores before treatment (median, 3; range, 1 to 3).

Conclusions and Clinical Relevance—Application of a carpal brace resulted in improved stability and resolution or reduction in lameness in dogs with carpal ligament instability. (J Am Vet Med Assoc 2014;244:438–443)

The carpus is a complex diarthrodial joint consisting of multiple smaller joints and supportive ligaments. In dogs, dorsal and palmar stability is provided by (in a dorsal to palmar direction) the extensor tendons, dorsal radiocarpal ligament, dorsal intercarpal ligaments, fibrous joint capsule, and palmar carpal fibrocartilage and by the palmar intercarpal ligaments, palmar ulnocarpal ligament, and palmar radiocarpal ligament as well as the accessoriotetacarpal ligament, accessoriolunar ligament, accessorioquartal ligament, and accessoriocondylar or palmar radiocarpal ligament. Lateral to medial stability is provided by the medial and lateral collateral carpal ligaments.

During motion, the canine carpus is involved in the storage of elastic energy, which then contributes to propulsion. During the stance phase, the flexor muscles of the carpus, which are stretched by extension of the carpal joint, store elastic energy that provides recoil at the moment of propulsion. Efficient propulsion is dependent on a stable carpal joint. Excess medial to lateral motion as a result of carpal joint instability will produce kinetic vectors that are not parallel to the direction of desired travel, which renders the motion less efficient.

Joint stability is defined as the ability of articular surfaces to maintain their relationship and limit their relative displacements during physiologic postures and loads. Joint instability is classified as static or dynamic. Static instability is assessed (usually on the basis of goniometry or examination of stress radiographs) by use of a manual stress test with the joint in a fixed position, usually extension. Dynamic instability is defined as joint instability manually palpated or measured with electrogoniometry during passive or active motioning of the joint. Dynamic instability is further subclassified as dissociative (a situation in which one or more of the ligaments are torn) or nondissociative (a situation in which the ligaments are intact but stretched). In a study of carpal joints with nondissociative instability (stretched ligaments), these unstable joints more frequently elicited signs of pain when overloaded, compared with signs of pain when healthy stable joints were overloaded.

Joint instability is diagnosed in human medicine by patient-based assessments of pain and function, physical measures of joint function (eg, strength, range of motion, or stability), and diagnostic imaging (most often MRI). Goniometry has been validated in humans as a reliable measure of hypermobility.

Valgus stress...
testing has been described as a reliable method for assessing laxity in the medial collateral ligament of the thumb in humans. Management of these injuries has typically included rest or immobilization on a temporary (casting or bandages) or permanent (arthrodesis) basis. It can be difficult for both dogs and their owners to maintain cage rest. Management of joint instability with complete immobilization can have short- and long-term adverse effects. Immobilization can result in disorganized collagen deposition and slower recovery of tensile strength in healing ligaments; it will also have detrimental effects on cartilage health. However, allowing full motion and loading of an unstable joint can cause a decrease in strength of healing ligament fibers. Permanently immobilizing will result in reduced flexor tendon stretching because the carpal joint cannot move farther into extension during the stance phase of motion, and thus, elastic recoil of those flexor tendons is limited; this results in reduced efficiency of locomotion. An alternative treatment is a custom brace, which eliminates the need for cage rest while tissues are healing but, in contrast to complete immobilization of the carpus, allows some amount of tissue loading and can be removed by an owner to enable provision of passive therapeutic joint motion and daily inspection of the skin for abrasions. A brace also eliminates the need for frequent in-clinic bandage changes and is less costly (a brace costs approx $100, whereas weekly bandage changes would cost approx $300). The purpose of the study reported here was to evaluate the use of such a brace in dogs with forelimb lameness and measurable carpal joint laxity. We hypothesized that application of a brace to support carpal ligament injuries with nondissociative instability would improve joint stability and, therefore, reduce lameness.

