Palmar-plantar axial sesamoidean approach to the digital flexor tendon sheath in horses

Diana M. Hassel, DVM, DACVS; Susan M. Stover, DVM, PhD, DACVS; Thomas B. Yarbrough, DVM, DACVS; Christiana M. Drake, PhD; Kenneth T. Taylor, BS

EQUINE

The digital flexor tendon sheath (vaginae synoviales tendinum digitorum manus)[1] is a synovial structure that envelops the superficial and deep digital flexor tendons as they pass over the palmar and plantar aspects of the metacarpo- and metatarsophalangeal (fetlock) joints. It extends from the distal portion of the third metacarpal or metatarsal bone to the proximal half of the second phalanx.[2-4] The tendon sheath encircles the tendons except at the palmar or plantar aspects of the fetlock canal where the superficial digital flexor tendon is attached to the tendon sheath and forms the palmar or plantar walls of the sheath.[3,5-7] There are 2 major pouches in the sheath; 1 pouch is at the most proximal aspect between the suspensory ligament and the deep digital flexor tendon, and the other pouch is located distally, between the proximal and distal digital annular ligaments, at the bifurcation of the superficial digital flexor tendon.[2-4] The tendon sheath is 14 to 20 cm in length and is composed of an outer fibrous layer that provides the vascular supply to the sheath and an inner visceral layer that contains synoviocytes.[3,5,8]

Synoviocentesis is an important technique for the diagnosis and treatment of various infectious, traumatic, and inflammatory disorders of the digital flexor tendon sheath in horses. The most common clinical indication for centesis of the digital flexor tendon sheath is septic tenosynovitis, which develops commonly as a consequence of trauma to the limb; the digital flexor tendon sheath is the most commonly affected site.[3,9-12] As with any infectious process, early diagnosis and immediate treatment for septic tenosynovitis are important for successful management.[10] Prompt identification of tendon sheath involvement in lacerations of the distal portions of the limb can be achieved through distention of the tendon sheath with sterile infusing solutions to assess whether communication with a wound exists.[3] Once identified, reliable needle access to the sheath is essential for successful management of septic tenosynovitis by use of intrathecal antimicrobial treatment and lavage. When wounds involving the tendon sheath are actively draining, distention of the tendon sheath may be absent, and access to the tendon sheath is important to establish whether communication with the wound exists. Limitations for access to the tendon sheath may also exist, depending on location of the wound. In addition to septic processes, other reasons to gain access to the tendon sheath have been described for diagnostic intrathecal anesthesia, synovial fluid sampling, intrathecal contrast radiography, tenoscopy, through-and-through lavage, and therapeutic infusion of anti-inflammatory agents.[6,7,13-16]

Commonly, synoviocentesis is performed by penetration of the proximolateral pouch proximal to the palmar or plantar annular ligament and palmar or plantar to the lateral or medial suspensory branch. When prominent synovial fluid distention is present, this is a useful location for obtaining synovial fluid samples or medicating the sheath. However, when fluid distention of the sheath is absent, or the contents of the sheath consist predominantly of fibrin or proliferative synovial intimal tissue, the proximal approach to the tendon sheath may be difficult and may be associated with hemorrhage within or around the tendon sheath.

The purpose of the study reported here was to describe and compare a **palmar-plantar axial sesamoidean (PAS)** approach with the conventional **proximolateral (PL)** approach for synoviocentesis of the digital flexor tendon sheath in horses.

Procedures

Anatomic studies—The position, shape, and capacity of the digital flexor tendon sheath was determined by use of intrathecal casts in 8 cadaveric limbs of 2 mature Thoroughbred geldings (estimated body weight range, 450 to 500 kg [990 to 1,100 lb]). Casts were prepared by injecting 25 ml of plastic[a] by use of a PAS approach. The fetlock joints on each cadaver were manually held in the following positions prior to injection of plastic: 1 flexed forelimb, 1 extended forelimb, 1 flexed hind limb, and 1 extended hind limb. Fetlock angles of flexion and extension were manually fixed at 225° and 150°, respectively, as measured from the dorsal surface of the limb. After the intrathecal casts hardened, gross anatomic dissection of the limbs of 1 horse was performed, and anatomic relationships between the digital flexor tendon sheath and surrounding bone and soft tissues were recorded. In the limbs of the other horse, the digital flexor tendon sheaths were injected with plastic in a similar fashion, and the limbs were subsequently frozen and cut with a bandsaw into 2-cm transverse sections. Evaluation of all specimens was performed to determine the optimal position for needle entry into the tendon sheath and identify palpable anatomic landmarks for each approach.

