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Exostoses of the caudal perimeter of the radial physis as a cause of carpal synovial sheath tenosynovitis and lameness in horses: 10 cases (1999–2003)

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Objective—To determine the clinical, radiographic, ultrasonographic, and arthroscopic findings associated with tenosynovitis of the carpal synovial sheath induced by exostoses that originate from the caudal surface of the physeal scar of the distal radius and determine the results of surgical removal of those exostoses in horses.

Design—Retrospective study.

Animals—10 horses.

Procedure—Medical records of horses with effusion in the carpal synovial sheath and lameness evaluated from 1999 to 2003 were examined.

Results—All horses had a history of intermittent mild to moderate effusion of the carpal synovial sheath and lameness of 1 forelimb. Results of regional perineural and intrathecal anesthesia of the carpal synovial sheath confirmed that the lameness originated in the carpal synovial sheath. Radiography revealed exostoses originating from the caudal cortex of the distal radius at the level of the closed physis. Arthroscopy was performed for confirmation and removal of exostoses that penetrated the carpal synovial sheath and impinged on the deep digital flexor tendon. All horses returned to previous athletic activity. One horse had a recurrence of clinical signs 12 months after surgery, which resolved with medical treatment.

Conclusions and Clinical Relevance—Tenosynovitis of the carpal synovial sheath and lameness were caused by impingement of exostoses of the caudal radius on the lining and contents of the carpal synovial sheath. Although the clinical signs and surgical treatment were similar to that caused by osteochondromas, these exostoses developed at the level of the closed physis of the distal radius and were not radiographically or histologically similar to osteochondromas. (*J Am Vet Med Assoc* 2004;224:264–270)

Tenosynovitis of the carpal synovial sheath and lameness are recognized complications of osteochondroma arising from the caudal metaphyseal bone surface of the distal radius in horses.[1-6] The pathogenesis of a solitary osteochondroma in the long bone of a horse is thought to involve separation of a portion of a border of a physis during skeletal development. This island of chondrogenic tissue establishes a separate focus of endochondral ossification, resulting in the formation of a cartilage-capped exostosis that projects from the metaphyseal surface of a long bone and stops growth at the time of skeletal maturity.[4,7]

Solitary osteochondroma of the horse most frequently develops on the caudomedial surface of the metaphysis of the distal radius. Radiography reveals that the osteochondroma protrudes a variable distance toward the structures of the carpal synovial sheath. Impingement on the carpal synovial sheath can cause tenosynovitis, various degrees of fluid distension, and lameness. The lameness is often exacerbated by flexion of the carpus. Ultrasonography of the carpal synovial sheath and **deep digital flexor tendon (DDFT)** adjacent to the bony encroachment of the osteochondroma also reveals excoriation and fibrillation of collagen fibers of the epitenon and superficial collagen bundles of the DDFT.[4,6]

The diagnosis of osteochondroma of the radius is generally confirmed by radiography[4] The cartilage-capped exostosis originates from the cortical surface of the metaphysis 2 to 4 cm proximal to the residual physeal scar of the distal physis of the radius. There are no reports in the literature that describe solitary osteochondroma originating directly over the radial physeal remnant, although radial physeal remnant spikes have been mentioned as a cause of lameness in a recent proceedings.[8]

Advanced diagnostic techniques, including nuclear scintigraphy, ultrasonography, computed tomography, and tendon sheath arthroscopy, have revealed numerous causes for carpal sheath tenosynovitis other than osteochondroma.[4,6] Causes include tearing of the accessory ligament of the **superficial digital flexor tendon (SDFT**; proximal check ligament), proximal tendinitis of the SDFT or DDFT, tearing of the flexor tendons at their myotendinous junction, overextension injury of the carpus, compression from accessory carpal bone fracture callus, and caudal intrusions to the carpal sheath from exostoses unrelated to osteochondromas.

