How to Perform Standing Needle Arthroscopy Beyond the Stifle

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1. Introduction
Joint pathology is the leading cause requiring veterinary referral in horses and a prompt diagnosis is crucial to maximize athletic performance and minimize the progression of osteoarthritis.1,2 Current advancements in traditional and advanced imaging have improved the diagnostic capabilities of equine veterinarians.3–5 Nonetheless, arthroscopy remains the gold standard for the diagnosis and/or treatment of most articular pathologies, especially for cartilage evaluation and intra-articular soft-tissue lesions.3,5–8 Arthroscopy has been traditionally performed under general anesthesia (GA) but nowadays, there are standing arthroscopic techniques reported for diagnostic and treatment purposes to avoid the risks and cost associated with GA.9–12

A needle arthroscope has been recently introduced in veterinary medicine and has the potential to change the diagnostic approach of veterinarians as it has been done in the human field for some instances.13 This technology is portable, affordable, allows direct joint evaluation through a minimally invasive approach, and can be performed in the standing patient. Thus, needle arthroscopy can allow practitioners to bypass the diagnostic limitations found in certain areas difficult to image with traditional and advanced imaging (i.e., stifle and shoulder), to improve the diagnostic capabilities before recommending surgery or advanced diagnostics under GA for cases with unrewarding results after traditional imaging (i.e., carpus, tarsus, and carpal sheath) or to perform arthroscopic removal of simple osteochondral fragments in standing patients (i.e., dorso-proximal first phalanx fragments).

The objective of this paper is to describe how to perform standing needle arthroscopy in several synovial structures where its use could be beneficial for diagnostic or therapeutic purposes. In addition, the benefits and limitations of the technique for every region will be highlighted.

2. Materials and Methods
The procedures were carried out with a 1.2-mm diameter and 65-mm long or 100-mm long (only for the shoulder joint) needle arthroscope. This arthroscope has a 10° forward-viewing angle and is reusable (5 to 8 times in general) after performing gas or cold sterilization.

A custom-made splint adjustable in length and foot angle and a splint base adjustable in height and angle were designed in collaboration with an orthotics research center to ensure stable limb flexion during arthroscopic examination of the car-
pus, tarsus, and carpal sheath (Fig. 1). Several segments of the splint were adjustable (vertical length, hoof piece and base angle, height and thickness of padding blocks) to accommodate limbs of different sizes and to warrant sterility during the procedure. Minimal pre-operative splint training was performed with the horses to avoid an acclimation effect.

The technique and feasibility of the needle arthroscope to arthroscopically explore the metacarpo/tarsophalangeal (MCP/MTP), middle carpal (MC), radiocarpal (RC), scapulohumeral (SH), and tarsocrural (TC) joints and the carpal sheath was first assessed in cadaveric specimens. Then, 6 horses without history of musculoskeletal disease were enrolled to validate the use of the needle arthroscope in the aforementioned synovial structures except the MCP/MTP joint (clinical cases only). The studies were approved by the local Institutional Animal Use and Ethics Committee. For the MCP/MTP joint, horses admitted for standing arthroscopic removal of simple osteochondral fragments located in the dorsal recess of the joint were enrolled.

For the synovial structures experimentally evaluated, an intra-articular visualization score was attributed to every articular structure, with 3 for complete visualization, 2 for sub-complete (approximately 51% to 99% of the structure visualized), 1 for partial (approximately 1% to 50% of the structure visualized) and 0 for no visualization.

The pre-operative protocol, arthroscopic technique and post-operative care followed after horses were introduced in standing stocks and sedated with detomidine and butorphanol will be described next for every synovial structure. During the procedure, a light plane of sedation was maintained with a constant rate infusion (CRI) of 0.1% detomidine ± butorphanol titrated as needed. Horses were administered phenylbutazone before and 8 to 12 hours after the procedure. To prevent urine contamination of the surgical field from males, a bag attached to a metallic ring and held in place with a roll of gauze around the abdomen of the horse (Fig. 2) was placed below the prepuce for forelimb surgeries except the SH joint and they were catheterized in a standard fashion for hindlimb surgeries. For mares, a plastic sheet was attached to the back of the stocks and placed right behind the thigh area to prevent urine spillage into the surgical field for hindlimb surgeries. The region of interest was clipped immediately before the procedure.