**Materials and Methods**

**Case selection**—Medical records of all dogs examined because of carpal valgus or varus instability at the Twin Cities Animal Rehabilitation Clinic between August 1, 2008, and August 1, 2011, were reviewed. Criteria for inclusion in the study were a diagnosis of carpal valgus or varus instability with the presence of forelimb lameness and signs of pain elicited by manipulation of the carpal joint of the affected limb with no additional signs of pain or lameness in other limbs. Additional inclusion criteria were a previous treatment period of forced inactivity that had not yielded satisfactory resolution of lameness, radiographs of the carpus obtained prior to application of a carpal brace, and evaluation before brace application, at brace removal, and at the end of long-term follow-up monitoring (2-16 weeks after brace removal). Patients receiving analgesic medications at the time of the initial evaluation or during the period of brace application were excluded from the study. Dogs with hyperextension of the carpal joint were also excluded from the study.

**Medical records review**—Information gathered from the medical records included signalment, body weight, duration of lameness, radiographic images, physical examination results, diagnosis, treatment, and outcome. Examination included lameness evaluation on a scale of 0 to 5 (0, no observable lameness; 1, intermittently lame; 2, lame under exacerbating circumstances; 3, consistently lame during trotting; 4, lame during walking; and 5, non-weight-bearing lameness). Goniometric measurements of maximal flexion and extension in all appendicular joints of each limb (excluding joints of the digits) in addition to valgus and varus (abduction and adduction) movements of the carpus. All goniometric measurements (including carpal valgus and varus flexion and extension) were obtained by 1 clinician (JET) with a goniometer indexed in 5° increments. When the movement arm of the goniometer was positioned between 5° marks, the angle recorded was the lower of the 5° increments. Measurements were repeated once for verification of the angle. A diagnosis of carpal valgus or varus instability was made when the angle for the forelimb with carpal valgus or varus differed by >10° (twice the margin of error for the method used at the clinic) from the value for the nonaffected contralateral forelimb.

Plain radiographs of both carpal regions were obtained before brace application and evaluated by one of the investigators (JET), who was board certified in veterinary surgery and also board certified in veterinary sports medicine and rehabilitation. Follow-up radiographs were obtained for 3 dogs in which lameness persisted after treatment via application of the brace.

A diagnosis of carpal valgus or varus instability was made when the angle for the forelimb with carpal valgus or varus differed by >10° (twice the margin of error for the method used at the clinic) from the value for the nonaffected contralateral forelimb. The brace was placed for a minimum of 8 weeks on each dog. Examination by a veterinarian and evaluation of the brace fit were performed every 1 to 2 weeks. Owners were instructed in use and application of the brace. Owners were to remove the brace only twice daily to allow inspection of the skin for lesions (which were recorded) and to enable gentle, slow, passive flexion and extension of all forelimb joints for 20 repetitions, as instructed and demonstrated at the time of initial brace application, which was followed by replacement of the brace. Exercise was limited to leash-restricted activity for the first 2 weeks after initial application of the brace; off-leash, nonagility activity was allowed thereafter with the brace still applied on the affected forelimb. Static strengthening exercises (ie, the dog bearing weight on 3 limbs [the affected forelimb and both hind limbs]) were instituted beginning 2 weeks after initial
application of the brace and continuing until week 8 after brace application.

After 8 weeks of full-time brace application, brace use was gradually reduced over the following 2 to 4 weeks, depending on owner compliance. This consisted of gradually increasing the amount of time the brace was not applied to the forelimb; however, the brace was still applied when the dog exercised at gaits faster than a trot. Gradual reduction of brace use started with short walks with the dog on a leash without the brace applied to the affected forelimb, which progressed to increasing periods of activity in the house when the brace was not applied. Outdoor activity without the brace was slowly introduced via short sprints (gallop) during recall training (calling the dog to return to the owner) for increasing distances over the period of 2 to 4 weeks after complete brace removal. Once the dog was comfortably running during recall training, training for return to sporting events was implemented. The investigator who was board certified in veterinary sports medicine and rehabilitation (JET) supervised the training for return to sporting events over a 4- to 6-week period (full return to competition by 10 weeks after brace removal).