Arthroscopic examination of the carpal synovial sheath as previously described[9] permits visual verification and, in certain horses, repair of the multitude of syndromes causing lameness originating from the carpal sheath and enclosed structures. Removal of solitary osteochondromas by arthroscopy has been described,[2,3] and release of the constricting carpal flexor retinaculum causing carpal tunnel syndrome has

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been reported.[10] Moreover, arthroscopic examination of the carpal synovial sheath during release of the accessory ligament of the SDFT[11] has revealed other lesions associated with the flexor tendons within the carpal synovial sheath that may cause effusion or lameness from irritation of this tendon sheath.[12] Tenoscopy of the carpal synovial sheath is minimally invasive and permits complete examination of the entire sheath and its contents, as well as early institution of exercise in the convalescent period, without concern for wound dehiscence. These features make tenoscopy a logical choice for surgical correction of many of these syndromes.

The purpose of the study reported here was to determine the clinical, radiographic, ultrasonographic, and arthroscopic findings associated with tenosynovitis of the carpal synovial sheath induced by exostoses that originate from the caudal surface of the physeal scar of the distal radius and determine the results of surgical treatment of those exostoses in horses. This study also defines the differences between exostoses of the caudal radial physis and the cartilage-capped exostoses of solitary osteochondroma.

Criteria for Selection of Cases

Medical records of horses with effusion in the carpal synovial sheath and lameness evaluated at the College of Veterinary Medicine, Cornell University or Wellington Equine Associates from 1999 to 2003 were examined. Horses with a lameness that originated in the carpal synovial sheath were identified as determined by diagnostic regional or intrathecal anesthesia combined with radiographic evidence of a bony exostosis arising from the caudal cortex of the physeal scar of the distal radius.

Procedures

Data obtained from the medical records included signalment; detailed history; clinical and lameness findings; and results of ultrasonography, radiography, and regional or intrathecal anesthesia. Laboratory analysis of synovial fluid obtained from the carpal synovial sheath was performed on samples from several horses. A recommendation was made in all horses for treatment by arthroscopic examination of the carpal synovial sheath and removal of the protruding physeal exostosis.

All horses were anesthetized and positioned in lateral recumbency with the affected limb uppermost. A 4-mm skin incision for entry of the arthroscope was made in the proximal one-third of the lateral aspect of the carpal synovial sheath, as previously described.[9] Examination of the carpal synovial sheath, including the DDFT and visible portions of the SDFT, was performed. In all horses, 1 or 2 protruding spikes of bone penetrating the cranial portion of the carpal synovial sheath and excoriating the cranial surface of the DDFT were evident (**Fig 1**). An instrument portal was made at the level of the palpable remnant of the distal physis of the radius after inserting a 3-inch spinal needle to verify the correct site for instrument entry. A 6-mm skin incision was extended into the carpal synovial sheath, and a serrated, curved arthroscopic knife[a] was initially used to incise the soft tissues around the base of the intruding exostosis. A 4-mm osteotome was inserted, and a mallet was used to separate the exostosis at its base on the caudal radius. The freed bone fragment was removed with large rongeurs. Additional exostoses were also removed if they were found to protrude into the carpal synovial sheath. Other more lateral or medial exostoses that were palpable through the interior of the carpal synovial sheath were left in situ if they did not impact on the flexor tendon structures. Damage to the cranial surface of the DDFT was smoothed by use of a motorized resector or biopsy punch rongeurs.[b] Deeper linear lacerations on the cranial surface of the DDFT were smoothed on their lateral and medial borders. None of the defects were sutured. The base of the excised exostosis on the radius was smoothed with a bone rasp or motorized bone burr,[c] the debris flushed from the carpal sheath, and instruments removed. Where ultrasonography revealed widespread tendinitis lesions, the major echolucent regions were injected with insulin-like growth factor-1 during direct visualization[12] or the tendon sheath was infiltrated with 20 to 40 mg of hyaluronan at the completion of the surgery. Accumulation of excess subcutaneous fluid was frequently a complication of the arthroscope and instrument entry portals and was readily