In vitro evaluations—Synoviocentesis by the PAS and PL approaches was compared by use of paired forelimbs and paired hind limbs from 8 equine cadavers. Cadavers had no observable musculoskeletal abnor-

From the Departments of Surgical and Radiological Sciences (Hassel, Yarbrough), Anatomy, Physiology, and Cell Biology (Stover, Taylor), and Statistics (Drake), School of Veterinary Medicine, University of California, Davis, CA 95616.

Presented in part at the American Association of Equine Practitioners Convention, Phoenix, Ariz, 1998.

malities of the distal half of the limbs, and injections were performed within 6 hours of death. Forelimbs and hind limbs were injected with the limbs intact and the joints maintained at defined angles, as described. The PAS approach was used to perform synoviocentesis in 1 forelimb of each cadaver, and the PL approach was used in the contralateral forelimb. Approaches were alternated between the left and right limbs for successive cadavers. A similar alternating approach was used for hind limb pairs.

The horses were positioned in lateral recumbency with the assigned leg oriented upward to facilitate access to the lateral surface of the limb. Injections were performed with the limb intact to avoid anatomic irregularities associated with transection of tendons and ligaments proximally. In the forelimbs, the carpus was manually maintained in full extension, and the fetlock joint was maintained in extension at an angle of 150° for the PL approach. In the hind limbs, the tarsus was maintained in full extension, and the distal portion of the limb was positioned in a manner similar to the forelimbs during injection. A 20-gauge 2.5-cm needle was used to attempt entry into the tendon sheath. After clipping and aseptic preparation, synoviocentesis was performed by the PL approach on the lateral aspect of the limb, 1 cm proximal to the proximal border of the palmar or plantar annular ligament and 1 cm palmar or plantar to the lateral branch of the suspensory ligament. Following initial needle placement, the needle was attached to a 12-ml syringe containing 8 ml of radio-opaque solution[b]; criteria for probable entry into the tendon sheath included lack of resistance to injection combined with distention of the tendon sheath. The number of times the needle was repositioned after initial skin penetration and the time required to obtain entry to the tendon sheath were recorded. All injections were performed by a single investigator (DMH), and limb position was manually maintained by the same individual throughout all procedures. The limbs were subsequently transected at the level of the proximal aspect of the metacarpus or metatarsus for radiographic evaluation and gross anatomic dissection. Dorsopalmar, dorsoplantar, and lateromedial radiographs were taken.

The PAS approach was used in the assigned limb of each cadaver specimen. The fetlock joint was flexed to a standardized angle of 225° as measured from the dorsal cortices of the third metacarpus or metatarsus and the first phalanx. The needle was placed at the level of the midbody of the lateral proximal sesamoid bone, through the palmar or plantar annular ligament, and 3 mm axial to the palpable palmar or plantar border of the lateral proximal sesamoid bone. The needle was inserted in the transverse plane and directed 45° from the sagittal plane, angled toward the central intersesamoidean region, to a depth of 1.5 to 2.0 cm. Depth of needle penetration on initial insertion was determined by palpable evidence of entrance into a potential space.

Radiographs were interpreted by an observer blinded to the technique used to confirm access to the tendon sheath and evaluate the amount of contrast material deposited in subcutaneous tissues. Each limb was dissected and examined grossly for evidence of damage to surrounding soft-tissue structures such as the neurovascular bundle, superficial digital flexor tendon, deep digital flexor tendon, and intersesamoidean ligament.

Number of successful tendon sheath injections, number of attempts to access the tendon sheath, time required to complete the injection, and number of limbs with subcutaneous deposition of contrast material were compared between the 2 approaches and between the forelimbs and hind limbs. Subjective assessments of ease of entry into the tendon sheath and degree of needle injury to soft tissues were recorded for each approach.