Metacarpo/Tarsophalangeal Joint (Dorsal Recess)

- Horse position was adjusted within the stocks with a transverse bar placed either cranially (forelimb surgery) or caudally (hindlimb surgery) to increase the distance of the operated limb/s from the stocks’ frame. If available, a modified stocks door as used to perform standing tie-back surgery may facilitate distancing the affected limb from the stock frame. The
horse is covered by a blanket to prevent hair from falling into the surgical field.

- If unilateral hindlimb surgery was performed, a Kimzey splint was placed in the contralateral limb to prevent the horse from resting the affected hindlimb during the procedure. Additionally, butorphanol was not used for hindlimb surgeries to further prevent limb resting.

- Local analgesia, limb preparation, and draping was similar to previously described. Briefly, after aseptic preparation of the fetlock region, a line block just above the dorsal joint recess and intra-articular anesthesia (30 mL) were performed with 2% mepivacaine hydrochloride. In addition, a sterile self-adhesive elastic bandage was placed from proximal cannon bone to mid-radius/tibia to prevent hair from falling into the surgical field. Next, a sterile adhesive drape was placed around the fetlock and then the foot and kneeling mat were covered with a surgical drape first and then, by an adhesive “U” drape.

- The surgeon should kneel just laterally to the affected limb on a soft mat or wear knee pads unless the stocks can be lifted. Additionally, the arthroscopic screen can always be placed cranially (author’s preference) or alternated between cranial or caudal according to fragment location, limb affected and/or dominant hand (Fig. 3A).

- A 65-mm-long needle arthroscope and a 2.4-mm outer diameter cannula (regular cannula is 2.2-mm diameter) is recommended to be able to provide enough fluid delivery after an instrument portal is placed (Fig. 3F). Either a pressure infusion bag or a peristaltic pump (author’s preference) is used to ensure joint distention during the procedure. Special attention to fluid delivery settings during each phase of surgery is critical to prevent fluid extravasation or joint capsule rupture if a peristaltic pump is used.

- A standard approach to the MCP/MTP joint was carried out after a 3-mm skin incision with an 11# blade was performed. A sharp obturator was used to penetrate the joint capsule perpendicularly to the incision. At this level, cartilage is covered by the synovial plica and cannot be damaged. After joint penetration, the sharp obturator was replaced by a blunt obturator and the cannula and obturator were advanced into the joint in a horizontal direction. Lastly, the blunt obturator was replaced by the arthroscope and joint exploration started.

- At the end of the procedure, 250 to 500 mg of gentamicin or amikacin were injected into the joint. The 3-mm arthroscopic portal was left unsutured to improve cosmetic appearance and prevent suture removal complications for that portal. Routine bandaging was performed for 2 weeks. At 2 weeks, sutures were removed from the instrument portal and hand walking was started.

Fig. 3. Set-up to perform standing-needle arthroscopy in the metacarpophalangeal (A), radiocarpal (B), tarsocrural (C), carpal sheath (D), and scapulohumeral (E) joints. 65-mm and 100-mm needle arthroscopes, cannulas (2.4-mm diameter in blue and 2.2-mm in green), and obturators are depicted in the image (F).
Middle Carpal and Radiocarpal Joints (Dorsal Recesses)