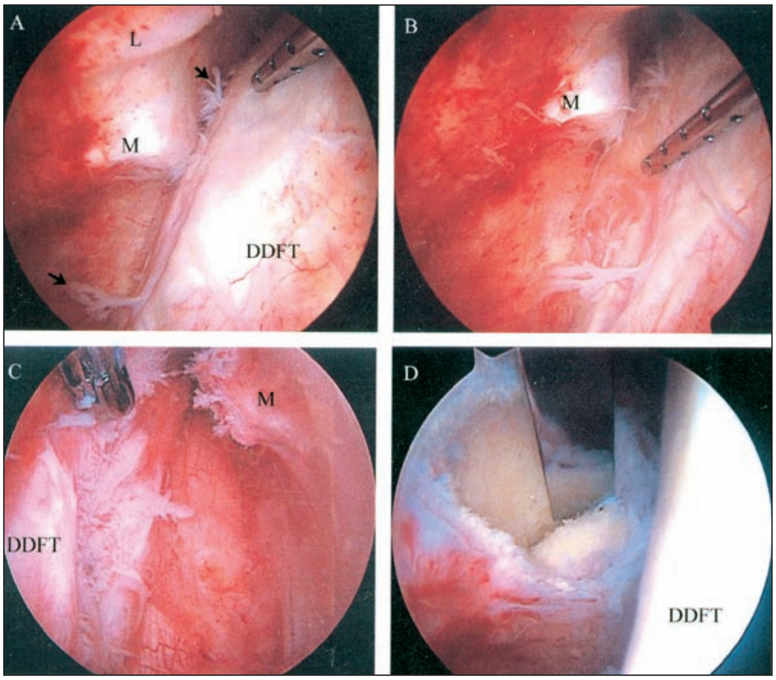

Figure 1—Arthroscopic views of the carpal synovial sheath in 2 horses. A—Lateral and medial exostoses of the caudal radial physis of the right hind limb have caused erosion and discoloration of the deep digital flexor tendon and proliferation of the epitenon (arrows). B—Excoriation of the epitenon and cranial surface of the deep digital flexor tendon (tip of cannula) of the right hind limb. C—A biopsy rongeur is used to debride erosion of the deep digital flexor tendon caused by a single medial exostosis in the left forelimb. D—Removal of an exostosis of the right forelimb with an osteotome. DDFT = Deep digital flexor tendon. L = Lateral. M = Medial.

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forced from the subcutaneous tissues by digital pressure. Skin incisions were closed with 2-0 monofilament polypropylene. Deeper tissues were not sutured. Limbs were bandaged from the middle of the radius to the hoof with a padded bandage maintained by adhesive elastic tape.

Excised bony exostoses were fixed in neutral-buffered 10% formalin and subsequently decalcified, processed, and embedded in paraffin in a proximodistal orientation for sectioning. Sections 6 μm thick were stained with H&E or Masson trichrome and evaluated under bright-field microscopy.

Convalescence after surgery included follow-up radiography to document that the caudal exostoses had been removed, evaluate residual bony protrusions and any bone debris, and document initial postoperative radiographic findings for comparison with subsequent radiographic studies. Nonsteroidal anti-inflammatory medication was administered for 3 to 7 days, and graded walking exercise started 5 to 7 days after surgery. A recommendation for 8 to 12 weeks of rest before returning to athletic activity was made to the trainer or owner.

Follow-up information regarding the degree of residual carpal synovial sheath effusion, residual lameness, and need for medication was obtained by repeat veterinary examination of 7 of the 10 horses or by telephone consultation for the remaining 3 horses from 5 months to 4 years after surgery. A return to previous athletic activity at the same or improved level was used as the criterion for a positive outcome.

Results

Ten horses met the criteria for inclusion in this study. Seven of the 10 horses were Thoroughbreds, 2 were warmbloods, and 1 was mixed breed. The age of affected horses ranged from 3 to 12 years (mean, 6.1 years). All horses were affected in only 1 forelimb, and 7 of the 10 horses were affected in the right forelimb. Eight of the 10 horses were castrated males; the remaining 2 horses were mares. All horses had a history of intermittent carpal synovial sheath effusion and lameness that was localized to the carpal synovial sheath by intrathecal infiltration of local anesthetic. The onset of lameness was sudden in 2 of the 10 horses. Median, ulnar, and cutaneous antebrachial perineural anesthesia was induced in 2 horses to confirm that the lameness originated in the carpal region. All horses had lameness evaluations that included a failure to respond to regional anesthesia of the palmar and palmar-metacarpal nerves up to the level of the proximal metacarpus. Intrathecal local anesthesia of the carpal sheath was then used in all horses.

