Journal of Equine Veterinary Science 35 (2015) 849–855

Contents lists available at ScienceDirect

Journal of Equine Veterinary Science

journal homepage: www.j-evs.com

Original Research

Development and Evaluation of Ultrasound-Guided Navicular Bursa Injection Using the Palmarodistal Digital Approach in Horses: an Ex Vivo Study

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ARTICLE INFO

Article history:
Received 14 June 2015
Received in revised form 2 August 2015
Accepted 3 August 2015
Available online 13 August 2015

Keywords:
Horse
Foot
Navicular bursa injection
Ultrasound

ABSTRACT

Navicular bursa injections are routinely used in horses with foot pain for diagnostic and therapeutic purposes. Ultrasound-guided injections to the navicular bursa have been proposed as an alternative to traditional techniques. The objective of this study was to develop an ultrasound-guided injection technique to access the navicular bursa using the palmarodistal digital approach and evaluate the success rate, total execution time, number of needle positioning, and ultrasonographic verification of bursal injection compared with contrast radiology. We hypothesized that this technique would be fast and accurate; necessitating few needle repositions and allowing real-time ultrasonographic guidance and verification of bursal injection. Overall success rate was 92.5% (37 of 40). Optimal images presented a success rate of 100% (32 of 32) and suboptimal images of 62.5% (5 of 8). Intrabursal accumulation of radiographic contrast media was correlated in 97.3% (36 of 37) of the limbs to ultrasonographic evidence of fluid and gas in the navicular bursa. Mean total execution time was 16.1 second (±7.84 seconds). Mean number of needle insertions per limb was 1.23 (±0.42). All the needle repositions (9 of 40) were performed within the digital cushion. Our results using cadaver limbs suggest that this approach allows a high injection success rate, high execution speed, accurate confirmation of intrabursal injection, and a low needle reposition rates. Needle repositioning within the digital cushion could minimize the number of unnecessary needle penetrations to the deep digital flexor tendon. Acquisition of suboptimal ultrasound images may preclude the use of this technique because it importantly impacts the injection success rate.

1. Introduction

Foot pain is often encountered during equine lameness examinations [1–4]. Pathologies of the podotrochlear apparatus are regularly diagnosed as the source of pain in this region [1,5–8]. Magnetic resonance (MR) evaluation is currently the gold standard for the diagnosis of lesions in the equine foot [7,8]. Using MR imaging, lesions in the podotrochlear apparatus are commonly found in horses with foot pain; nevertheless, horses with no clinical signs of foot-related lameness could also present pathologic changes in this region [7]. An inconsistent correlation between imaging findings and clinical findings has been reported [9,10]. Therefore, the clinical significance of the lesions should ideally be determined based on the clinical examination findings and response to diagnostic analgesia [11].

Navicular bursa injections are subject of controversy, because of the difficulty of performing this procedure in primary veterinary care [12] and also to the eventual risk of

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http://dx.doi.org/10.1016/j.jevs.2015.08.005