- The animals were placed slightly outside of the stocks to prevent interference with the stocks’ frame. A lower limb bandage was placed and then the splint was attached to the limb to be operated on (Fig. 3B).
- After a first scrub of the carpal region, a line block with lidocaine hydrochloride 2% just proximal to the dorsal aspect of the RC joint and intra-articular anesthesia of both joints with 20 mL of mepivacaine hydrochloride 2% were performed. The carpus was then steriley prepped and draped as follows: a sterile elastic bandage was placed proximally and distally to the carpus and a sterile adhesive drape was placed around the carpal region.
- After draping, the splinted limb was attached to the splint base to achieve a carpal angle of 110° flexion, which achieved satisfactory evaluation of both joints in cadaveric specimens. This step was purposely done right before arthroscopic exploration to minimize the time horses were held with their carpi flexed.
- The surgeon sat cranio-laterally to the limb during the procedure and used one hand to direct the scope while the other hand was used to held/stabilized the limb. Thus, the 360° sterile draping is recommended.
- Routine dorsal arthroscopic approaches to the carpus were performed after a 3-mm skin incision was done.14
- During the procedure, an assistant was available to hold the splinted limb as needed to reduce limb movement. Additionally, the splint base was designed with a wide base to prevent limb rocking and also to allow the surgeon to step on it to further prevent limb movement (Fig. 3B). The described features to minimize limb movement were also used during TC arthroscopy and carpal sheath tenoscopy.
- A 65-mm long-needle arthroscope and a 2.2-mm outer-diameter cannula (regular cannula) was used. A pressure infusion bag was used to ensure joint distention during the procedure.
- Joints were injected with 250 mg of gentamicin at the end of the procedure, incisions were left unsutured, and limbs were routinely bandaged for 4 to 5 days. After this period, horses returned to paddock turnout.

Carpal Sheath (Proximolateral Recess)

- As for the carpus, a regional line block with lidocaine hydrochloride 2% just proximal to the dorsomedial, dorsolateral, and plantarolateral joints recesses was administered following a surgical scrub. Then, intra-articular anesthesia with 20 mL of mepivacaine hydrochloride 2% diluted in 30 to 40 mL of an isotonic solution was administered. The tarsal region and the contralateral limb were next draped as described for the carpal region. Lastly, the splinted limb was attached to the splint base with the tarsus flexed at 90°.
- The surgeon sat cranio-laterally to the limb during the procedure and used one hand to direct the scope while the other hand held/stabilized the limb. Thus, the 360° sterile draping is recommended.
- A 65-mm long-needle arthroscope and a 2.2-mm outer-diameter cannula (regular cannula) was used. A pressure infusion bag was used to ensure joint distention during the procedure.
- As for the previous joints, it is recommended to use the sharp trocar first to pierce the joint capsule and then replace it by the blunt trocar before further advancing the cannula within the joint. This approach ensures a tight seal around the arthroscopic cannula and minimizes fluid extravasation. The dorsolateral approach was made slightly axial to the center of the dorsolateral outpouching and the cannula/obturator were introduced toward the lateral malleolus of the tibia. The dorsomedial approach was made between the extensor tendon bundle and the saphenous vein to maximize joint visualization and the cannula/obturator were introduced toward the medial malleolus of the tibia. The plantarolateral approach was made in the caudocentral to caudoproximal aspect of the outpouching to prevent interference with the lateral trochlea of the talus (Fig. 3C).
- Joints were injected with 250 mg of gentamicin at the end of the procedure, incisions were left unsutured, and limbs were routinely bandaged for 4 to 5 days. After this period, horses turned to paddock turnout.

Tarsocrural Joint (Dorsal Recesses and Plantarolateral Recess)

- Horses were placed inside the stock as far as possible from the back to prevent interference with the stocks’ frame. A lower limb stable bandage was placed and the splint applied.
The joint was injected with 250 mg of gentamicin at the end of the procedure. The incision was left unsutured and a sterile adhesive bandage was applied for 24 to 48 hours. Horses were kept in stall rest for 2 to 3 days after the procedure before being turned out in a small paddock.

3. Results

Metacarpo/Tarsophalangeal Joint (Dorsal Recess)

Eight females and 13 geldings, from 1.7 to 11 years of age (mean, 4.5 years; median, 4 years) of different breeds (12 Warmbloods, 4 Quarter Horses, 3 Standardbreds, 1 Friesian, and 1 Lusitano) were operated with the technique.

