Evaluation of clinical and tenoscopic findings in the carpal flexor sheath of horses

Sandra M. Zetterström DVM

Bengt C. Johansson DVM

James L. Carmalt VetMB, MVetSc

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From Hallands Djursjukhus, Björkgatan 19, 311 68 Slöinge, Sweden (Zetterström, Johansson, Carmalt); and the Department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, SK S7N 5B4, Canada (Carmalt).

Address correspondence to Dr. Carmalt (james.carmalt@usask.ca).

OBJECTIVE
To evaluate clinical and tenoscopic findings in a large group of horses undergoing surgery of the carpal flexor sheath (CFS) and determine whether any of the presurgical clinical signs were associated with tenoscopic findings.

ANIMALS
242 horses that had undergone diagnostic and therapeutic tenoscopy of the CFS because of aseptic tenosynovitis.

PROCEDURES
Medical and tenoscopic video records (when available) of 242 horses undergoing tenoscopy of the CFS at a single equine clinic between January 2005 and June 2014 were reviewed. Tenoscopic findings were categorized as present or absent, and tears in the deep digital flexor tendon (DDFT) were subjectively graded according to severity. Logistic regression analysis was used to examine whether presurgical clinical findings were associated with intraoperative tenoscopic findings.

RESULTS
242 horses (411 limbs) were evaluated by use of tenoscopy. An exostosis was detected in 228 horses (379 limbs) and was often multipartite. Most exostoses were found medial to, or within, the sagittal plane at the caudal margin of the scar on the distal physis of the radius. Effusion in the CFS was associated with tears in the DDFT. Other presurgical clinical findings were not predictive of intrathecal findings.

CONCLUSIONS AND CLINICAL RELEVANCE
Synovial effusion was predictive of DDFT lesions within the CFS but was not predictive of the severity of lesions. Further studies will be necessary to determine whether any tenoscopic findings are associated with reduced athletic performance and to assess the effect of surgical intervention in affected horses. (*Am J Vet Res* 2017;78:840–846)

Aseptic tenosynovitis and lameness originating from the common carpal sheath of the digital flexor tendons (ie, CFS) was first reported in 1972.[1] It has since been reportedly associated with a number of originating causes, including osteochondroma at the caudal aspect of the distal portion of the radius,[2,3] physeal remnant spikes at the caudal margin of the closed distal physis of the radius,[4,5] myotendonitis or tendonitis of the proximal ensheathed regions of the DDFT[6] or SDFT,[7] intrathecal desmitis[8,9] or tearing of the ALSDFT,[10] desmitis or rupture of the accessory ligament of the DDFT,[11] intrathecal mastocytosis,[12] and fracture of the accessory carpal bone.[13] Exostoses on the caudal aspect of the distal portion of the radius, including both osteochondromas and physeal remnant spikes, account for a substantial proportion of the initiating causes.[2–5]

Solitary osteochondromas of the caudal aspect of the distal portion of the radius are thought to arise after translocation of peripheral chondrocytes from the metaphyseal growth plate, which move proximally with bone growth.[2] Physeal remnant spikes arise directly over the physeal scar on the caudal border of the distal portion of the radius at the time of physeal closure and are speculated to be the result of physeal disturbance (eg, physeal dysplasia or physitis).[4] Thus, osteochondromas are found at a more proximal location on a limb than are physeal remnant spikes.

Despite the multitude of inciting causes, horses with aseptic tenosynovitis of the CFS have similar clinical signs. Intermittent or chronic CFS distention is typically associated with lameness, which is frequently recurrent. The treatment of choice depends on the originating and secondary pathological condition; however, tenoscopic evaluation is minimally invasive and allows for verification of a disease process

ABBREVIATIONS

ALSDFT	Accessory ligament of the superficial digital flexor tendon
CFS	Carpal flexor sheath
CI	Confidence interval
DDFT	Deep digital flexor tendon
PACL	Palmar annular carpal ligament
SDFT	Superficial digital flexor tendon

and subsequent surgical treatment.[2,4,6,10,12–14] Success rates after surgical intervention differ depending on the pathological condition, but the prognosis for athletic performance is excellent, with up to 100% of horses resuming activities after treatment.[2,4]

The objectives of the study reported here were to evaluate the clinical and tenoscopic findings in a large group of horses admitted for tenoscopy of the CFS and determine whether any of the presurgical clinical signs were associated with tenoscopic findings.