traumatizing the deep digital flexor tendon (DDFT) when perforating the structure with the needle [12–14]. Even though there is no proof that injections to the navicular bursa using non tendon-sparing techniques cause a detrimental effect on the DDFT [13], it has been reported in the literature as a reason to avoid intrabursal injections [12–14]. However, this technique is widely used in horses with foot pain for diagnostic [1,15–17] and therapeutic purposes [5,18–21]. Numerous recommendations exist regarding the injection technique [22,23], nevertheless the selection of an image-guided approach should adhere to the principles of interventional radiology, which aim at diagnosing and treating patients using the least invasive approaches currently available [24]. The distal palmar approach to the navicular bursa using the navicular position for orientation [23] is apparently the most accurate radiographic controlled technique in the hands of inexperienced operators [14]. Nonetheless, radiographic examination is time consuming, requiring leaving the needle inserted in the foot during the initial radiographic verification and the potential repositions. Lastly, while using this technique there is no possibility of minimizing the trauma to the DDFT rather than trying to decrease the injection attempts. The transcuneal approach for the ultrasonographic evaluation of the distal podotrochlear apparatus has been previously described [25]. Ultrasound-guided injections to the navicular bursa using this approach have been proposed as an alternative to the usage of traditional bursa injection techniques and radiographic control [26]. This approach has proven to be accurate and fast, allowing real-time needle positioning and eventually precluding the need for radiographic control [26]. Spriet and others suggested that in horses with dry frogs, trimming of the frog and soaking the feet for at least 30 minutes prior to the ultrasonographic examination would be necessary to improve ultrasound penetration [26]. Therefore, the foot preparation needed for this technique would be laborious, time consuming, and eventually discouraging, when used in a clinical setting. Furthermore, the transcuneal approach allows confirmation of the needle positioning, but not ultrasound guidance, as the needles were blindly advanced to the “navicular position” until resistance to needle progression was encountered [26]. This situation might increase the difficulty of the procedure, the needle repositions and the number of perforations to the DDFT, especially when performed by inexperience operators. The normal ultrasonographic appearance of the palmarodistal aspect of the digital area between the bulbs of the heels has been reported [27]. This technique allows the visualization of the proximal aspect of the podotrochlear apparatus and therefore may allow guiding a needle to the navicular bursa using ultrasonographic control. The objective of this study was to develop an ultrasound-guided injection technique to the navicular bursa using the palmarodistal digital approach and evaluate the success rate, total execution time, number of needle positioning, ability to confirm intrabursal injections and report difficulties or complications. We hypothesized that this technique would be feasible, fast and accurate; necessitating few needle repositions and allowing real-time ultrasonographic guidance and confirmation of successful bursa injection. We believed this approach would allow needle repositions in the digital cushion, avoiding unnecessary perforations of the DDFT.

2. Materials and Methods

2.1. Cadaveric Limbs

Forty distal cadaver forelimbs were collected at abattoir from mature horses of a range of breeds, sizes, and hoof conformations. Limbs presenting sheared heels were not excluded from the study to try to emulate a clinical situation. The limbs were stored 24 to 48 hours at −20°C until used in the study. Before the injection, the limbs were thawed at room temperature (25°C) for at least 24 hours. The palmar aspect of the pastern and the heels were clipped, washed with water and soap, and rinsed with alcohol.

2.2. Ultrasound-Guided Injection Technique to the Navicular Bursa

The same clinician (R.J.E.) performed all the injections and evaluated the ultrasound images. All the authors were involved interpreting the radiographic images. To emulate the conditions of a navicular bursa injection in a living animal, the clinician injected 0.5 mL of mepivacaine 2% (Scandicain, AstraZeneca, Schleswig-Holstein, Germany) between the heel bulbs just proximal to the coronary band; the transducer was covered with a latex glove, and the limbs were held off the ground by an assistant, mimicking the position of a distal forelimb held parallel to the ground. The assistant stood craniolaterally to the limb, with one hand holding the dorsal aspect of the third metacarpal bone and with the other pulling the toe (Fig. 1). This position allowed an efficient extension of the distal limb. Acoustic coupling was achieved using alcohol. The clinician positioned a multi-frequency micro-convex transducer (14-mm ray of curvature, 9-3 MHz, CA123 VET; Esaote,

Fig. 1. Limb, transducer, and needle positioning for the ultrasound-guided injection of the navicular bursa using the palmarodistal digital approach in cadaver limbs. An assistant kept the limb in extension. The probe was positioned in a palmaroproximal–dorsodistal direction between the bulbs of the heels, and the needle was placed just proximal to the coronary band.