In the case of dogs not involved in sports competitions, the recall training was completed as described and then followed with a program of gradually increasing the amount of time allowed each day for off-leash activity; this was continued until the dog had returned to normal activity levels.

Passive range-of-motion measurements of the carpal joint when it was moved into maximal valgus and varus flexion and extension positions were obtained on the affected and contralateral (nonaffected) limb at 3 time points (before brace application, at the time of brace removal, and at the end of long-term follow-up monitoring [≥16 weeks after brace removal]). Lame ness scores were assigned at those same times.

Statistical analysis—Descriptive statistics were calculated for lameness-related variables (age at onset and duration of lameness). Goniometric measurements subjected to statistical analysis were carpal valgus and varus flexion and extension. Results of Shapiro-Wilk normality tests and evaluation of QQ-plots of the residuals from the goniometric measurements (on the original data and after the data were logarithmically transformed) revealed that the data were not normally distributed. Thus, the original data were retained, and nonparametric statistical tests were used. A Friedman test, with P values adjusted by the Dunn test for multiple comparisons, was used to compare differences in repeated goniometric measurements of the affected limb between brace application and brace removal, brace application and the end of long-term follow-up monitoring, and brace removal and the end of long-term follow-up monitoring. The Friedman test with Dunn multiple comparisons adjustment was then repeated for these same comparisons with the goniometric values for the contralateral limb. The nonparametric, 2-tailed Wilcoxon matched-pairs signed rank test was used to compare differences between goniometric measurements of the affected and contralateral limb at each of the 3 times (brace application, brace removal, and end of long-term follow-up monitoring). Data were analyzed with statistical software, \(^*\) and significance was set at values of \(P < 0.05\).

Results

A total of 910 medical records were reviewed, and 30 dogs with forelimb lameness and signs of pain in the carpal region were identified that potentially met the inclusion criteria. Of these initial 30 dogs, 14 (4 males and 10 females) with a mean ± SD age of 6 ± 1.9 years and body weight of 13.45 ± 7.95 kg (34.0 ± 17.5 lb) with unilateral forelimb lameness of various durations (11.4 ± 17.2 weeks [range, 2 to 52 weeks]) met all of the inclusion criteria. Twelve of the 14 dogs were involved in agility competitions, 1 was a herding dog, and 1 was not in competitions but was a family pet. Each dog was included in the study only once.

At the time of brace application, dogs ranged from 4 to 9 years of age (mean ± SD, 5.6 ± 1.8 years). The right forelimb was affected in 9 dogs, and the left forelimb was affected in 5 dogs. Duration of lameness prior to brace application ranged from 2 to 52 weeks (mean, 11 ± 17 weeks). Examination of initial radiographs of the carpal region revealed no abnormalities for 13 of 14 dogs (a Shetland Sheepdog had evidence of degenerative changes in the antebrachioarcarpal joint). Duration of long-term follow-up monitoring ranged from 16 to 80 weeks (mean, 41 ± 16 weeks).

Overall, owners reported that 11 of 14 dogs returned to normal function. Owners reported that 11 of 12 dogs returned to agility competitions. Only a minor complication was reported for use of the brace. Small areas of hair loss were reported for 3 dogs; placing additional padding (memory foam) in the brace resolved the problem in all 3 dogs.