Dorso-proximal first phalanx fragments were found in 18 horses (24 joints, 30 fragments), fragments embedded in the distal aspect of the synovial plica in 2 horses (2 joints, 4 fragments) and a free-floating fragment believed to have come from the dorsal sagittal ridge of the third metatarsal bone (MT3) in one horse (1 joint). Fifteen of 21 horses (71%) were unilaterally affected and 6 (29%) bilaterally. Thirty-five osteochondral fragments were arthroscopically removed from 27 joints: 15/27 (56%) frontlimbs (9 right and 6 left) and 12 (44%) hindlimbs (7 right and 5 left). One solitary fragment was removed from 19/27 joints (71%) and 2 from 8 (29%) joints.

Patient preparation was approximately 60 minutes while the surgical procedure took 15 to 20 minutes for most patients. Joint visualization was considered equivalent to performing the surgery standing with a 4-mm arthroscope.

Intra-operative complications included mild fluid extravasation in two horses and one horse urinated at the end of hindlimb surgery despite urinary catheterization but did not contaminate the surgical field. Moderate movement during the procedure leading to arthroscope exit and reintroduction was seen in 5/21 horses but only in one after the technique was refined (use of a contralateral Kimzey splint for unilateral hindlimb surgeries and performing the line block just proximal to the joint recess) after the first 5 horses.

No equipment damage occurred and the arthroscopes were reused approximately 5 to 8 times (it was not necessary to reuse them more than 1 to 2 times for the other synovial structures in the study). None of the joints became septic and all arthroscopic incisions were macroscopically healed 2 days postoperatively. This was also the case for the other synovial structures investigated.

The following synovial structures were evaluated in 6 healthy medium-sized breed horses (4 mares and 2 geldings) with a mean age of 9 years old (range, 3–13) and mean weight of 450 kg (range, 380–528).
Middle Carpal and Radiocarpal Joints
Arthroscopy of the RC joint was performed on all horses (3 left and 3 right forelimbs), whereas arthroscopy of the MC (first joint evaluated) was only carried out on the first 3 horses (2 left and 1 right forelimbs). Mild weight-bearing movements during the procedure transiently limited visualization of the caudal aspect of the weight-bearing surface of the bones in the MC joint. This made thorough MC joint evaluation time consuming, which subjectively affected procedure tolerability/movement during RC arthroscopy. Thus, for the following three horses it was decided to explore only one joint and the RC joint was chosen.

For both joints, most IA structures were completely visible from the dorsolateral approaches (radiocarpal joint [RCj] mean dorsolateral visualization score: 2.75 and middle carpal joint [MCj]: 2.83) while they were mainly completely to subcompletely visualized from the dorsomedial approaches (RCj mean dorsomedial visualization score: 2.28 and MCj: 2.12). Despite the superior scores for the dorsolateral approaches, both arthroscopic approaches are recommended for a thorough joint evaluation.

Mean ± SD arthroscopic times for the RCj and MCj were 6.24 ± 1 minute and 9.75 ± 1.75 minute, respectively. Splint wear was well tolerated by all horses. The procedure was considered feasible with only minor complications (mild hemorrhaxis in 1/6 and mild iatrogenic damage in 2/6) associated to the technique other than movement. Moderate limb movement occurred in 2 of the 3 first horses where both joints were evaluated during the same procedure.

Tarsocrural Joint
A mean visualization score of 2.53 was obtained for the dorsal arthroscopic approaches (2.69 for the dorsolateral [first approach performed] and 2.38 for the dorsomedial approach [second approach performed]) while only a mean score of 1.88 was obtained for the plantarolateral approach (third approach performed). The main visualization limitation for the dorsolateral approach was partial to subcomplete visualization of the medial malleolus and short medial collateral ligament thereby, thorough evaluation of the dorsal joint recesses requires both arthroscopic approaches.

The lower scores for the dorsomedial and plantarolateral approaches were associated with the presence of profuse hemorrhaxis and therefore, limited visualization in 3/6 horses during the dorsomedial approach. The dorsomedial vasculature was damaged during the initial arthroscopic approach in one horse and due to movement (cannula exit and reintroduction) in the two other horses. Additionally, residual deep digital flexor tendon tension prevented arthroscopic evaluation of the plantaromedial structures in one horse.