Geneva, Italy) between the bulbs of the heels in longitudinal plane and a palmaroproximal–dorsodistal direction (Fig. 1). The ultrasound machine (MyLab 5; Esaote) was set at 6.6 MHz, the gain at 76%, and the depth at 4–5 cm depending on the size of the limb. An initial ultrasound image of the proximal podotrochlear region (Fig. 2) was acquired to determine good acoustic coupling and for further classification depending on the visualization of certain anatomical landmarks. Optimal images were those where the sagittal union of the collateral sesamoidean ligament and the bone line of the palmaroproximal aspect of the navicular bone were visualized (Fig. 2). On the other hand, suboptimal images were those where only a poorly demarcated collateral sesamoidean ligament or navicular bone line was visible (Fig. 2). After the image classification, a new image was immediately acquired and a 20-gauge 8.9-cm spinal needle (Spine-Ject; M. Schilling, Gelnhausen, Germany) was inserted at the site of the local block (Fig. 1). Using ultrasonographic guidance, the needle was directed through the digital cushion, as sagittal as possible, until contacting the palmaroproximal aspect of the navicular bone (Fig. 3). In cases where only the collateral sesamoidean ligament was visible, the needle was directed distal to this structure until significant resistance was encountered. Once in position, 2 mL of a 510-mg/mL iopamidol (Solutrast, Milan, Italy) and 0.5 mL of air were injected into the navicular bursa. After the bursa was injected with a contrast agent, no further attempts to optimize needle positioning were made. The confirmation of intrabursal or extrabursal injections was then performed using ultrasonographic and radiological control. The total execution time and number of repositionings were recorded. Total execution time was defined as the summation of the ultrasonographic image acquisition time and the injection time. Number of repositions was defined as the number of redirections of the needle.

2.3. Injection Verification

Immediately after injection, a new ultrasound image was acquired using the same settings as described previously. The presence of gas and fluid in the bursa or in any other adjacent structure was recorded. Lateromedial radiographs of the hoof were used as the gold standard to verify the results of the ultrasonographic evaluation after the navicular bursa injection. Each foot was radiographed with the needle left in position after injection contrast media. Presence of gas, fluid distension in the bursa was recorded as ultrasonographic evidence of a successful bursal injection. A finding of radiocontrast medium within the navicular bursa on a lateromedial radiograph was used to verify results of the ultrasonographic evaluation of the navicular bursal injection (Fig. 3).

2.4. Statistical Analysis

Data were analyzed using a spreadsheet (Excel; Microsoft Corp, Washington). Descriptive statistics were used to