Statistical analyses—The effect of approach on categoric variables was evaluated by use of a 2-tailed Fisher exact test within the forelimb and hind limb and on continuous variables by use of a repeated measures ANOVA with limb (forelimb and hind limb) and approach (PL and PAS) as fixed factors. For statistical analyses, numbers of attempts were analyzed as a square root transformation, and time required for injection was log transformed. Significance was set at $P \le 0.05$.

Results

Anatomic studies—A 25-ml volume of plastic casting material resulted in adequate filling of the digital flexor synovial sheath with moderate distention of the most proximal and distal portions of the sheath. No anatomic variability was identified within each individual between forelimbs and hind limbs, and there were minimal changes in the distribution and sites of accumulation of casting material associated with flexion or extension of the limb. An optimal site for access to the proximal synovial recess was 1 cm proximad to the proximal border of the palmar or plantar annular ligament and 1 cm palmar or plantar to the lateral branch of the suspensory ligament. For the PAS approach, needle access was identified at the level of the midbody of the lateral proximal sesamoid bone, through the palmar or plantar annular ligament, and 3 mm axial to the palpable palmar or plantar border of the lateral proximal sesamoid bone **(Fig 1)**. The recommended position of needle insertion was immediately palmar or plantar to the palmar or plantar digital neurovascular bundle, in the transverse plane, and directed approximately 45° from the sagittal plane toward the midline **(Fig 2)**. Manual manipulation of the flexor tendons was not performed by use of either the PL or the PAS approaches.

In vitro studies—Horses included 2 Thoroughbreds, 4 Quarter Horses, 1 Arabian, and 1 Hanoverian. Median age was 11.5 years (range, 3 to 28 years), and estimated body weight ranged from 400 to 600 kg (880 to 1,320 lb). Access to the tendon sheath was achieved in 16 of 16 limbs by use of the PAS approach and in 14 of 16 limbs by use of the PL approach. Differences in measured variables between the forelimbs and the hind limbs were not observed. The time required for synoviocentesis was significantly ($P = 0.02$) shorter for the PAS approach (mean, 39.2 seconds; median, 28.0 seconds), compared with the PL approach (mean, 79.8 seconds; median, 52.5 seconds). Number of attempts

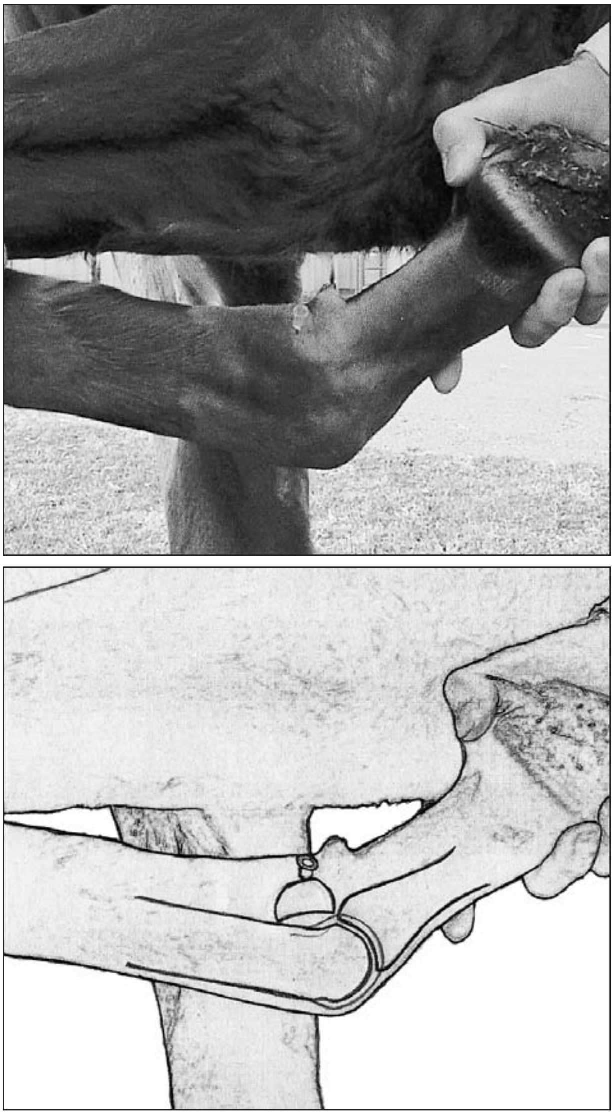

Figure 1—Photograph (upper) and schematic representation (lower) of the forelimb of a horse, illustrating needle position and anatomic relationships of the metacarpophalangeal joint and the proximal sesamoid bone for a palmar axial sesamoidean approach to the digital flexor tendon sheath.