Radiography was used to make the definitive diagnosis of caudal radial exostosis as a cause of the lameness in all horses. The lateromedial and flexed lateromedial projections were the most important for establishing the diagnosis (**Fig 2**). Radiography revealed a sharply angular (7 horses) or more rectangular (3) caudal radial exostosis that originated at the level of the closed distal physeal remnant of the radius. A macerated specimen from a horse not included in this study depicts the sharp and irregular shape of the caudal aspect of the radius at this level in affected horses (**Fig 3**). Radiography per-

Figure 2—Lateromedial radiographic view of the distal portion of the radius in a horse with persistent effusion of the carpal synovial sheath and lameness. The bony exostoses (arrow) originate from the caudal remnant of the distal physis of the radius. The exostoses appear as sharp bony spikes that protrude a variable distance toward the carpal synovial sheath.

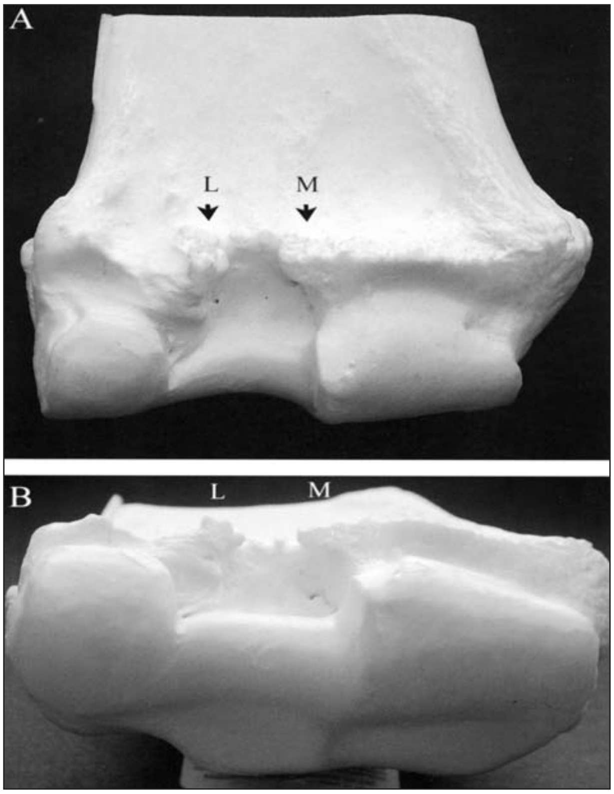

Figure 3—Photograph of a macerated specimen of the caudal distal (A) and articular surface (B) of a radius from a horse. The lateral and medial axial pair of exostoses associated with the area of the original physis of the radius impinge on the carpal sheath contents, while other abaxially located exostoses would not. *See* Figure 1 for key.

formed after surgery in all horses revealed removal of the axially located exostoses and persistence of the most medial and most lateral protrusions. The lateromedial radiographic projection obtained after surgery was not useful because the area where the exostoses were removed was obscured by lateral or medial exostoses that were not removed. The dorsolateral-palmaromedial projection clearly separated the area of the removed exostoses from those that remained (**Fig 4**). Mineralization of the DDFT, SDFT, or carpal synovial sheath was not evident in any horse.

Ultrasonographic examination of the carpal synovial sheath and contained flexor tendons was performed in each horse. Five horses had no evidence of abnormalities on the cranial surface of the DDFT on ultrasonography, whereas 5 horses had surface fraying or small masses on the cranial surface of the DDFT that was in contact with the bony exostosis. Ultrasonographic examination of the caudal radius, with the transducer positioned over the caudomedial aspect of the carpal synovial sheath, revealed soft tissue thickening and separate osteocartilaginous fragments at the level of the radial physeal remnant in 4 horses.