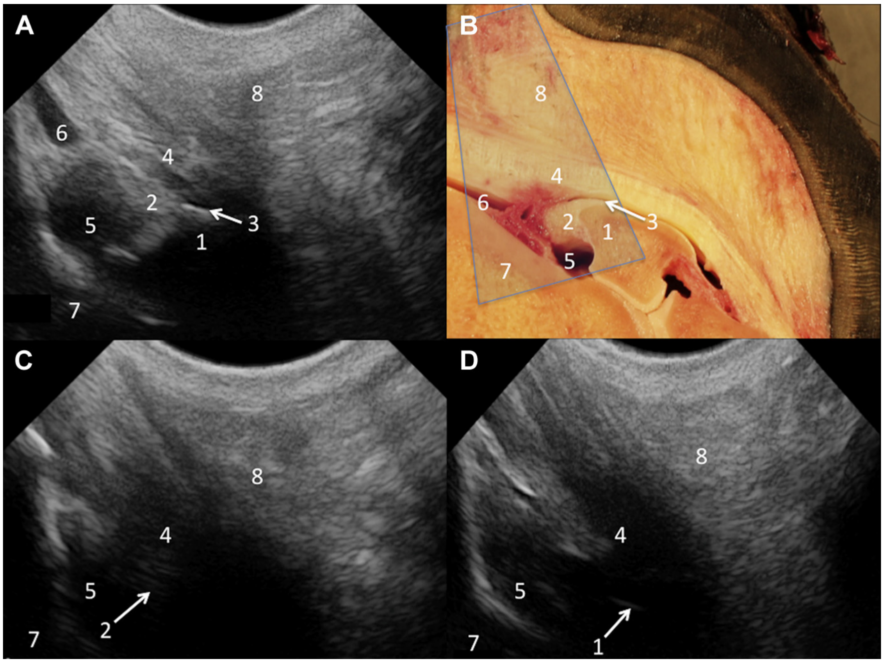

Fig. 2. Ultrasonographic examination of the proximal podotrochlear apparatus using the palmarodistal digital approach. Left is dorsoproximal. (A) Optimal image of the region acquired by performing a sagittal ultrasound of the palmarodistal aspect of the digit. (B) Sagittal section of the podotrochlear region in a forelimb cadaver limb. The scanned region is marked by a transparent trapezium. (C) Suboptimal image of the region. Only a poorly demarcated collateral sesamoidean ligament is visible (white arrow). (D) Suboptimal image of the region. Only a poorly demarcated bone line of the palmar aspect of the navicular bone is visible (white arrow). 1 = navicular bone, 2 = collateral sesamoidean ligament, 3 = navicular bursa (space between the deep digital flexor tendon and the navicular bone), 4 = deep digital flexor tendon, 5 = proximal recess of the distal interphalangeal joint, 6 = dorsal distal recess of the digital sheath, 7 = palmar aspect of the second phalanx, and 8 = digital cushion.

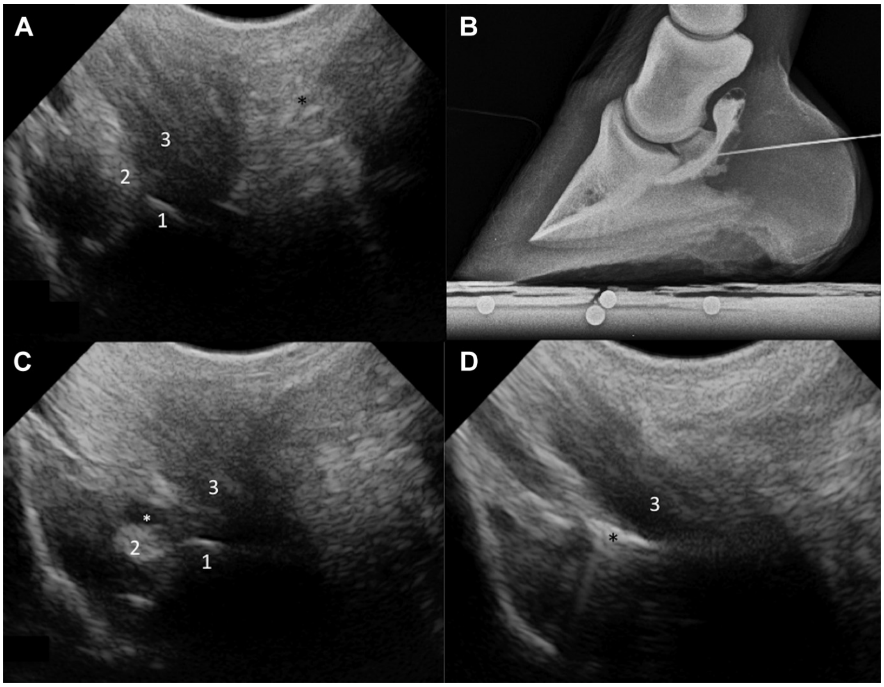

Fig. 3. (A) Ultrasound-guided injection of the navicular bursa using the palmarodistal digital approach. The black asterisk marks the needle. (B) Radiographic accumulation of contrast solution and gas in the navicular bursa. (C and D) Ultrasonographic confirmation of successful intrabursal injection. Fluid distension in the navicular bursa (white asterisk) (C) and gas causing a hyperechoic area (black asterisk) dorsal to the deep digital flexor tendon (D) were visible when intrabursal injections were achieved. 1 = palmar bone line of the navicular bone, 2 = collateral sesamoidean ligament, and 3 = deep digital flexor tendon. Left is dorsoproximal in all the ultrasound images.

describe the obtained results when evaluating the different parameters. Overall success rate, ultrasound image findings, success rate of the optimal ultrasound images, success rate of the suboptimal ultrasound images, correlation of radiologic and sonographic control, and correlation between radiographic and sonographic confirmation were described as percentage. Total execution time and needle positionings were described as a value ± standard deviation.