For the goniometric measurements obtained immediately prior to brace application, affected limbs had significantly \((P < 0.001)\) greater carpal valgus measurements (median, 30º; range, 30º to 35º), significantly \((P = 0.03)\) greater carpal varus measurements (median, 15º; range, 15º to 25º), and significantly \((P = 0.03)\) less flexion (median, 37.5º; range, 30º to 45º), compared with results for the contralateral limbs (Table 1). There was no significant difference in carpal extension between the affected and contralateral limbs at any time. At the time of brace removal, there were no significant differences between carpal valgus or varus measurements between the affected and contralateral limbs. At the time of brace removal, there was still significantly \((P = 0.03)\) less flexion in the affected limb (median, 35º; range, 30º to 45º), compared with results for the contralateral limb. At the end of long-term follow-up monitoring, there were no significant differences between the affected and contralateral limb for any measurement.

The carpal valgus measurements for the affected limb at time of initial brace application (median, 30º; range, 30º to 35º) were significantly higher, compared with measurements obtained at the time of brace removal (median, 15º; range, 15º to 20º; \(P < 0.001)\) and at the end of long-term follow-up monitoring (median, 15º; range, 15º to 20º; \(P = 0.01\) [Table 1]). Carpal valgus measurements obtained at the time of brace removal and the end of long-term follow-up monitoring did not differ significantly \((P > 0.999)\). There were no
turned to competing in agility events. The third dog polysulfated glycosaminoglycan, and 1 of the 2 re-
they were managed by administration of NSAIDs and 1 of the 2 re-

Table 1—Median (range) angle for goniometric measurements and lameness scores in dogs with carpal ligament instability at the time of carpal brace application, at brace removal, and at the end of long-term follow-up monitoring.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Brace application</th>
<th>Brace removal</th>
<th>End of long-term follow-up monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valgus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affected</td>
<td>30 (30–35)*†</td>
<td>15 (15–20)</td>
<td>15 (15–20)</td>
</tr>
<tr>
<td>Vary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affected</td>
<td>37.5 (30–45)*†</td>
<td>35 (30–45)</td>
<td>35 (30–45)</td>
</tr>
<tr>
<td>Contralateral</td>
<td>30 (30–45)</td>
<td>30 (30–45)</td>
<td>30 (30–45)</td>
</tr>
<tr>
<td>Extension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affected</td>
<td>200 (190–205)</td>
<td>200 (190–205)</td>
<td>195 (195–205)</td>
</tr>
<tr>
<td>Contralateral</td>
<td>195 (190–200)</td>
<td>195 (190–200)</td>
<td>195 (190–200)</td>
</tr>
<tr>
<td>Lameness score</td>
<td>3 (1–3)*†</td>
<td>0 (0)</td>
<td>0 (0–2)</td>
</tr>
</tbody>
</table>

Goniometric measurements are in degrees. Lameness score is on a scale of 0 to 5 (0, no observable lameness; 1, intermittently lame; 2, lame under exacerbating circumstances; 3, consistently lame during trotting; 4, lame during walking; and 5, non–weight-bearing lameness). Duration of long-term follow-up monitoring ranged from 16 to 80 weeks (mean ± SD, 41 ± 16 weeks). *Within a row, value differs significantly (P < 0.05) from the values for the other time points. †Within a column within a variable, value differs significantly (P < 0.05) from the value for the contralateral limb at that time point.

Turning to the discussion, significant differences over time in any other goniometric measurement for the affected or contralateral limb. Lameness score for the affected limb was significantly (P < 0.001) lower at the time of brace removal (median, 0; range, 0) and at the end of long-term follow-up monitoring (median, 0; range, 0 to 2), compared with the score prior to brace application (median, 3; range, 1 to 3). Lameness scores obtained at the time of brace removal and at the end of long-term follow-up monitoring did not differ significantly (P > 0.999).

Intermittent lameness was detected in 3 of 14 dogs after brace removal. Median lameness score for those 3 dogs at the time of the intermittent lameness was 1 (range, 1 to 3). Lameness in all 3 dogs was associated with radiographic evidence of osteoarthritis (1 dog had clinical evidence of osteoarthritis at the start of the study). Two of the dogs with intermittent long-term lameness had been involved in agility competitions; they were managed by administration of NSAIDs and polysulfated glycosaminoglycan, and 1 of the 2 returned to competing in agility events. The third dog was a family pet and was managed similarly to the other 2 dogs.