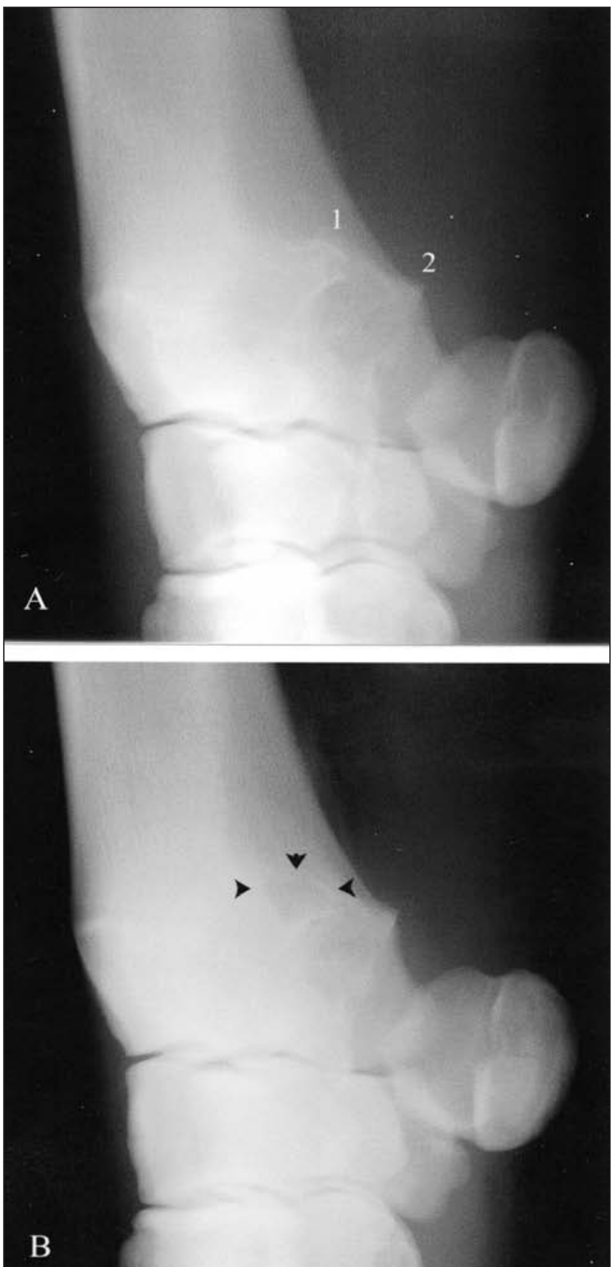

Figure 4—Dorsolateral-palmaromedial radiographic view of the caudal distal radius in a horse before (A) and after (B) surgery. This view separates the clinically relevant exostosis (1) from those located outside the carpal sheath (2). Notice the area where the exostosis was removed (arrowheads) and the residual lateral bone protrusion.

Synovial fluid was obtained during intrathecal anesthesia or surgery from 5 horses, and 2 samples were submitted for laboratory analysis. The concentration of total protein was < 2.5 g/dL for both samples, and nucleated WBC counts were 1.8 and $1.6 \times 10^3/\mu L$.

Surgery was performed on all 10 horses. All horses had 1 major protruding caudal exostosis that appeared to impinge on the cranial surface of the DDFT. Seven of the 10 horses also had a second exostosis that impinged on the discolored or disrupted epitenon covering the cranial surface of the adjacent DDFT, suggesting further trauma from the second exostosis. Twelve of 17 exostoses were removed with an osteotome and mallet, whereas 5 exostoses were removed with only a motorized resector with an elongated bone burr.[c] Residual fibrous tags and surface damage to the DDFT were removed by motorized synovial resectors. Deeper tears in the DDFT required smoothing of the deeper fibrillated tendon fascicles with a synovial resector. None of the tears in the DDFT were sutured. One horse with exostoses of the caudal surface of the physeal scar of the distal radius developed sufficient fibrosis of the carpal synovial sheath and retinaculum to constrict the carpal canal. Release of the constricted carpal canal required incision of the caudal flexor retinaculum of the carpus (**Fig 5**).[10]