3. Results

Results of the study are summarized in Table 1. The palmarodistal digital approach presented an overall success rate of 92.5%, with 37 of 40 limbs showing radiographic contrast accumulation in the navicular bursa. Eighty percent (32 of 40) of the images were classified as optimal. Optimal images presented a success rate of 100% (32 of 32), and suboptimal images presented a success rate of 62.5% (5 of 8). From the suboptimal image obtained, 75% (6 of 8) presented only a poorly demarcated collateral sesamoidean ligament and 25% (2 of 8) only a poorly demarcated navicular bone line. All the unsuccessful injections (3 of 40) occurred in limbs presenting suboptimal images, and in all the cases, the needle was positioned proximal to the navicular bone, injecting the palmar recess of the distal interphalangeal joint. In 66.6% (2/3) of the unsuccessful injections, a hyperechoic region palmar to the second phalanx was observed ultrasonographically (Fig. 4). In 97.3% (36 of 37) of the limbs, a hyperechoic region dorsal to the DDFT and proximal to the collateral sesamoidean ligament and distension of the proximal recess of the navicular bursa (both in sagittal images) were correlated to accumulation of radiocontrast media in the navicular bursa. One false positive result occurred in a suboptimal image. In this case, a hyperechoic region dorsal to the DDFT was observed

Table 1
Ultrasound-guided injection of the navicular bursa using the palmarodistal digital approach in forty equine cadaver forelimbs.

	Overall Success Rate (%)	Optimal Images Success Rate (%)	Suboptimal Images Success Rate (%)	Ultrasonographic/Radiologic Verification Correlation (%)
Percentage	92.50	100	62.50	97.30
Ratio	37/40	32/32	5/8	36/37
	Total Execution Time (s)	Needle positionings		
Mean	16.1	1.23		
SD	7.84	0.42		

Abbreviation: SD, standard deviation.

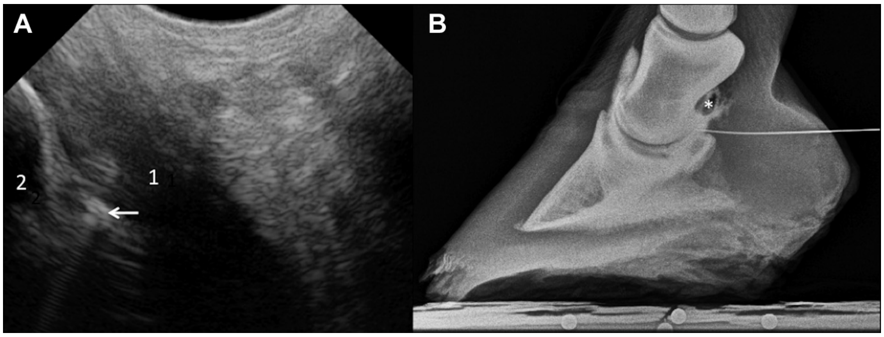

Fig. 4. Unsuccessful ultrasound-guided injection of the navicular bursa using the palmarodistal digital approach. (A) Suboptimal image of the proximal podotrochlea showing gas (white arrow) immediately palmar to the second phalanx, presumably in the palmaroproximal recess of the distal interphalangeal joint. (B) The same limb presented radiographic contrast accumulation in the DIPJ, showing gas in the palmaroproximal recess (white asterisk). 1 = deep digital flexor tendon and 2 = second phalanx. Abbreviation: DIPJ, distal interphalangeal joint.

