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Ex Vivo Assessment of an Ultrasound-Guided Injection Technique of the Navicular Bursa in the Horse

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Summary

Synovitis of the navicular bursa is common in performance horses. The objective of this study was to describe an ultrasound-guided technique to inject a distended navicular bursa and to evaluate its feasibility for use by a clinician not trained in the technique. Twenty distal limbs of horses of various breeds and sizes were used. To produce synovial distension, the navicular bursa of each limb was injected with contrast medium using a lateral approach and radiography was performed to confirm that the contrast medium was distending the bursa. The digit was positioned with the distal interphalangeal joint in hyperextension. A micro-convex ultrasound probe was placed in the hollow of the pastern, palmar to the middle phalanx and the region was assessed in a transverse plane slightly oblique to the horizontal plane. The ultrasound probe was rotated to visualize both the lateral and medial recesses and to select which side was more distended to inject. A 21G 0.8 × 50 mm needle was inserted abaxially to the probe in the plane of the ultrasound beam into the proximal recess of this navicular bursa and a methylene blue solution was injected. Following injection, dissection was performed to assess whether the navicular bursa had been successfully injected. This ultrasound-guided technique was reliably performed with a success rate of 68%. The success of injection is influenced by hyperextension of the foot, quality of ultrasound images and degree of distension of the bursa.

Introduction

Foot pain is a common cause of lameness in horses. Perineural anaesthesia of the digital nerves, intra-articular analgesia of the distal interphalangeal (DIP) joint or intrabursal analgesia of the navicular bursa are used to identify the origin of foot pain (Turner, 2003). Administration of corticosteroid and hyaluronate into synovial cavities, including the navicular bursa, is sometimes used in the treatment of chronic palmar foot pain (Dabareiner et al., 2003; Bell et al., 2009; Boyce et al., 2010; Gutierrez-Nibeyro et al., 2014).

Six techniques have been described to inject the navicular bursa, each relying upon different anatomical landmarks. Four approaches are in the sagittal plane: (1) distal palmar approach (needle inserted midway between the heel bulbs) parallel with the coronary band (DPPCB) (Scrutchfield, 1977; Stashak, 1987; Turner, 1989); (2) distal palmar approach parallel with the sole (DPPS) (van Kruiningen, 1963; Wheat and Jones, 1981; Worthmann, 1982; Dyson and Kidd, 1993; Grant, 1996); (3) proximal palmar approach (needle inserted in the hollow of the heel) with an angle of 30° to the horizontal plane (PP30) (Bishop 1960); (4) distal palmar approach to the navicular position (DPNP; towards the position of the navicular bone projected virtually on the hoof 1 cm distally to the coronary band, halfway between the toe and the heel) (Verschooten et al., 1990). Two approaches are lateral:

(5) between the latero-palmar border of the middle phalanx and the lateral border of the deep digital flexor tendon (DDFT) with an angle of 45° to the horizontal plane (L45) (van Kruiningen, 1963; Turner, 1989; Grant, 1996) and (6) dorsal to the dorsoabaxial margin of the DDFT at the level of the collateral cartilage with a palmaroproximolateral-palmarodistomedial oblique trajectory angled approximately 30–40° to the horizontal plane (Pa30Pr30L-PaDiMO) (Daniel et al., 2014). Lateral approaches would avoid puncture of the DDFT which occurs with sagittal approaches (Daniel et al., 2014).

Most techniques (DPPCB, DPPS, PP30, L45 and Pa30Pr30L-PaDiMO) are performed with the limb in a weight-bearing position with the solar surface of the foot horizontal (Schramme et al., 2000; Daniel et al., 2014), while in DPNP, the distal limb is either supported in a Hickman block with the metacarpophalangeal and DIP joints flexed (Schramme et al., 2000; Piccot-Crézollet et al., 2005), or held in flexion (Spriet et al., 2004).