Materials and Methods

Animals

Medical records of all horses undergoing diagnostic and therapeutic tenoscopy of the CFS because of aseptic tenosynovitis during a 10-year period (January 2005 through June 2014) were evaluated. Presurgical examinations were performed on horses at a referral equine clinic in Slöinge, Sweden, or were performed by the primary veterinarian before referral to the equine clinic for surgery. All horses had a history of lameness.

Data collection

Data collected included age, breed, sex, forelimb or forelimbs examined, date of surgery, tenoscopic findings, surgical treatment, and other surgeries performed during the same anesthetic period. Clinical findings, lameness scores (in accordance with the American Association of Equine Practitioners grading scale [scale, 0 {not lame} to 5 {most severe lameness}]),[15] results of diagnostic regional or intrathecal anesthesia, and diagnostic imaging findings were collected, when available. Tenoscopic video recordings (when available; n = 106) were also reviewed.

Tenoscopy of the CFS

Tenoscopy of the CFS was performed by a surgeon (BCJ) in accordance with a standard technique.[16] Briefly, anesthetized horses were placed in dorsal recumbency (to reduce the risk of hemorrhage), and the affected limbs were suspended and positioned with the carpus joint in full extension. Systematic examination of the CFS was performed by use of a standard 30° arthroscope[a] and lactated Ringer solution before exostosis removal. Most exostoses were subsequently removed with Ferris-Smith rongeurs, with the exception of the largest, which were initially sectioned from the radius by use of an osteotome positioned at the base of the exostoses and subsequently smoothed with a mechanical resector.[b] Defects in the DDFT were evaluated, and damaged tendinous tissue was debrided[c] when necessary. Tendon defects were not sutured. Division of the carpal flexor retinaculum (ie, PACL)[17] was performed when deemed necessary.[16,18] The CFS was then lavaged to remove hemorrhage and any debris, and skin incisions were closed with 2-0 polyamide pseudomonofilament[d] in an interrupted cruciate pattern. A sterile dressing was used to cover the sutured arthroscopic and instrument portal sites, and limbs were bandaged from the mid-radius to the hoof with multilayered cotton-wool bandages maintained by use of gauze and adhesive bandages.

Assessment of tendoscopic variables

Assessment of medical and video records allowed evaluation of the CFS, and a number of variables were identified as present or absent. Lesions of the DDFTs were subjectively graded on the basis of severity **(Appendix)**. Medical records were reviewed to obtain follow-up information regarding lameness and carpal sheath distention during examinations performed at the referral equine practice up to 2.5 months after surgery.

Statistical analysis

Data were recorded on a spreadsheet program[e] and subsequently transferred to a statistical program.[f] Sensitivity and specificity of radiographic imaging (a standard 4-view radiographic series) for identifying caudally located exostoses (osteochondromas and physeal remnant spikes) of the distal portion of the radius were calculated by use of a binary classification test. Logistic regression analysis that controlled for multiple limbs of individual horses was used to examine the odds that presurgical clinical findings were associated with intraoperative tenoscopic findings. Factors in the final models were considered significant at $P < 0.05$.

Results

Animals

Tenoscopy of the CFS was performed on 242 horses **(Figures 1 and 2)**. Presurgical examinations were performed at the referral equine practice on 122 (50.4%) horses, whereas 120 (49.6%) horses were examined by their primary veterinarian before referral to the equine clinic for surgery. Clinical data were not available for horses examined before referral to the equine clinic for surgery.