Discussion

Application of a carpal brace allowed for return to agility competition for 11 of 12 dogs and return to normal function for 11 of all 14 dogs with lameness previously refractory to treatment with rest, including cage rest. In tandem with this clinical improvement of lameness, affected limbs had significant improvement for valgus measurements both at brace removal and at the end of follow-up monitoring. Measurements for the contralateral limb did not change significantly over time, as expected. At the time of brace removal, all goniometric values were not significantly different from the values for the contralateral limb, except for flexion values. This may have been attributable to the fact that the amount of time a dog spent in the brace reduced flexion, with the range of motion only returning at the end of long-term follow-up monitoring after further limb use. However, considering that flexion of the affected limb was not significantly different across time, this may not have been clinically important for these dogs.

Because dogs are quadrupeds, the authors considered it more appropriate to compare therapeutic approaches to ankle and knee sprains in humans rather than to compare results for the carpus (wrist) of a biped. Complete immobilization of the ankle following an acute sprain in humans is no longer a recommended treatment; early mobilization with functional treatment (allowing some joint movement in flexion and extension but supporting the joint with a brace) is preferred. Authors of a systematic review of the scientific literature for human medicine concluded that treatment of acute ankle sprains by use of functional braces leads to better outcomes (eg, shorter amount of time until return to work or participation in sports, less swelling and instability, and greater overall satisfaction), compared with the outcomes for complete immobilization. Medial collateral ligament injuries of the human knee are common, and ligament laxity is tested with an applied valgus force with the knee flexed at 30°. Treatment of low-grade tears involves an initial 72-hour period of rest, and then the patient is allowed to bear weight with use of a hinged knee brace to protect the knee from valgus stress. Range-of-motion and strengthening exercises are used. Strength evaluation via tensile testing of the knee can be performed within weeks after the injury so that patients can return to work and participate in sports quickly with splints or braces.