As anatomical landmarks depend on the conformation of the foot, some authors have recommended guiding injection with imaging techniques. Needle insertion can be performed under radiographic guidance (Verschooten et al., 1990; Stashak, 2002; Piccot-Crézollet et al., 2005; Daniel et al., 2014). Fluoroscopy can also be used to assess injection in real time, but this is not feasible in ambulatory practice (Keegan and Dyson 2003). Ultrasonographic examination of the palmar part of the foot through the frog has been described (Busoni and Denoix, 2001) and has been used for control of navicular bursa injection (Spriet et al., 2004).

The proximal palmar recess of the navicular bursa can be identified on transverse oblique ultrasound images obtained at the palmar aspect of the middle phalanx (Rabba et al., 2011). Our experience suggests it is possible to inject the navicular bursa by a lateral approach under ultrasound guidance when the bursa is distended. The technique has been developed by the first author and has been used for treatment in clinical cases where, after a complete clinical workup, distension of the navicular bursa was considered as a sign of a synovitis that might cause foot pain. The objective of the current study was to describe this technique of injection of the navicular bursa under simulated conditions of bursal distension and to evaluate its feasibility for use by a clinician not trained in the technique.

Materials and Methods

Specimens

Twenty distal unpaired forelimbs of horses, collected at a slaughterhouse, were used. Ages, genders, breeds and clinical data were not known. Sizes of feet were also different. Imaging including radiography and MRI was not performed to identify pathological changes at baseline. Limbs were frozen at −12°C, then thawed to room temperature before experimentation.

Preliminary distension of navicular bursa

Limbs were clipped from the coronary band to the fetlock. To obtain synovial distension, the navicular bursa was injected with 2 ml of contrast medium (meglumine and sodium ioxaglate 320 mg/ml) by a lateral approach and by one author (JMV) who has the experience of this approach in clinical cases. The sulcus between the DDFT and the branch of the superficial digital flexor tendon was identified with the thumb. The thumb was positioned against the collateral cartilage. A 21G 0.8 × 50 mm needle was introduced palmar to the thumb, between the two tendons. It was introduced with an angle of 45° to the medial plane until the needle contacted the dorsal border of the distal sesamoid bone. Then, the needle was slightly retracted and introduced more palmarly over the facies flexoria. This movement was repeated if the needle was still impacting the dorsal border of the distal sesamoid bone. Once the operator confirmed correct needle placement by feeling the needle pass over the distal sesamoid bone, injection was performed. In this technique, the foot was held in a flexed position during the whole procedure to open the bursal space between the DDFT and the distal sesamoid bone by reducing the tension in the DDFT, allowing easier injection (Scrutchfield, 1977). After injection, a lateromedial radiographic projection of the foot (90 kV, 125 mA, 0.05 s with a grid) was obtained to confirm that the contrast medium was filling the bursa. The procedure was repeated if the injection was not successful.

Ultrasound-guided injection

This part of the study was performed by a clinician who had experience of ultrasonography of the foot but had never injected the navicular bursa under ultrasound guidance (CP). The digit was placed on a table with the DIP joint in hyperextension, as close as possible as it would be in living animals (Fig. 1). Isopropyl alcohol was used to improve penetration of ultrasound. A microconvex ultrasound probe (6 MHz; ESAOTE MyLab ClassC Solution Imagerie vétérinaire, 11, Rue des Roitelets, 91400, ORSAY, France) was placed in the hollow of the pastern palmar to the middle phalanx and the region was assessed in a transverse plane, slightly oblique to the horizontal plane (Fig. 1). The DDFT and the distended navicular bursa were identified. The ultrasound probe was rotated (only very slightly) laterally or medially. The size of the