Standardbred trotters comprised the majority (213/242 [88.0%]) of horses. The remaining 29 (12.0%) horses represented various breeds, including warmbloods (n = 22), mixed-breed ponies (2), Lusitano (1), Connemara pony (1), New Forest pony (1), and Welsh Cob (1); breed of 1 imported pony was not recorded. There were 151 geldings, 60 mares, and 29 stallions (sex was not recorded for 2 horses). Mean ± SD age of horses at the time of surgery was 5.6 ± 2.7 years (range, 1.36 to 19.30 years). There was bilateral involvement of the CFS in 167 (69.0%) horses and unilateral involvement in 77 (31.0%) horses; thus, 411 forelimbs were affected. The CFS was affected in 213 (51.8%) left forelimbs and 198 (48.2%) right forelimbs.

Presurgical assessment

Clinical signs, response to diagnostic tests, results of macroscopic analysis of synovial fluid, and diagnostic imaging data of the 122 horses (191 limbs)

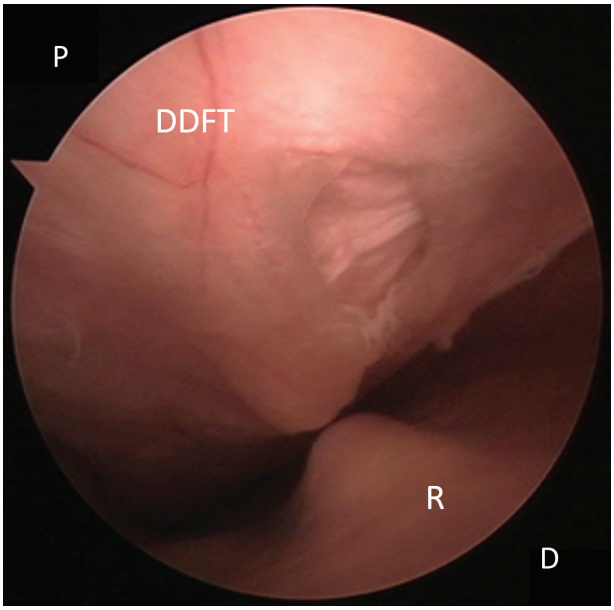

Figure 1—Tenoscopic image of a representative example of an impingement lesion in the epitenon (severity score, 1 [scale, 0 to 13]) of the main body of the DDFT adjacent to an exostosis on the caudal aspect of the distal portion of the radius (R) of a horse. D = Distal. P = Proximal.

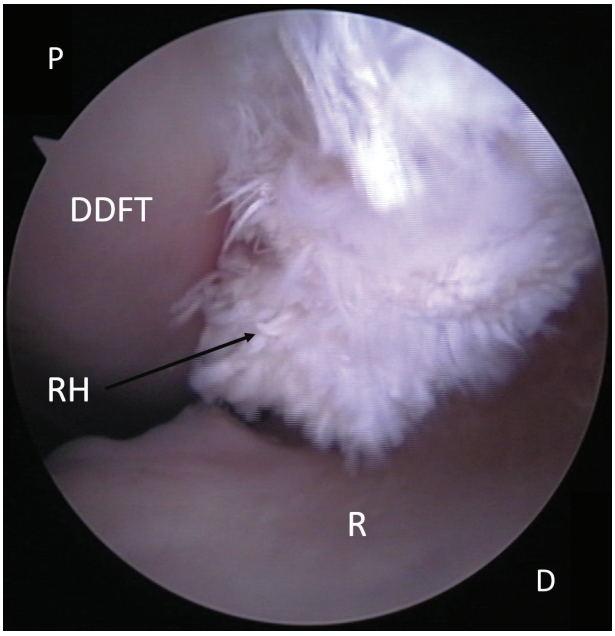

Figure 2—Tenoscopic image of a representative example of a medially located exostosis on the caudal aspect of the distal portion of the radius (R) with a deep tear in the epitenon and body of the radial head (RH) of the DDFT (severity score, 3 [scale, 0 to 13]) of a horse. D = Distal. P = Proximal.