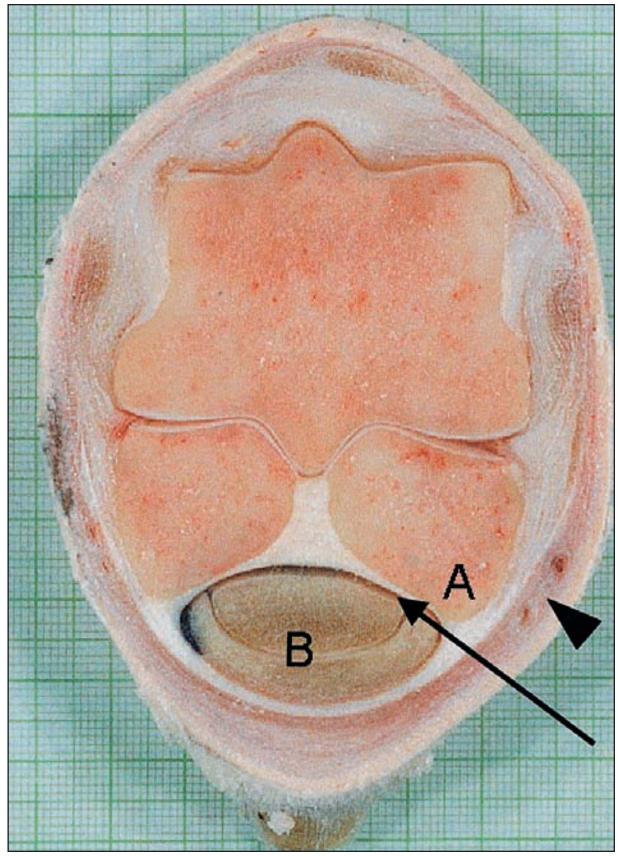

Figure 2—Photograph of a transverse section of a horse's forelimb at the level of the midbody of the proximal sesamoid bones. The dorsal aspect of the limb is toward the top of the photograph. The arrow represents the path of the needle during a palmar axial sesamoidean approach to the digital flexor tendon sheath. Notice that the path is bounded by the lateral neurovascular bundle (arrowhead), the palmar surface of the lateral proximal sesamoid bone (A), and the digital flexor tendons (B).

required to access the tendon sheath were significantly ($P = 0.03$) fewer for the PAS approach (mean, 3.4; median, 2.0), compared with the PL approach (mean, 9.1; median 6.0). Subcutaneous deposition of radiographic contrast material was identified in 0 of 16 limbs by use of the PAS approach and 3 of 16 limbs by use of the PL approach, but this difference was not statistically significant ($P = 0.22$). For either approach, gross anatomic evaluation did not reveal evidence of soft-tissue injury to the palmar annular ligament, intersesamoidean ligament, neurovascular bundle, or flexor tendons. However, needle penetration of the peripheral region of the flexor tendons likely occurred during both approaches.

Discussion

Advantages of the PAS approach over the PL approach include reliable access to the tendon sheath when synovial fluid distention is absent and reduced time required for successful entry. Percutaneous access to the sheath was accomplished with fewer attempts at repositioning the needle by use of the PAS approach. This is desirable, because manipulation and repositioning of the needle increases the likelihood of inducing hemorrhage.[17] Additionally, the anatomic boundaries of the PAS approach ensure successful access to the digital flexor tendon sheath. Substantial increases in syringe pressure would develop if the needle was inserted into the flexor tendons, intersesamoidean ligament, and palmar or plantar annular ligament, and subcutaneous deposition would result in a readily identifiable localized swelling under the skin.