on a parasagittal image, apparently caused by gas in the palmar recess of the distal interphalangeal joint. The mean total execution time of the procedure was 16.1 seconds (±7.84 seconds). The mean number of needle insertions per limb was 1.23 (±0.42). All needle redirections (9 of 40) were performed without removing the needle from the digital cushion. In the limbs presenting sheared heels, the needle could not be inserted in a proximal injection site with healthy skin because of the position of the transducer in the distal pastern.

4. Discussion

Successful ultrasound-guided injection of the navicular bursa using the palmarodistal digital approach was observed in 92.5% of the limbs. It is arguable that this success rate is similar to what has been previously reported for non–ultrasound-guided techniques [14]. Nevertheless, a perfect injection success rate was achieved in limbs where optimal ultrasound images were acquired. The success rate in limbs with suboptimal ultrasound images was lower. Even though it was possible to effectively inject the bursa in limbs where one or more anatomic landmarks (collateral sesamoidean ligament and navicular bone line) were not reliably visible, our results suggest that this technique is only highly accurate when optimal images are acquired. Therefore, acquisition of suboptimal ultrasound images using the palmarodistal digital approach may preclude the use of this technique since it importantly impacts the injection success rate. We believe that it is possible that hoof conformation might play a role in the ultrasound image quality; nonetheless, this was not evaluated in our study, and therefore, no conclusions can be drawn in this regard. Three of 40 navicular bursa injections were unsuccessful. This occurred in limbs presenting suboptimal images, and in all of them, the needle was positioned just proximal to the navicular bone, injecting the palmar recess of the distal interphalangeal joint. Interestingly, in 2 of 3 unsuccessful injections, we were able to identify on ultrasound a hyperechoic region in the palmar recess of the distal interphalangeal joint. Even though this number of failed attempts is too low to draw final conclusions, these findings suggest that this technique would also allow the identification of unsuccessful injections.

Ultrasonography, even considering suboptimal images, proved to be a very reliable tool for detection of successful injection of the navicular bursa as ultrasonography correlated closely with radiographs demonstrating contrast medium within the navicular bursa. This result would eventually preclude the use of radiographic examination and contrast agents, allowing an accurate verification of the needle positioning and/or intrabursal injection in hospital settings and ambulatory practice and decreasing unnecessary radiation exposure. Even though the acquisition time of the confirmation images was not measured for each limb, the procedure was straightforward and usually performed in <20 seconds.

Even though this approach proved to be considerably faster (16.1 second vs. 42 seconds) than a previously reported ultrasound-guided approach [26], these data should be interpreted cautiously because the procedures were performed in cadaver limbs and not in living horses. It is most likely that performing the technique in living animals would have increased the execution times due to movements of the limb during the procedure and/or the presence of fractious horses. The aim of measuring and presenting the execution times in this study was not to directly compare with the aforementioned study [26] but to show to the reader that this is not a lengthy procedure. Moreover, based on our experience in a limited amount of animals, very similar results are obtained when using this technique in living horses.

The use of the transcuneal approach could be laborious and time consuming, because it requires frog trimming and soaking of the feet (at least for 30 minutes), to acquire optimal images [26]. In contrast, the palmarodistal digital approach needs no further preparation than what is needed for the navicular bursa injection itself. Therefore, ultrasonographic guidance and confirmation using the distal palmar approach for centesis of the navicular bursa could reduce the overall preparation and execution time, unnecessary radiation exposure, and eventual complications related to prolonged needle insertion.