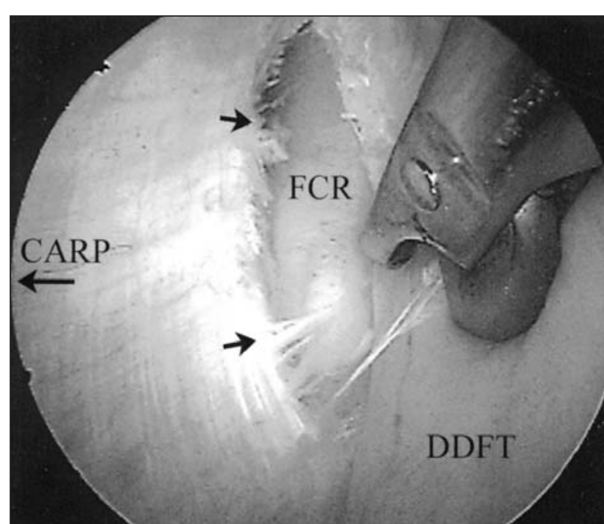

Figure 5—Endoscopic release of the carpal canal within the carpal sheath of a horse. An incision was made in the carpal retinaculum because of concurrent fibrosis of the carpal synovial sheath. The edges of the carpal retinaculum (arrows) have retracted, revealing the flexor carpi radialis tendon. The deep digital flexor tendon is retracted caudally. CARP = Palmar surface of the carpus. FCR = Flexor carpi radialis tendon. *See* Figure 1 for remainder of key.

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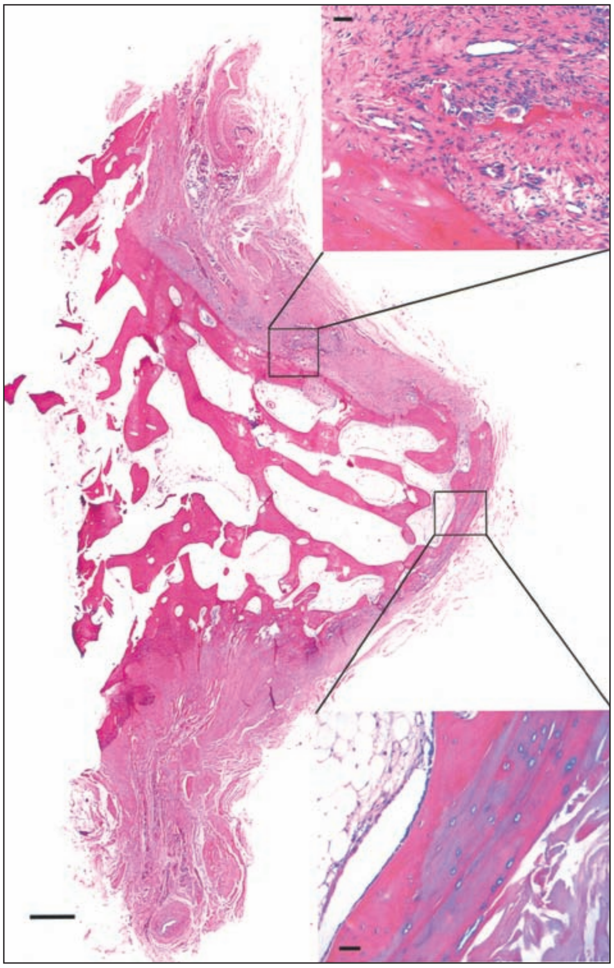

Figure 6—Photomicrograph of an exostosis that was removed from the caudal distal radius of a horse. The cut surface is oriented to the left. The thin cortical bone layer has areas of active bone remodeling on the cortical surface of the proximal border of the exostosis (upper inset). The distal perimeter of the exostosis (lower inset) is smooth and curved upward, potentially as a result of pressure from the deep digital flexor tendon. A dense connective tissue insertion line marks the attachment of the joint capsule of the antebrachiocarpal joint to the base of the exostosis along its distal border. H&E stain; bar = 500 µm. Inset bar = 18 µm.

Histologic examination was performed on 8 exostoses that were removed from 6 horses. Exostoses consisted of a bony stalk with a thin, smoothly contoured cortical surface of compact bone that terminated in a rounded to spike-like eminence, whereas the body of the stalk was composed of cancellous bone that blended with the cancellous bone of the underlying distal radius (**Fig 6**). Mature fibrovascular tissue and dense fibrocartilaginous insertion lines were attached to the thin cortex along the basal half of the exostoses. Active osteoclastic remodeling was evident over certain of the cortical surfaces of the exostoses, especially on the proximal surface, whereas a dense fibrocartilaginous insertion line attached to the base of the exostosis on the distal surface was most likely associated with the joint capsule insertion line of the antebrachiocarpal joint. None of the specimens contained residual hyaline cartilage remnants of the physis. The base of the bony fragments consisted of open trabecular bone framework, with normal osteoblasts lining the bone surfaces and fatty marrow filling the intertrabecular marrow spaces. None of the specimens had a cartilage cap covering the apex similar to an osteochondroma.