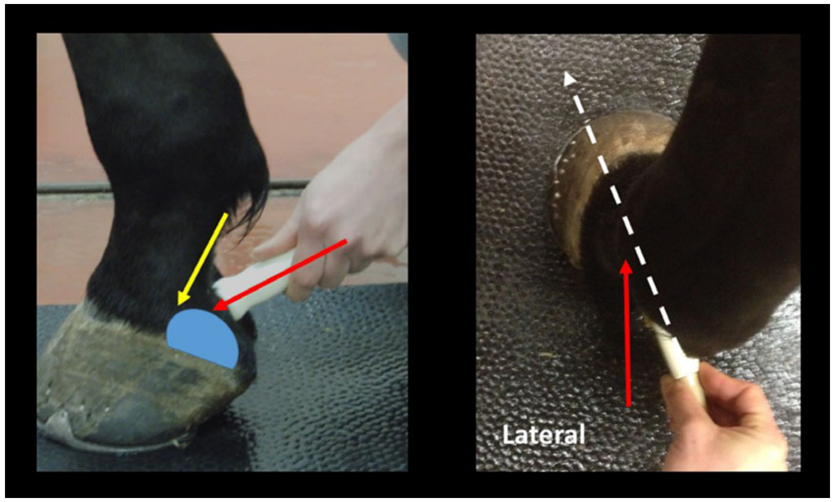

Fig. 1. Description of the injection technique in the current study. The technique is illustrated on a living animal. The horse is positioned with the distal interphalangeal joint in hyperextension. The limb is pulled backwards as much as possible with the axis of the cannon obliquely orientated to the ground. A microconvex ultrasound probe is held in a transverse plane slightly oblique to the horizontal plane. It is slightly rotated medially or laterally to identify the proximal palmar recess of the navicular bursa that is the most visible (the dotted arrow indicates the axis of the ultrasound probe). The needle (illustrated by the red arrow) is introduced abaxially to the ultrasound probe in the plane of the ultrasound beam towards the proximal recess of the navicular bursa. The yellow arrow illustrates the direction of the needle in the Pa30Pr30L-PaDiMO technique described by Daniel et al. (2014). The blue area indicates the collateral cartilage. [Colour figure can be viewed at wileyonlinelibrary.com]

bursa was assessed subjectively. The synovial recess that appeared more visible, either lateral or medial, was selected for injection. A 21G 0.8 × 50 mm needle was inserted abaxially to the ultrasound probe in the plane of the ultrasound beam in the direction of the proximal recess of the navicular bursa (Fig. 2). Accurate needle position was achieved when the tip of the needle was seen penetrating the dorsal recess of the navicular bursa on ultrasound images. If an accurate needle position was not obtained, the needle was then repositioned under ultrasound guidance. When the needle was observed in adequate location, one ml of a methylene blue solution was injected. A maximum period of 10 min was allowed to reach the adequate location for the needle and to perform the injection. At the end of this period, the operator had to inject the methylene blue even if he thought the needle could have been better located.

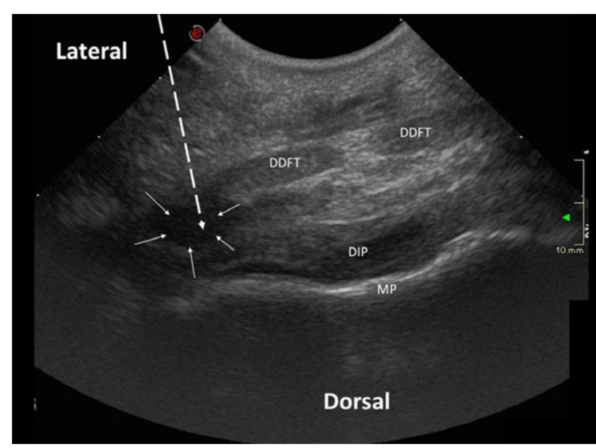

Fig. 2. Ultrasound image for guiding injection. DDFT, deep digital flexor tendon; DIP, synovial fluid in the distal interphalangeal joint; MP, middle phalanx. Plain white arrows show the proximal recess of the navicular bursa. Dotted white arrow illustrates the direction of the needle. [Colour figure can be viewed at wileyonlinelibrary.com]

Experimental outcomes

The number of re-positioning attempts required, as determined by withdrawal and re-orientation of the needle, was counted. The time between beginning of the procedure and assessment by ultrasonography of correct needle positioning was recorded.

A dissection was performed afterwards to assess whether the navicular bursa had been successfully injected, and methylene blue could be observed in its synovial cavity. The dorsal and palmar pouches of the DIP joint, the digital flexor tendon sheath (DFTS), the DDFT and surrounding tissues were also examined for the presence or absence of methylene blue. Outcomes were recorded as positive (presence of methylene blue) or negative (absence of methylene blue) in the navicular bursa. Coloration of other synovial cavities (DIP joint, DFTS), DDFT and the surrounding tissue was also recorded as full (well marked), intermediate (presence of traces of methylene blue) or absent. The presence of adhesions in the navicular bursa or bone changes were assessed during dissection.