examined at the referral equine practice were summarized **(Table 1)**. Lameness was detected in 62 of 88 (70.5%) horses (mean ± SD lameness score, 2.9 ± 0.47). For those 62 lame horses, 57 (91.9%) were scored as grade 3 lameness, 4 (6.5%) were scored as grade 2 lameness, and 1 (1.6%) was scored as grade 4 lameness during trotting. Lameness in the affected limb was recurrent in 17 of the 62 (27.4%) horses. Baseline lameness was exacerbated or induced during flexion in 48 of 72 (66.7%) horses. There was no effect of age, sex, or breed on the degree of lameness or other clinical findings.

Sensitivity of radiography for detecting exostoses was 75.7%, whereas specificity was 22.2%. Ultrasonography was never used as the sole diagnostic modality; however, when it was used (n = 48 horses), all exostoses identified ultrasonographically were confirmed tenoscopically.

Table 1—Results of presurgical evaluation of the CFS of 122 horses (192 forelimbs) performed at a referral equine practice.

Clinical examination and diagnostic tests	Horses	Limbs
CFS effusion*	58/100 (58.0)	67/153 (43.8)
Lameness*	62/88 (70.5)	62/133 (46.6)
Positive response to local intrathecal or regional perineural anesthesia*	59/62 (95.2)	70/73 (95.9)
Sanguineous or xanthochromic synovial fluid in the CFS†	21/92 (22.8)	21/122 (17.2)
Radiography	94/122 (77.0)	140/192 (72.9)
Exostosis identified	NA	94/124 (75.8)
Exostosis not identified	NA	30/124 (24.2)
Ultrasonography	48/122 (39.3)	58/192 (30.2)
Exostosis identified	NA	26/26 (100)

Values reported are number of horses or limbs with the condition or on which specific diagnostic procedures were performed/total number of horses or limbs examined (percentage).

*One or both affected limbs. † Seen at the time of diagnostic anesthesia or intrathecal treatment.

NA = Not applicable.

Surgery

The tenoscopic findings were summarized **(Table 2)**. More than 1 exostosis was identified in 170 of 379 (44.9%) limbs. Review of the surgical video recordings for 106 horses (180 limbs) indicated that parts of a single exostosis were located proximal to the physeal scar, whereas the remaining 259 exostoses in the 106 horses were found at the caudal margin of the scar on the distal physis of the radius. The proximodistal position of the exostosis relative to the physeal scar was not recorded in all horses without video records. Most tears of the DDFT were longitudinal, and > 1 tear was identified in several horses. Tears of the ALSDFT or fractures of the accessory carpal bone were not endoscopically apparent in any of the horses. In 213 horses (338 of 379 [89.2%] limbs), exostoses were deemed clinically important (there was evidence [however slight] of paratenon or tendon impingement) and excised. A total of 396 of 550 exostoses were excised. Release of the PACL was performed in 221 horses (369 limbs). Both surgical interventions (exostosis excision and PACL division) were performed in 311 limbs.

More than 1 surgical procedure was performed during the same anesthetic period in 96 of 242 (39.7%) horses. The most common second surgical procedure was arthroscopy of the carpal joints in 39 of 96

Table 2—Results for tenoscopic evaluation of the CFS of 242 horses (411 forelimbs).*

Factor	Horses	Limbs
Exostosis	228/241 (94.6)	379/410 (92.4)†
Nonintact synovium and periosteum covering the exostosis	62/228 (27.2)	82/379 (21.6)
Defects of the DDFT	186/239 (77.8)	272/408 (66.7)‡
Defects of the SDFT	4/231 (1.7)	4/398 (1.0)
Proliferative synovium	169/181 (93.4)	266/300 (88.7)
Evidence of previous hemorrhage§	25/117 (21.4)	28/190 (14.7)
Petechial hemorrhage	26/115 (22.6)	27/188 (14.4)
Acute hemorrhage in CFS wall	29/114 (25.4)	31/187 (16.6)
Acute hemorrhage in tendon	27/115 (23.5)	28/187 (15.0)
Sanguineous or xanthochromic synovial fluid	33/129 (25.6)	33/212 (15.6)
Adhesions‖	38/170 (22.4)	47/288 (16.3)
Fibrous strands or synovial-synovial adhesions	139/159 (87.4)	219/266 (82.3)
Fibrin	29/162 (17.9)	32/274 (11.7)

Values reported are number of horses with the condition/total number of horses examined (percentage).