The selection of an image-guided approach should adhere to the principles of interventional radiology, which aim at diagnosing and treating patients using the least invasive approaches currently available, minimizing tissue damage, and eventually improving the health outcome [24]. Even though there is no proof that navicular bursa injections through the DDFT have a detrimental effect on the tendon, perforations of the DDFT are common reasons of concern when injecting the navicular bursa [12–14]. Daniel et al [13] reported a technique that avoids the puncture of the DDFT, but it is time consuming, needs a considerable amount of radiographs to control the needle (2 to 11), and is not applicable for analgesia of the bursa because an abaxial sesamoid nerve block is recommended [13]. Even though the ultrasound-guided palmarodistal digital approach would not avoid the DDFT, it might minimize unnecessary tendon perforations because the needle can be redirected without removing it from the digital cushion. This approach would also allow needle guidance from the start of the procedure on, in contrast with the transcuneal approach where the injection is done blindly and the needle position is only controlled once it reached the navicular bone.

The main technical limitation for the clinical application of the approach, other than the effect of the image quality on the injection accuracy, was that the presence of sheered heels caused needle insertions through unhealthy skin. In these cases, the probe positioned between the heel bulbs precluded the reposition of the needle to a more proximal injection site. To decrease the risk of infections, we suggest the usage of other injection approaches in horses showing significant sheering of the heels. In most horses, just the most proximal aspect of the navicular bone was visible on ultrasound. To increase the chances of contacting the bone and to decrease the possibility of inadvertent centesis of the palmar pouch of the distal interphalangeal joint, we aim at positioning the needle just distal to the visible bone line of the navicular. Interestingly, the needle was observed throughout the digital cushion and part of the DDFT, but it was not further visualized approximately 1.5 to 2 mm before contacting the navicular bone (Fig. 3). We believe that the tip of the needle being off-beam caused this phenomenon. Nonetheless, this was not a problem because the needle was further advanced and the navicular bone was immediately contacted. The acquisition of optimal ultrasound images of the proximal podotrochlear region and the realization of ultrasound-guided injection might pose an important challenge for inexperienced operators. Because of this, we believe it would be ideal to practice this approach on cadaver limbs before injecting the bursa in a living horse.

There are limitations to this study. Even though we tried to emulate the conditions of this injection technique in a living horse (limb position, assistant and operator position, and subcutaneous block), we could never exactly replicate this situation. The use of this technique in living animals may cause variations of the parameters measured in this study. Although this might be true for the injection speed and success rate, it is highly unlikely that this situation affects the capacity of the ultrasound to confirm a successful navicular bursa injection. Therefore, even though this technique seems to be a promising option for the injection of the navicular bursa, further experience using it in living animals should be gained to draw final conclusions. Interestingly, in the limited experience we have using this technique on living animals, we have seen that there are not many differences when compared with the results of this study. Because we did not grossly examine the navicular apparatus of the cadaver limbs for evidence of disease, we cannot be certain of whether pathologic changes in the navicular apparatus will affect ultrasound-guided verification of navicular bursal injection using the palmarodistal digital approach.

5. Conclusions

Ultrasound-guided injections to the equine navicular bursa using the palmarodistal digital approach seem to be a promising alternative to traditional techniques; nevertheless, further experience in living animals should be gained to draw final conclusions. Our results in cadaver limbs suggest that this approach allows a high injection success rate and execution speed and a low needle reposition rate. Moreover, this technique allows an accurate confirmation of successful intrabursal injection, eventually precluding the need of radiographic control. All needles were repositioned while visualized within the digital cushion, which can possibly minimize unnecessary perforations of the DDFT. Suboptimal ultrasound images acquired using the palmarodistal digital approach have an important negative effect on the injection success rate and therefore would preclude the use of this technique.

Acknowledgments

The Equine Clinic of the Free University of Berlin supported the study with the materials and equipment needed. R.J.E. and A.P. contributed equally as co-first authors: study development, data collection. R.J.E., A.P., and C.J.L. did the data analysis and article preparation. C.J.L. is the senior author of the study: overall study design and project coordination. All authors approve the publication of this article. No conflicts of interest have been declared.

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