The function of ligaments is to provide joint stability by transmitting force across a joint and facilitating joint articulation during movement. Ligaments provide feedback on joint position to aid proprioception. The present study was performed to evaluate the use of a removable functional brace, which did not completely immobilize the joint but instead allowed a limited range of motion. A brace that allows some motion at the carpal joint and therefore some stress on the supporting carpal ligaments is a good method of providing sufficient mechanical load (stress) to increase extracellular matrix production, which stimulates healing while limiting excess motion and preventing further injury. Motion of the carpal joints of dogs was evaluated by use of electrogoniometry during walking with and without bandaging. Bandaged limbs had only 28° of motion in the carpus joint from flexion to extension, whereas unbanded limbs had 99° of motion from flexion to extension. Support with light tape (strapping) resulted in less reduction in carpal motion than did a full bandage, with a range of motion from flexion to extension of 63°. The carpal brace in the present study allowed for 45° of motion from flexion to extension, which was more limiting than light tape but not as limiting as a full bandage.
Casting to immobilize the carpus during healing has the potential to slow ligament healing. Additionally, investigators in a study of complications of full-limb casting found that there were soft tissue injuries secondary to casting in 63% of dogs and cats with casts and that these injuries could occur at any time during coaptation and were unrelated to the initial degree of orthopedic injury. The cost of treating these complications ranged from 4% to 121% more than the cost of treating the original injury. Ligament laxity was diagnosed in the present study by the use of goniometry. Goniometric measurements of joint range of motion, including carpal valgus and varus movements, have been validated in Labrador Retrievers. In human medicine, goniometry is used to classify diagnosis of collateral ligament injuries of the metacarpophalangeal joint of the thumb. The ulnar and radial collateral ligaments are primary stabilizers of the metacarpophalangeal joint of the thumb of humans; a sprain (slight pain along the ulnar carpal ligament with laxity, compared with no pain during laxity of the contralateral ligament), is generally classified as a grade I injury. An increase in laxity of ≤ 10° to 15° compared with that for the contralateral thumb and with a definitive endpoint (ie, a partial rupture), is defined as a grade II injury. An increase in laxity of > 15° without a definitive endpoint (ie, a complete rupture) is classified as a grade III injury. On the basis of this classification scheme, the dogs in the present study would have been classified as having grade II injuries of the medial or lateral carpal collateral ligaments. The diagnosis of ligament laxity as the cause of lameness in the dogs of the present study was supported by the decrease in the angle of passive valgus laxity that corresponded with resolution of the lameness. There is a paucity of data about the time scale for healing of periarticular ligaments (eg, the carpal ligaments). Therefore, we compared results for tendon healing. Tendons and ligaments have some structural similarities. Both consist principally of bundles of collagen embedded in ground substance with a poor blood supply, and they both heal slowly. In an early study in dogs, healing of repaired flexor tendons that were immobilized in a cast was monitored histologically in combination with serial measurements of tensile strength. Complete immobilization in a cast allowed healing; however, when a cast was maintained beyond 21 days, recovery of tendon tensile strength was retarded, compared with healing in dogs with partial immobilization. Experiments on healing in rabbits, horses, and rats with induced tendon damage reveal that the time to reach maximal postinjury tensile strength (approx 60% of preinjury values) ranges from 8 to 16 weeks. Dogs in the present study were in a brace for 8 weeks, then an additional 4 weeks was spent with gradual reduction of use of the brace, which provided a 12-week recovery period during which it was assumed that the brace restricted carpal valgus and varus movement, which in turn possibly reduced stress or strain on the carpal collateral ligaments. This 12-week recovery period was within the time range stated in the study on tendon healing in rabbits, horses, and rats; thus, there should have been adequate time to reach maximal postinjury tensile strength in the ligaments supporting the carpus.

Limitations of the present retrospective case series were that only 1 treatment was used in the clinic for dogs with carpal valgus or varus instability; thus, no affected dogs were treated with cage rest for comparison. However, cage rest had been tried and had failed to resolve lameness in each of the dogs prior to the initial evaluation at our clinic. Additionally, there was no treatment group of dogs without the brace and undergoing only the prescribed rehabilitation exercises. Finally, the veterinarian performing the goniometric measurements was aware of the medical history and treatment for each dog.

Alternative therapeutic options to the carpal brace would have included temporary or permanent immobilization. Temporary immobilization in the form of bandaging has been associated with a variety of complications, including swelling, erythema, signs of pain, and ischemic lesions, some of which resulted in the loss of use of the limb and subsequent amputation. Arthrodesis of the carpal joint would have been a highly interventional option for treating the dogs of the present study, but it could be argued that arthrodesis would have resolved lameness in the 3 dogs that had persistent signs of pain. In a study conducted to evaluate working herding dogs after pancarpal arthrodesis, 50% of the treated dogs performed duties in a manner similar to that before surgery, and 33% performed most of the duties; however, only 50% were totally free from lameness after surgery. Additionally, there were problems associated with carpal arthrodesis in 50% of dogs in that study. These included pin loosening, wound complications, surgical site infection, and cast complications. Another potential issue arising from carpal arthrodesis is that most negative external work (elastic storage of energy) of the flexor muscles in the forelimbs is produced as the carpus extends in the stance phase of motion; the energy is then used for propulsion.

Forelimbs produce most of the negative work during trotting and galloping, which are gaits commonly used during agility events. Permanent elimination of carpal motion secondary to arthrodesis is detrimental in dogs involved in agility events, whereas temporary application of a brace allows for healing and return to a functional mobile carpus. Therefore, we believe that application of a carpal brace offers a reasonable treatment option for dogs with carpal instability.

References