*The number of horses and limbs differs among factors because video records were not available for all horses. For horses and limbs for which there were no video records available, individual intrathecal variables were considered present or absent only when the surgery report categorically included that information. †Location of the exostoses was medial (179 [47.2%]), central (121 [31.9%]), lateral (14 [3.7%]), ridge (spanned from medial to lateral; 25 [6.6%]), and unknown (41 [10.8%]) in the 379 affected limbs. ‡The 272 defects were located in the radial head of the DDFT (174 [63.9%]), main body of the DDFT (60 [22.1%]), aponeurosis (32 [11.8%]), and musculotendinous junction (6 [2.2%]). §Hemosiderin deposits or hemochromatosis. ‖Confirmed between flexor tendons and the CFS wall in 6 horses (6 limbs); the remaining adhesions may have been synovial-synovial adhesions or adhesions between flexor tendons and the CFS wall.

(40.6%) horses. Other surgical procedures included desmotomy of the ALSDFT (n = 21 horses), orchiectomy (14), intralesional injection of fresh bone marrow into the SDFT or suspensory ligament (9), tenoplasty or desmoplasty (7), desmotomy of the palmar or plantar proximal annular ligament (2), arthroscopy of the metacarpophalangeal joint (1), arthroscopy of the stifle joint (1), removal of a patellar fragment (1), and fixation of a fracture of the proximal phalanx by use of a compression screw (1).

Follow-up results

Follow-up examinations were performed on 93 horses (157 limbs) at the referral equine practice. Of those 157 limbs, 53 (33.8%) had CFS effusion. Of the 93 horses, 80 (86.0%) had no evidence of lameness (ie, were sound). Mean ± SD lameness grade for the remaining 13 (14.0%) horses was 2.9 ± 0.4, which was not significantly (P = 0.36) different, compared with the presurgical lameness grade.

Logistic regression analysis of evaluated potential risk factors indicated that effusion of the CFS was significantly (P = 0.001) associated only with a lesion in the DDFT (OR, 3.69; 95% CI, 1.67 to 8.14). No other clinical findings were predictive of individual intrathecal findings or the total score (sum for individual components) for pathological changes of the CFS. Within the CFS, horses with a lesion in the DDFT had significantly greater odds of having proliferative synovium (OR, 2.7; 95% CI, 1.1 to 6.74; P = 0.03) and an exostosis (OR, 6.0; 95% CI, 1.96 to 18.34; P = 0.002) than did those without lesions. Neither the number of exostoses nor size of exostoses were associated with depth of a lesion in the DDFT within the CFS. No presurgical, clinical, or intrathecal tenoscopic findings (including the total sum for individual pathological changes) were predictive of postoperative clinical findings.

Discussion

The distal physis of the radius is the most active physis in the distal portion of the limb of horses, and it closes between 26 and 35 months of age.[19] Physitis can be caused by a high rate of growth and exercise,[20] and it is possible that 2-year-old Standardbreds racing before physeal closure may be predisposed to develop exostoses and concurrent clinical signs of CFS disease. This theory is also supported by results of previous studies[2,4] in which the condition was described in Thoroughbreds. Additionally, clinical signs may become more obvious with strenuous exercise and frequent full extension of a limb, which may cause the DDFT to press more firmly on exostoses in the region of the distal physis of the radius.