No other complications were seen during the pre-operative or post-operative period.

Mean ± SD arthroscopic time to perform the dorsolateral, dorsomedial, and plantarolateral approaches were 2.57 ± 0.65 minutes, 2.55 ± 1.10 minutes, and 5.06 ± 2.05 minutes, respectively.

All 6 horses tolerated the splint and base during the procedure. Nonetheless, 2 horses were shorter and did not require the splint base to achieve a 90° of tarsal flexion.

Carpal Sheath
The procedure allowed complete visibility of most proximal carpal sheath structures up to the carpo-metacarpal joint level. Nonetheless, visualization of the intertendinous recess was partial in most horses (4/6) due to remaining flexor tendon tension in standing horses. The splint was well tolerated by all horses (6/6) but placement of the splinted limb on the splint base resulted in occasional drastic limb movement during the procedure in one horse. Mean tenoscopic time was 7 ± 3 minutes.

Besides the aforementioned movement in one horse, only mild complications were found: mild and transient intrathecal bleeding in 3/6 horses, mild-to-moderate fluid extravasation in 3/6 horses, and mild cannula bending while accessing the tight intertendinous recess in 2/6 horses.

Scapulohumeral Joint
Joint distraction and limb adduction without joint collapse is not possible in the standing horse, and therefore it was anticipated that the medial aspect of the joint would not be visible.

The joint was arthroscopically accessed on the first attempt in all but one case (2 attempts). The glenoid rim up to 2 cm medially, humeral head and synovial membrane were completely visualized centro-laterally in all cases and caudo-laterally in 3/6. The visualization of the most caudal aspect of the joint was partial in three cases. Visualization of the cranial aspect of the glenoid rim and glenoid notch was partial in two and three cases, respectively, and complete in the remaining cases.

Arthroscopic evaluation took a mean time of 7 minutes (ranging from 5 to 10 minutes). Arthroscopic manipulation and maneuverability was considered easy in all instances and all horses tolerated the procedure well without any undesirable movements. Fluid extravasation was encountered in all cases, being mild in 5 cases and moderate in one. Mild iatrogenic cartilage damage during trocar penetration was seen in 2 horses; however, no lesions were identifiable when horses were euthanized 8 months later for reasons unrelated to the project.

Representative arthroscopic and tenoscopic images of all the synovial structures explored are shown in Fig. 4.
4. Discussion

The mortality rate associated with GA has been reported to be approximately 1% in horses. Additionally, other perianesthetic risks are also prevalent and remain significantly higher in horses than in other species. Nonetheless, GA is required to perform arthroscopy and advanced imaging in most instances due to the size and temperament of horses. Moreover, traditional imaging has a limited diagnostic accuracy in certain regions (i.e., shoulder), yields a moderate diagnostic rate for certain articular lesions and does not offer information regarding cartilage health. For example, radiography and ultrasonography still miss a percentage of intra-articular soft-tissue injuries and osteochondrosis dissecans lesions in the tarsus, especially for osteochondrosis lesions at the level of the medial malleolus (sensitivity of 71% and 83%, respectively). In the carpus, some lesions such as nonmarginal osteochondral fragments, cartilage damage, and palmar intercarpal ligament tearing can be radiographically silent and difficult to diagnose preoperatively. Lastly, a definitive diagnosis for soft-tissue pathologies involving the carpal sheath require an expert ultrasonographer and tenoscopy remains the gold standard for diagnostics. Thus, the use of standing arthroscopic techniques for diagnostic purposes will eliminate the risks associated with GA and may improve the diagnostic rate before a treatment is pursued. Additionally, good characterization of the lesions will provide clients with a more accurate prognosis before pursuing surgery and will help veterinarians with surgical planning. Finally, the technique could also be used as a second-look arthroscopic technique for clinical or research purposes.

The techniques reported offered a quick, safe, and reliable diagnostic evaluation of the investigated synovial structures but as for other diagnostic techniques, they are not exempt of limitations. General and specific limitations and tips are discussed below.