All 10 horses returned to their previous activity and were able to compete at the same or improved level. One horse relapsed 1 year after surgery; the new lameness was confirmed to originate in the carpal synovial sheath and was permanently resolved by intrathecal administration of hyaluronan. Three horses returned to previous activity for 12 to 24 months and then developed a new lameness associated with the metacarpophalangeal joint of the same limb (n = 1) or the distal tarsal joint (1), both of which required further medication, or the thoracolumbar portion of the vertebral column (1), which resulted in retirement from active jumping. The duration of follow-up ranged from 9 months to 3.9 years (mean, 2.2 years).

Discussion

Many disease mechanisms may cause lameness associated with the carpal synovial sheath region. Effusion and moderate lameness as a result of a caudally protruding osteochondroma of the radius are well described in the literature.[1-5,13,14] Exostoses of the caudal aspect of the radial physis are similar in many ways to osteochondroma of the radius. However, radiography is used to rule out the diagnosis of radial osteochondroma on the basis of the site of origin and integral nature of the bony spikes with the closed physeal line on the caudal aspect of the radius. The exostoses are the sharp edges of an irregular bone remodeling process of the caudal surface of the distal radial physis that develop at the time of physeal closure. Diagnostic arthroscopy was indicated to verify the cause of the effusion and lameness and permitted removal of the exostoses in the 10 horses in the study reported here. Treatment by excision of the exostoses was effective in the long-term resolution of clinical signs in all 10 horses.

The structure and cause of exostoses of the caudal aspect of the radial physis are different from that described for radial osteochondromas.[4,7] Morphologic examination of the excised bony fragments identified a bony stalk that resembled the bony base of an osteochondroma; however, the distal radial exostoses had no cartilage cap or remnants, which are the unique distinguishing features of an osteochondroma.[4,7] In our study, exostoses of the caudal perimeter of the radial physis appear to be an abnormal variant of closure of this physis. One of the authors (RRP) has found similar caudal radial exostoses in necropsy specimens from other horses not included in this report that had an episode of physeal dysplasia and physitis before they were euthanatized for unrelated causes. Abnormal shape to the final form of the epiphysis and physis is believed to have resulted from a disturbance in bone modeling of the caudal border of the distal radial physis that caused caudal extension of the closed physeal line and impingement on the carpal synovial sheath and its contents. In the horses treated surgically in this report, only axial physeal spikes that impinged on the carpal synovial sheath were important in the development of this syndrome. Other exostoses that were observed on radiographic projections to originate from either side of the midline axis of the caudal surface of the sharply angulated physeal scar were not important because they did not contact the carpal synovial sheath and its contents. The concurrent presence of clinical signs, although in some horses transitory, is therefore important in the decision for surgery.

Other causes of carpal synovial sheath effusion may also cause clinical signs similar to those associated with caudal bony exostoses of the distal radius. Ultrasonographic examination may be helpful in confirming an exostosis that impinges on the DDFT and in defining the depth of tendon injury. The final diagnosis may require arthroscopy and verification of an intruding bony spike. In this study, evidence for a positive association between clinical signs and the radial spike was provided by the excoriated cranial surface of the DDFT. Radiographs obtained after surgery were carefully evaluated to identify exostoses that were removed from those that did not impinge on the carpal synovial sheath and remained after surgery.

Morphologic examination of the excised bony fragments from these horses revealed few of the characteristics that have been previously reported in osteochondromas.[4,7] No remnants of cartilage consistent with a cartilage cap undergoing endochondral ossification were identified. The bone was characterized as normal corticocancellous bone, with a thin layer of cortical bone overlying deeper trabecular bone. Evidence of remodeling was apparent on the outer perimeter of the bone spike. The role of bone remodeling in the overall cause of the exostoses was not clear.