In the present study, 62 of 88 (70.5%) horses were lame at the time of surgery. However, all horses had a history of lameness. Horses examined by a primary veterinarian were not reexamined at the referral equine practice prior to surgery. Additionally, a number of horses were examined while harnessed to a vehicle, and despite responding positively to intrathecal analgesia of the CFSs, this precluded assignment of a classical lameness score. Most of the horses in the study reported here were affected bilaterally, with no significant difference between the forelimbs. This is in contrast to previous reports in which all 10 horses in one study[4] and 19 of 22 horses in another study[2] were affected unilaterally. The difference in results may simply have been a function of population size, but breed (Standardbred vs Thoroughbred) or other unidentified factors may also have played a role.

Radiography and ultrasonography are commonly used noninvasive diagnostic tools for identification of pathological changes in the CFS.[2,4,5] In the present study, sensitivity of radiography for identifying exostoses was high, but specificity was low, which is in disagreement with another study[5] in which 8 of 13 exostoses were not detected radiographically. A major problem is that radiography does not predict the severity of the pathological changes within the sheath. Some horses in the present study had no or extremely subtle radiographically identified exostoses with severe impingement lesions on the cranial aspect of the DDFT. Similarly, there were horses that had obvious exostoses apparent radiographically but that had no or only mild impingement of the DDFT.

The low specificity of radiography for identifying exostoses was probably a result of exostoses located abaxial to the CFS being interpreted as having clinical importance or the naturally uneven caudal border of the physeal scar being interpreted as bony protuberances. The retrospective nature of the study precluded assessment of the ultrasonographic appearance of the CFS and its contents for most of the horses.

For the study reported here, exostosis was used with no delineation between osteochondromata and physeal remnant spikes because the osseus material removed was not submitted for histologic examination and thus a definitive diagnosis was not made. The lack of analysis was unfortunate; however, although it would have been academically interesting, a definitive diagnosis was unlikely to alter subsequent management of these horses. Despite this, 259 of 260 (99.6%) exostoses in horses with tenoscopic video records were found at the caudal margin of the scar for the distal physis of the radius and were likely physeal remnant spikes. In the study population of the present study, exostoses were most frequently located medial to or within the sagittal plane of a limb. This finding (ie, location with regard to the medial position of the exostoses) is in agreement with other reports on osteochondromas[2,21] but has not been reported for physeal remnant spikes. Interestingly, physitis of the forelimbs typically occurs on the medial aspect of a limb, rather than the lateral aspect,[20,22] which possibly is a result of greater load being applied to the medial aspect of a limb.[22] Although the authors are aware of no published evidence to support this theory, the tendency of exostoses (of either type) to occur on the medial or central aspect in the present study may have been the result of asymmetrically disturbed endochondral ossification.

In the present study, 174 of 272 (63.9%) horses in which DDFT lesions were detected tenoscopically had defects in the radial head of the tendon. Anatomically, the radial head of the DDFT terminates by merging with the conjoined humeral and ulnar tendons at a point proximal to the physeal line. Caudal radial osteochondromas (which are invariably situated proximal to the physeal line) can lacerate the DDFT distal to the point of insertion of the radial head and the humeral and ulnar heads.[2,6] It is possible that some of the horses in the present study had primary tears of the radial head of the DDFT; however, because these defects were usually proximal to an exostosis, it is possible that they developed at the time of maximal limb loading. The type of training or racing surface, conformation of the horse, and whether there is carpal hyperextension at higher speeds may all play a role in determining whether an exostosis contacts the DDFT and causes damage.

Division of the PACL was performed as the sole treatment or in addition to excision of exostoses to relieve pressure within the CFS. The necessity of PACL division may be debatable; however, we believed it was important to use PACL division to allow sufficient decompression of soft tissue injuries within the CFS. This was especially true in horses with swollen, lacerated DDFTs and probable secondary soft tissue compression. Release of the PACL in combination with removal of exostoses in these horses was considered to provide more assurance of recovery than exostosis excision alone. As has been previously reported,[4] more studies are needed to determine whether PACL division is necessary.