Number of reorientations of the needle and duration of the procedure were plotted over time to assess whether a learning curve could be identified. The Student's *t*-test was used to compare circumferences of feet between the group of limbs successfully injected and the group where injections were not successful. A *P*-value < 0.05 was considered to indicate a statistically significant difference.

Results

The success rate of this ultrasound-guided technique was 13/19 (68%) (Fig. 3). In positive outcomes, that is in injections that resulted in staining of the navicular bursa, the average number of re-orientations of the needle was 3 (range 1–5) and the mean time of the procedure was 8.5 min (range 6–10). In negative outcomes, that is when no staining of the navicular bursa was observed, the number of re-orientations was 5 (range 1–7), and the mean time was 9 min (range 5–10 min).

No abnormality of the distal sesamoid bone or of the navicular bursa was identified by dissection. None of the dissected limbs had methylene blue within the DDFT. Maximal hyperextension could not be achieved to the same extent as in living animals (Fig. 1) in any of the 19 cadaveric limbs.

Circumference of the feet measured at the coronary band varied between 235 and 430 mm. Success rate was not statistically influenced by the size of the feet. The number of reorientations of the needle and the time to perform the injection did not change over the course of the experimentation, indicating there was no learning curve during this study.

Discussion

The number of different techniques of injection of the navicular bursa described in the literature suggests that the technique can be difficult to perform or that it can produce inconsistent results (Schramme et al., 2000). When trajectories of injections are based on angles determined by reference to external landmarks such as coronary band or solar surface, they can be influenced by the foot conformation. The DPNP approach is more accurate because it uses a fixed reference target point corresponding to the distal sesamoid bone, rather than a given angle (Piccot-Crézollet et al., 2005). In a study in cadaver limbs without imaging guidance, inexperienced operators performed DPNP injection very successfully; the success rate was 92% versus 16, 32, 32 and 40%, respectively, for DPPCB, DPPS, PP30, and L45 (Schramme et al., 2000). Experienced clinicians performed DPNP successfully in 82% (Piccot-Crézollet et al., 2005) and 100% (Spriet et al., 2004) of living animals, respectively, under radiographic and ultrasonographic guidance. A recent study described a radiography-guided lateral approach with a 100% success rate in 71 limbs (Daniel et al., 2014). The