As with all approaches to synovial structures, identification of palpable landmarks is critical for success. The most distinct landmarks for the PAS approach are the proximal sesamoid bones and the neurovascular bundle. When identifying the midbody of the lateral or medial proximal sesamoid bone on its palmar or plantar border, it is essential to remember the anatomic changes that occur with flexion of the distal portion of the limb. The proximal sesamoid bones move proximal and palmar or plantar in relationship to the third metacarpus or metatarsus, respec-

EQUINE

EQUINE

tively, during fetlock flexion. The neurovascular bundle is readily identifiable across the palmar or plantar aspect of the fetlock joint. For the PAS approach, percutaneous puncture should be performed immediately palmar or plantar to the neurovascular bundle. The needle should be inserted 3 mm axial to the palmar or plantar border of the midbody of the proximal sesamoid bone and perpendicular to the skin surface (45° from the sagittal plane). If palpation of the neurovascular bundle and proximal sesamoid bones is not possible because of swelling or injury to the soft tissues, an alternative approach to the tendon sheath is recommended.

Obtaining a representative sample of fluid from the tendon sheath may be difficult. When traumatic or septic tenosynovitis of the digital flexor sheath is present, chronic synovitis, substantial fibrosis, adhesion formation, and accumulation of fibrin and debris may develop within the proximal recess of the tendon sheath.[3,7,9,13,15,16,18] These inflammatory changes may be associated with increases in blood supply, capsular fibrosis, and intimal proliferation, resulting in reduction in sheath volume and making access to the lumen difficult.[14] Hemorrhage from inflamed synovium or occlusion of the needle by synovial villi may occur during synoviocentesis of the proximal pouch. Proximally, the synovium is more villous, cellular, and mobile, compared with the smooth filamentous region between the intersesamoidean ligament and digital flexor tendons.[6,19] Traumatic, inflammatory, or infectious synovitis may be more difficult to diagnose if blood contamination of the synovial fluid sample occurs.[17]

An alternative site for synoviocentesis is the distal pouch at the palmar or plantar midline of the pastern. This site may be advantageous when there is palpable synovial fluid distention, because it can be performed with the limb in a flexed or weight-bearing position, is unlikely to induce iatrogenic damage to the flexor tendons or induce hemorrhage, and is likely to result in the acquisition of a diagnostic synovial fluid sample. Because penetration of tendon tissue with a needle is less likely by use of this method, compared with the PAS approach, it may be a preferable technique in many circumstances. During through-and-through lavage for treatment of septic tenosynovitis, the distal pouch may provide an additional portal for lavage. However, access via this route may be limited when palmar or plantar lacerations involving the pastern region are present.

Synovial fluid sampling was not attempted in our study because of an absence of fluid distention within the tendon sheath. Because of the anatomic restrictions of the digital flexor tendons, intersesamoidean ligament, and palmar or plantar annular ligament, pooling of fluid at the PAS site does not develop, regardless of joint angle. However, fluid sampling from this site has been successfully performed by the authors in horses with clinical septic tenosynovitis when moderate distention of the tendon sheath was evident. Although use of the PAS technique may not consistently provide a fluid sample for diagnostic evaluation when the tendon sheath lacks fluid distention, it remains a reliable technique for intrathecal injection of pharmaceuticals or lavage fluids and assessment of whether communication with a wound exists.

A flexed fetlock joint angle was selected for the PAS approach in our study, because the non–weight-bearing flexed position is most likely to be applied in clinical situations. This provides greater control against movement by the patient during synoviocentesis. The technique can effectively be accomplished by 1 individual holding the limb in flexion in 1 hand and the needle in the other, using a single sterile glove. Because penetration of the periphery of the digital flexor tendons may occur in many instances when using the PAS approach, guarding against excessive motion may help minimize trauma associated with movement of the needle. Because of the anatomic restrictions associated with the sesamoid bone, intersesamoidean ligament, flexor tendons, and palmar or plantar annular ligament, manual manipulation of the flexor tendons during needle placement would likely be ineffective in avoiding needle penetration of the peripheral regions of the tendons. Although substantial needle-induced trauma was not identified via gross dissection of the limbs in our study, it is likely that needle penetration of the abaxial region of the flexor tendons occurred by use of the PL and PAS approaches. Access to the digital flexor tendon sheath can also be achieved by use of the PAS approach with the limb in an extended or weight-bearing position; however, this method is not recommended because of the potential for injury to the flexor tendons during limb movement.