1. Needle arthroscopy is mainly conceived for diagnostic purposes but a therapeutic use has been shown for the dorsal compartment of the fetlock and could also be possible for simple osteochondral lesions in other regions. Nevertheless, further investigations are needed before it can be recommended.

2. The needle arthroscope has a 10° lens viewing angle and the field of view is smaller. This translates to working closer to the area of interest and having a sub-complete to partial visualization for certain structures during specific arthroscopic approaches (i.e., limited visualization of the medial malleolus of the tibia from the dorsolateral approach and of some carpal structures from a contralateral arthroscopic approach). To minimize this limitation, a good arthroscopic knowledge is mandatory before attempting the technique. Also, some joints (i.e., MC, RC, and TC) will require two arthroscopic approaches to obtain a thorough joint evaluation. Lastly, the required arthroscope and console are specialized equipment and require a practice investment.

3. Fluid delivery could be a problem if an instrument portal or intense joint lavage (i.e., moderate hemarthrosis is present) is required. This could be completely or partially solved by using the 2.4-mm diameter...
cannula and a peristaltic pump. Additionally, a needle can be used to allow joint lavage in cases of mild hemorrhosis or darkening of the synovial fluid. This needle can also be used to retract the synovium from the field of view as required.

4. Joint distension is usually achieved at the same time that anesthetics are delivered. Nevertheless, anesthetics can leak into the subcutis by the time of the procedure and lead to suboptimal distension. In those cases, it is recommended to redistend the joint immediately before arthroscopic entry to minimize the possibilities of iatrogenic cartilage damage.

5. A custom-made splint and a base were designed to obtain the required tarsal and carpal angle for the procedures while ensuring sterility. The current splint fits forelimbs and hindlimbs of different sizes and has a heavy and wide base to minimize horse movement during the procedure. Unfortunately, the splint is not yet commercially available and performing the procedure with other commercially available splints will likely jeopardize sterility. In contrast, the author anticipates that standing carpal sheath tenoscopy could be performed with commercially available splints without risking the sterility of the procedure.

6. Horse temperament should be taken into consideration before attempting the technique to prevent horse, personnel, or equipment damage. Anxious or unbroken horses or horses that cannot get rapidly acclimated to splint use are not good candidates. The research horses used for the experimental arthroscopies received minimal splint training before the procedures to prevent an acclimation effect. Additionally, the behavior was unknown before acquiring these horses for the studies.

7. Despite good splint tolerance, horses may move during the procedure and limit or lengthen the procedure. Several steps can be put in place to reduce/minimize this movement: 1) Appropriate sedation and analgesia. A relatively light plane is preferred to prevent animals from resting the limb to be operated on or being wobbly. 2) Local and intrasynovial anesthesia is mandatory. 3) Excellent arthroscopic knowledge is crucial to minimize procedure time. 4) Minimize the time horses wear the splint base, if required for the procedure, and therefore, they are partially weight bearing on the limb. 5) Have an assistant available to hold the limb as required and step on the wide splint base to further improve limb stability.

8. The unsutured arthroscopic portals are macroscopically healed around 2 days after the procedure and no septic synovitis have been encountered. Leaving the portals unsutured avoids a recheck appointment for suture removal, which reduces cost for clients and improves cosmetics. Nevertheless, the use of cyanoacrylate glue or wound closure strips could be used if desired.

9. When the technique was used for diagnostic purposes, horses required a short convalescence period (4 to 5 days maximum) before turnout was resumed. This period is significantly shorter than after performing therapeutic arthroscopy. Nevertheless, a therapeutic procedure may follow diagnostic needle arthroscopy in many cases.

10. No clinical cases were included for the synovial structures experimentally evaluated and therefore, further investigations are needed to determine other benefits and limitations of the technique. As clinical cases are recruited, it will be easier to determine the diagnostic accuracy of the technique for the different pathologies and synovial structures.