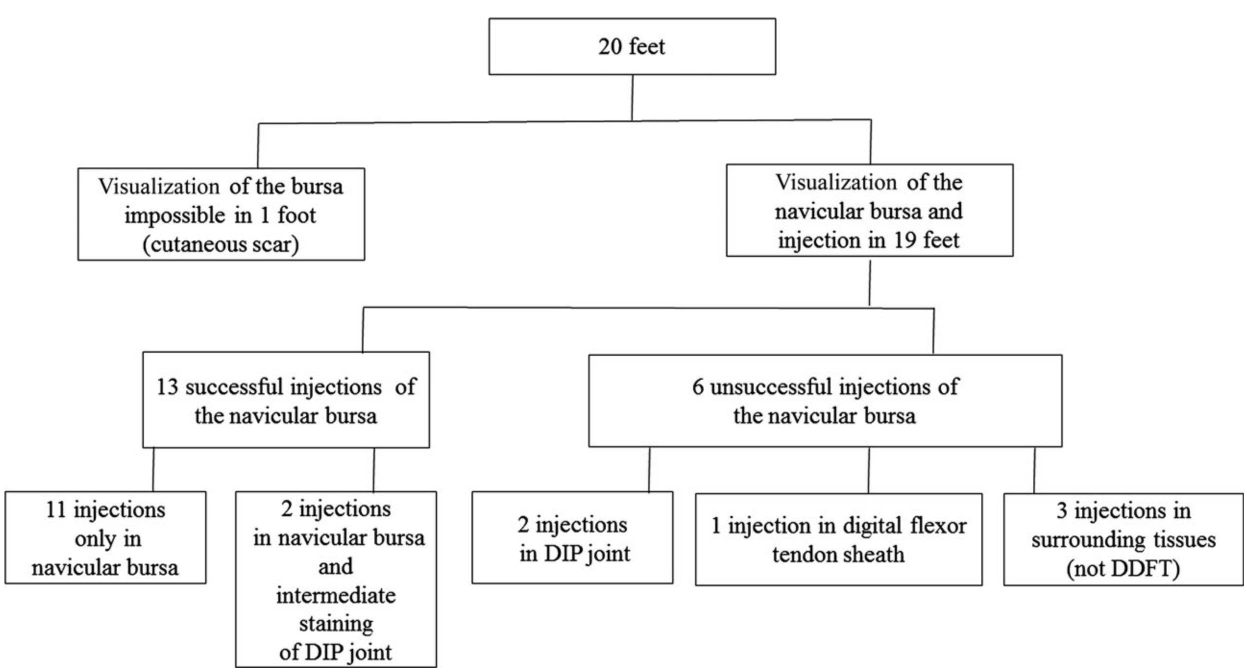

Fig. 3. Results of injections in this study. DIP, distal interphalangeal; DDFT, deep digital flexor tendon.

success rate of our technique was lower (68%) than all other techniques under imaging guidance.

Another indicator of the feasibility of the technique was the mean number of needle insertions before the needle was visualized in appropriate position. In the current study, the mean number of attempts was three in successful injections. This number is difficult to compare with those (1.3, 1.6, 1.5, 1.6 and 1) in a study assessing respectively DPPCB, DPPS, PP30, L45 and DPNP techniques performed without imaging guidance (Schramme et al., 2000): they correspond to the number of needle introductions to reach the position requested by technique description but not to the number of attempts to ensure satisfactory positioning in the navicular bursa. In other studies, mean number of attempts, performed under radiographic guidance, was 1.88 for DPPS and 1.65 for DPNP (Piccot-Crézollet et al., 2005). Similar results (number of injections ranging from 1 to 2) were observed when DPNP was performed under ultrasound guidance (Spriet et al., 2004). Conversely, the Pa30Pr30L-PaDiMO under radiographic guidance necessitated 2–11 radiographs and adjustments of the direction of the needle before it was considered appropriately placed (Daniel et al., 2014). In fact, in the DPNP technique, introduction of the needle relies upon accurate external landmarks and imaging is used to confirm position rather than to guide insertion. On the contrary, the current technique and the Pa30Pr30L-PaDiMO approach (Daniel et al., 2014) rely entirely on imaging to orientate the needle and adjustments are therefore more frequent.

A learning curve with consecutive improvement of performance was not identified in the current study. This lack of improvement for an operator experienced in ultrasonography of the foot might indicate that other technical issues influenced the results independently of his skills such as the adequate position of the foot, the quality of ultrasound images and the degree of distension of the navicular bursa.

Adequate position of the limb seems to be important for the current technique. Although we have not conducted studies to determine the optimal foot position for injection, experience in using this technique has shown that hyperextension of the digit results in improved accuracy of bursal injection, and achieving hyperextension is easier in live animals than in cadaveric limbs. Figure 1 demonstrates how much hyperextension is possible in clinical cases. Performance was not correlated to the size of the foot in the current study. The skin sometimes influences the quality of ultrasound images. The presence of scars made it impossible to produce useful images and to inject one limb.