Horses with exostoses of the caudal perimeter of the radial physis are diagnostically challenging because they have few clinical signs and lameness characteristics to separate them from other causes of lameness that originate from the region of the carpal synovial sheath. In the study reported here, the caudal radial exostoses caused a mild or moderate lameness in all 10 horses. Moreover, the effusion in the carpal synovial sheath was intermittent and often resolved within several days of reduced exercise regimens. Definitive diagnosis usually required intrathecal anesthesia and radiographic findings of suspicious caudal bony protrusions. Further complexity was introduced in these cases by secondary thickening of the fibrous layers of the carpal synovial sheath and by the associated tendon lesions caused by the exostoses impacting on the tendon surface. Despite this, resolution of clinical signs after the exostoses were removed was apparent in all horses. Further examination and treatment of the horse that had developed a relapse in clinical signs resolved the lameness. Three horses recovered from the original tenosynovitis of the carpal synovial sheath and needed treatment for unrelated lameness conditions.

Release of the carpal flexor retinaculum was required in 1 horse in this series and is proposed as an additional mechanism to relieve pressure within the carpal canal. Because the proximal portion of the carpal canal is level with the caudal exostoses originating at the level of the distal radial physis, some of these horses may also have a form of carpal canal syndrome. Removal of the exostosis, although relieving some of the constriction, may be inadequate if extensive fibrosis of the carpal synovial sheath has developed. Debridement of the exostosis in combination with release of the retinaculum may provide more assured recovery, although the requirement for both surgeries was not confirmed by results of this study. Further study of horses with recurrent lameness may provide support for this supposition.

Surgical access through arthroscopic approaches to the proximal cul de sac of the carpal synovial sheath provided ample access for removal of the exostoses. The larger bony masses were readily removed with an osteotome; however, in all horses, the base of the resection line required further smoothing of the caudal cortex of the radius to protect the cranial surface of the DDFT from further irritation. Bone abrasion by use of a motorized bone burr was an efficient method and permitted effective removal of bone debris during the procedure. A lateral approach to the carpal synovial sheath permitted an assessment of other portions of the flexor tendons, the radial head of the DDFT, accessory ligament of the SDFT, and carpal flexor retinaculum. The lateral approach was less effective for assessment of the flexor tendons in the distal regions of the carpal synovial sheath. However, a medial approach to the distal portion of the carpal synovial sheath has been described[15] and provides excellent visual assessment of these portions of the flexor tendons.

The majority of horses in this study did not have clinically important tendinitis within the DDFT on the basis of ultrasonographic and surgical findings. The surface damage associated with the exostosis extended several millimeters into the DDFT. However, architecture of the deeper tendon fibers of the DDFT appeared normal after arthroscopic resection of discolored epitenon and fibrin adherent to the surface of the tendon. Given the lack of substantial tendinitis, the eventual resolution of the lameness and return to athletic activities were not unexpected.

These cases illustrate a clinical syndrome associated with tenosynovitis of the carpal synovial sheath and its contents that results from bony exostoses originating at the caudal border of the closed distal physis of the radius. These bony protuberances need to be recognized on radiographs, and although they may not always cause clinical signs of lameness, exostoses should be included as a possible cause for mild carpal sheath effusion and moderate lameness. This pattern of caudal radial exostoses centered on the recently closed physeal line likely represents the end stage of an earlier episode of physeal dysplasia or physitis. The associated metaphyseal flaring of the radius would not be visible caudally, compared with metaphyseal flaring on the lateral or medial aspects of the limb, and may mature to form this type of bony protuberance. Most of the horses in this study were young mature horses that had recently entered strenuous exercise programs. The involvement of exostoses as a cause of lameness is apparent from this series, and a relatively simple method for treatment by surgical removal appears to improve the prognosis for return to athletic activity.

[a]Serrated, curved banana knife, Dyonics-Smith & Nephew, Andover, Mass.
[b]5.5-mm Dyovac, Dyonics-Smith & Nephew, Andover, Mass.
[c]Acromionizer, Dyonics-Smith & Nephew, Andover, Mass.

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