The extended or weight-bearing position was selected for the PL approach, because in the authors' experience, this is a commonly used method for access to the tendon sheath; however, this may not reflect the experience of others. Maximal distention of the proximal pouches develops during weight bearing, which facilitates access to the fluid-filled lumen of the tendon sheath and allows sufficient drainage of excess fluid from the synovial cavity. However, the PL approach can also be successfully used during fetlock flexion, with the similar advantage of increased control of limb movement, as described for the PAS approach.

Thus, the PAS approach offers an option for synoviocentesis of the digital flexor tendon sheath in horses that is reliable, technically simple, and rapid. Use of the PAS technique for intrathecal injection should be considered when synovial fluid distention is absent, synovial proliferation within the proximal pouch is suspected, an additional portal for lavage is necessary, or other techniques for access to the tendon sheath have failed.

[a]Batson's No. 17 plastic replica and corrosion kit, Polysciences Inc, Warrington, Pa.

[b]Renografin 76, Bristol-Meyers Squibb Co, Princeton, NJ.

References

1. International Committee on Veterinary Gross Anatomical Nomenclature. *Nomina anatomica veterinaria; with nomina histologica.* 3rd ed. Ithaca, NY: International Committee on Veterinary Gross Anatomical Nomenclature, 1983;A45.

2. Hago BED, Vaughn LC. Radiographic anatomy of tendon sheaths and bursae in the horse. *Equine Vet J* 1986;18:102–106.

3. Honnas CM, Schumacher J, Watkins JP, et al. Diagnosis and

treatment of septic tenosynovitis in horses. *Compend Contin Educ Pract Vet* 1991;13:301–311.

4. Bradley JR, Baxter GM, Parks AH, et al. The use of indwelling drains in the treatment of septic tenosynovitis, in *Proceedings*. Am Assoc Equine Pract 1989;35:251–258.

5. Van den Berg MJ, Rijkenhuizen ABM, Nemeth F, et al. The fetlock tunnel syndrome: a macroscopic and microscopic study. *Vet Q* 1995;17:138–142.

6. Nixon AJ. Endoscopy of the digital flexor tendon sheath in horses. *Vet Surg* 1990;19:266–271.

7. Van Pelt RW. Tenosynovitis in the horse. *J Am Vet Med Assoc* 1969;154:1022–1033.

8. Hago BED, Vaughan LC. Equine synovial tendon sheaths and bursae: a transmission electron microscope study. *Equine Vet J* 1991;23:475–478.

9. Honnas CM, Schumacher J, Cohen ND, et al. Septic tenosynovitis in horses: 25 cases (1983–1989). *J Am Vet Med Assoc* 1991;199:1616–1622.

10. Bertone AL. Infectious tenosynovitis. *Vet Clin North Am Equine Pract* 1995;11:163–176.

11. Schneider RK, Bramlage LR, Moore RM, et al. A retrospective study of 192 horses affected with septic arthritis/tenosynovitis. *Equine Vet J* 1992;24:436–442.

12. Chan CC-H, Munroe GA. Septic tenosynovitis and focal osteomyelitis of the lateral proximal sesamoid bone in a Thoroughbred gelding. *Vet Rec* 1997;141:147–150.

13. Barr ARS, Dyson SJ, Barr FJ, et al. Tendonitis of the deep digital flexor tendon in the distal metacarpal/metatarsal region associated with tenosynovitis of the digital sheath in the horse. *Equine Vet J* 1995;27:348–355.

14. Lamb CR. Contrast radiography of equine joints, tendon sheaths, and draining tracts. *Vet Clin North Am Equine Pract* 1991; 7;241–257.

15. Hago BED, Vaughn LC. Use of contrast radiography in the investigation of tenosynovitis and bursitis in horses. *Equine Vet J* 1986;18:375–382.

16. Nixon AJ, Sams AE, Ducharme NG. Endoscopically assisted annular ligament release in horses. *Vet Surg* 1993;22:501–507.

17. Misheff MM, Stover SM. A comparison of two techniques for arthrocentesis of the equine metacarpophalangeal joint. *Equine Vet J* 1991;23:273–276.

18. Verschooten F, Picavet TM. Desmitis of the fetlock annular ligament in the horse. *Equine Vet J* 1986;18:138–142.

19. Hago BED, Plummer JM, Vaughn LC. Equine synovial tendon sheaths and bursae: an histological and scanning electron microscopical study. *Equine Vet J* 1990;22:264–272.