The first author uses this injection technique for treatment of cases where a complete clinical examination (including radiography, ultrasonography and sometimes MRI) indicates that the bursa is distended and is possibly causing pain. However, distension is subjectively assessed. For experimentation, definition and standardization of synovial distension would have been important. However, synovial fluid volume is generally difficult to determine accurately. Forced aspiration of synovial fluid is not reliable in general (Rekonen et al., 1973), and in our experience, it is very difficult to obtain synovial fluid from the navicular bursa. A colorimetric dilution method has been used to assess the volume of synovial fluid in the radiocarpal joint of horses (Robion et al., 2001); however, this technique has not been validated for small synovial cavities such as the navicular bursa. In addition, the optimal volume to be injected into the navicular bursa in clinical cases is not known. Volumes from 3 to 5 ml have been administered (Wheat and Jones, 1981; Worthmann, 1982; Grant, 1996; Piccot-Crézollet et al., 2005; Daniel et al., 2014). Injection of large volumes (5 ml) has resulted in lameness (Daniel et al., 2014). We avoid such large volumes in our clinical cases. As it was difficult to quantify and standardize the distension in a clinically relevant way, we assumed, empirically, that by injecting 2 ml of contrast solution, we would distend the bursa sufficiently while leaving space for further administration of methylene blue solution.

Other parameters may have affected the results in the current study. Repeated introduction of the needle through the tissues, either during the initial distension of the bursa with contrast medium or during the injection with methylene blue solution, is likely to have created needle tracts. In three feet that were successfully injected, the DIP joint presented an intermediate coloration by methylene blue that could be due to those needle tracts. The effects of needle tracts on the performance of the technique are difficult to assess as they are difficult to identify at dissection. Recently, it was reported that MRI was also unable to identify needle tracts and these do not always remain patent after needle redirection (Daniel et al., 2014).

Some authors have suggested some advantages of ultrasonography over radiography (Spriet et al., 2004). The time to record and develop a radiograph was considered as a disadvantage in comparison with the 42 s to correctly position the needle under ultrasonographic guidance (Spriet et al., 2004). However, it is likely that this does not hold true anymore due to the advent of digital radiography. Furthermore, the time to perform the injection has not been compared between studies. Radiographic guidance necessitates leaving the needle in place during the examination. It remains to be seen whether leaving a needle in position for an extended period of time is more of a risk factor for bacterial contamination or trauma to the tissues, than inaccuracy of the technique, number of attempts and penetration of tendons or other soft tissues. In the current study, the mean time for the procedure was 8.5 min. More experienced clinicians (RP, LB) perform the injection in 3–4 min in clinical cases.

It is possible that increasing the distance between the injection site and the ground reduces the risk of bacterial contamination. That distance is increased in approaches with the distal limb supported in a Hickman block (Schramme et al., 2000; Piccot-Crézollet et al., 2005) or held in flexion (Spriet et al., 2004), and in lateral approaches (van Kruiningen, 1963; Turner, 1989; Grant, 1996; Daniel et al., 2014). Our lateral approach is different from that described by Daniel et al. (2014) where the needle entry is along the proximal and dorsoproximal margin of the collateral cartilage and the needle is angled at approximately 45° to the horizontal plane. In the current technique, the needle is positioned more proximally in the digit than in sagittal approaches (DPPCB, DPPS, PP30, DPNP) but more distally than in the other lateral approaches (L45, Pa30Pr30L-PaDiMO) (Fig. 1).

It has been demonstrated that the lateral approach allows avoidance of the DDFT (Daniel et al. (2014). This is also suggested in our study as methylene blue was never found penetrating the DDFT. As shown in Fig. 1, real-time visualization with ultrasonography helped confirm that the needle does not penetrate the tendon. However, there is so far no published evidence that needle penetration of the DDFT is problematic.

In conclusion, several injection techniques of the navicular bursa have been described and they should ideally be performed under guidance by imaging techniques. The currently described technique uses ultrasonography. It can be performed with reasonable success by a clinician not trained in the technique. Adequate hyperextension of the foot, quality of ultrasound images and distension of the bursa are factors that influence the success of visualization and injection of the navicular bursa. The technique has currently a lower success rate in cadaver limbs in comparison with other reported guided approaches either sagittal (DPNP) or lateral (Pa30Pr30L-PaDiMO). One advantage is the avoidance of the DDFT. Furthermore, limited access to digital radiography either at all, or in the case of a shared unit in ambulatory practice, may also make this ultrasound technique useful. Further studies in living animals are warranted.

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Conflict of Interests

None of the authors of this manuscript has a financial or personal relationship with people or organizations that could inappropriately influence or bias the content of the manuscript.

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