11. MC/MTP joint: Standing arthroscopy of the MC/MTP joint for diagnostics or for removal of simple dorsal osteochondral fragments is undoubtedly beneficial for horses. However, many surgeons still prefer to do the technique under GA due to concerns regarding surgeon position during the procedure, equipment damage, or familiarity with the technique. The reported technique is safe for horses and personnel and in case of damage, needle arthroscopes are significantly cheaper than a traditional 4-mm arthroscope. Nonetheless, equipment damage is rare to occur with either arthroscope. The author found that the learning curve for the technique was not steep and the MC/MTP joint is likely a good starting point for surgeons willing to initiate on standing arthroscopy. The landmarks and intra-articular structures of the MC/MTP joint are simple to identify for surgeons already familiar with traditional arthroscopic techniques.

12. MC/RC joints: Horses only tolerate partial weight bearing on a forelimb for a very limited time. Thus, moderate movement occurred in 2/3 horses when both joints were performed at the same time and only the RC joint was evaluated for the remaining 3 horses. It is recommended to explore one joint at a time to minimize limb flexion time and movement and therefore, increase procedure tolerability. Nevertheless, it is uncommon that both joints will need to be evaluated in clinical cases. For most clinical scenarios, it is recommended that both dorsal approaches be performed for a thor-
though joint evaluation. This is also recommended for traditional carpal arthroscopy under GA.\textsuperscript{14}

13. TC joint: The dorsolateral approach is safe and allowed an exhaustive evaluation of the joint except for the medial malleolus and the short medial collateral ligament. Thus, it is possible to perform only this approach unless concerns are focused on the most medial aspect of the joint or a thorough joint evaluation is desired. Profuse hemorrhage was a significant complication when the dorsomedial approach was performed. This was mostly related to reintroduction of the arthroscope after the horse has moved (2/3 horses). At this point, the dorsomedial vasculature may have rolled under the original incision and the surgeon inadvertently punctured it. Thus, critical attention is required while performing the original dorsomedial approach or reintroducing the cannula to avoid the saphenous vein and its branches. Alternatively, a larger incision could be performed to clearly determine the absence of vasculature before cannula introduction.

14. Carpal sheath: This technique offered a thorough evaluation of the proximal sheath structures, where pathology tends to occur, except the intertendinous recess (partial evaluation in 4/6 and complete in 2/6). This was associated with residual tendon tension during the standing procedure, which could potentially be resolved by having the limb held by an assistant while the practitioner explores the region. Evaluation of the intertendinous region is important to detect tearing of the superficial digital flexor tendon accessory ligament. Nevertheless, all reported cases with this lesion have also been tenoscopically identified medial to craniomedial to the deep digital flexor tendon and this technique has the potential to identify them at this location.\textsuperscript{20}

15. Scapulohumeral joint: This technique did not offer a thorough joint evaluation as arthroscopy under GA does because it was impossible to obtain joint distraction and limb adduction with the animal standing. Nonetheless, the cranialateral, centrolateral, and caudolateral aspect of the glenoid rim and the humeral head are visible and pathology can be identified at this level. The technique described does not identify some conditions involving the SH joint but the simplicity of the procedure should encourage surgeons to use it due to its diagnostic potential. The technique is very similar to performing an SH joint injection. Moreover, the technique could also be used as a screening tool to better select surgical candidates.

5. Conclusion
The described techniques mainly offer an alternative diagnostic tool for a subset of cases where traditional imaging modalities are unrewarding or fail to obtain a definitive diagnosis. Additionally, it may be useful for horses where an accurate prognosis is required before arthroscopic treatment under GA is pursued (cartilage evaluation and extent of cartilage and soft-tissue damage). Lastly, the technique has the potential to be used as a second-look arthroscopic technique to monitor healing/damage in clinical and research settings. Further investigations are needed to determine its applicability in clinical cases as joint visualization, limb movement, and splint tolerance may be challenging in horses with pathology.

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Declaration of Ethics
The Author has adhered to the Principles of Veterinary Medical Ethics of the AVMA.

Conflict of Interest
There is an agreement between the University of Montreal and the orthotics center Topmed to seek the commercialization of the custom-made splint and base in the near future. The author is one of the co-inventors of the splint.

References and Footnotes


*Kimzey, Inc., 164 Kentucky Ave., Woodland, CA 95695.