It is interesting to note that 96 of 242 (39.7%) horses in the study reported here underwent a second surgical procedure at the time of diagnostic CFS tenoscopy. Of these, arthroscopic examination of 1 or both carpal joints was the most common second procedure (39/96 horses). In the authors' experience, the response to diagnostic local analgesia is not always definitive for horses with pathological changes to the CFS. There occasionally is a physical communication between the middle carpal joint and CFS,[23,24] and a communication between the antebrachiocarpal joint and CFS was visible tenoscopically in at least 1 horse of the present study. In horses for which diagnostic analgesia was not definitive or for which intra-articular administration of corticosteroids prior to surgery had been at least partially successful, concurrent carpal arthroscopy and CFS tenoscopy were performed.

Despite variations in the severity of tenoscopic findings within the CFS, it was surprising to find that the severity of tendon defects was not associated with lameness grade at the time of a follow-up examination. This was counterintuitive and most likely represented a lack of statistical power. A case-control study[25] has been conducted to evaluate the effect of specific tenoscopic findings on postoperative athletic performance.

The present study highlighted the fact that Standardbreds predominated in the study population. It is possible that this breed may be more prone to disease of the CFS than other breeds; however, a prospective cohort study would be necessary to determine a breed disposition. Effusion of the CFS noted during presurgical clinical examination was predictive of DDFT pathological changes, and radiography had high sensitivity but low specificity for predicting the presence of caudally located exostoses on the distal portion of the radius.

Acknowledgments

The authors declare that there were no conflicts of interest.

Footnotes

a. Videoarthroscope, Smith & Nephew Dyonics, Andover, Mass.
b. Notchblaster 4.5-mm blade, Smith & Nephew Dyonics, Andover, Mass.
c. Synovator 4.5-mm blade, Smith & Nephew Dyonics, Andover, Mass.
d. Supramid, B. Braun, Melsungen, Germany.
e. Microsoft Excel, Microsoft Canada Inc, Mississauga, ON, Canada.
f. SPSS, IBM Canada Ltd, Markham, ON, Canada.

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Appendix appears on the next page

Appendix

Scoring system used for tenoscopic evaluation of the CFS of horses.*

Factor	Description	Score
Exostosis	Absent	0
	Present	1
Position (sagittal plane of radius)	Medial	NA
	Central	NA
	Lateral	NA
Number	None	NA
	1	NA
	> 1	NA
Contour	≥ 1 eminences or formed a ridge	NA
Proximodistal position	Level with or proximal to the distal physeal remnant	NA
Periosteum and synovium covering the exostosis	Intact	0
	Nonintact	1
Proliferative synovium or synovitis	Absent	0
	Present	1
Petechia hemorrhage†	Absent	0
	Present	1
Evidence of previous hemorrhage†‡	Absent	0
	Present	1
Acute hemorrhage†§	Absent	0
	Present	1
Sanguineous or xanthochromic synovial fluid	Absent	0
	Present	1
Lesion in flexor tendon	Absent	0
	Present	1
Localization	DDFT‖	NA
	SDFT	NA
Depth	Epitenon only	NA
	Epitenon and superficial tear in tendon	NA
	Epitenon and deep tear in tendon	NA
Lesion at musculotendinous junction	Absent	0
	Present	1
Intrathecal tear of the ALSDFT	Absent	0
	Present	1
Adhesions¶	Absent	0
	Present	1
Fibrin	Absent	0
	Present	1
Fibrous strands or synovial-synovial adhesions	Absent	0
	Present	1

*Highest total score possible was 13; total score was the sum of scores for the individual factors. †Within the CFS wall or DDFT. ‡Hemosiderin deposits or hemochromatosis. §Ecchymoses or petechia. ‖Defect in the DDFT was noted in the main body, radial head, or within the aponeurosis between the main body and radial head. ¶Between flexor tendon and the CFS.

NA = Not applicable.