EQUINE VETERINARY JOURNAL
Equine vet. J. (2009) **41** (1) 00-00
doi: 10.2746/042516409X454565

Accuracy of ultrasound-guided injections of thoracolumbar articular process joints in horses: A cadaveric study

V. FUGLBJERG, J. V. NIELSEN†, P. D. THOMSEN and **L. C. BERG***

Department of Basic Animal and Veterinary Sciences, Faculty of Life Sciences, University of Copenhagen, Groennegaardsvej 7, 1870 Frederiksberg C; and †Ansager Veterinary Hospital, Gartnerhaven 5, 6823 Ansager, Denmark.

Keywords: horse; ultrasound-guided; facet joints; injections

Summary

Reasons for performing study: **Arthrosis of the articular process joints (APJs) in the caudal thoracolumbar region of horses may cause back pain and subsequent reduced performance or lameness. Ultrasound-guided injections of the APJs of the equine back have been described only briefly in the literature.**

Objectives: **To evaluate factors affecting the accuracy of intra-articular injections of the APJs in the caudal thoracolumbar region.**

Methods: **One-hundred-and-fifty-four injections with blue dye were performed on APJs including the T14–L6 region in 12 horses subjected to euthanasia for reasons unrelated to back problems. The backs were subsequently dissected to verify the location of the injectate in relation to the APJs.**

Results: **Twenty-seven percent of the injections were found to be intra-articular and a total of 77% found to be within 2 mm of the joint capsule including the intra-articular deposits. Application of a medial approach and 18 gauge needle were significantly associated with an intra-articular injection or deposition close to the joint capsule. Operator, APJ (location) and back number (chronological) did not significantly affect the accuracy of injection.**

Conclusions and potential relevance: **Injection of the vertebral APJ in the thoracolumbar region using ultrasound guidance is a reliable method, as most of the injections were either in or within 2 mm of the joint. Based on the findings of this cadaver study, the medial approach is expected to be the most accurate in live horses. Further investigations are required to evaluate the diagnostic and therapeutic potential of this method in clinical practice.**

Introduction

Back pain is a potential cause of poor performance or lameness in the performance horse (Jeffcott 1975; Denoix 1999a). Assessing the equine case with back problems is a challenge to clinicians (Jeffcott 1985; Gundel and Schatzmann 1997; Denoix and Dyson 2003) and, in addition, the clinical significance of degenerative lesions (arthrosis) of the articular process joints (APJs, also known as facet joints) the caudal thoracolumbar region is still under debate. Jeffcott (1985) stated that degenerative lesions are normal findings in horses with increasing age seemingly without any clinical effect, whereas Denoix (1998, 1999a) recognised degenerative lesions, especially from T16–L2, as being associated with back pain and subsequent reduced performance due to the higher intervertebral mobility in this area. This has been investigated further in a recent study by Girodroux *et al.* (2009), who found osteoarthritis of the APJs to be more prevalent in the region T15–L1 and the cause of back pain either alone or in association with other degenerative lesions of the axial skeleton. The importance of any abnormalities as the origin of pain can be determined with analgesic intra-articular injections and/or periarticular depositions (Denoix 1999b; Girodroux *et al.* 2009; P.H. Benoit, personal communication).

Intra- and periarticular injection techniques of the limbs are a well established and important diagnostic tool for the clinician (Gibson and Stashak 1989; Snyder and Spier 2001; Bassage and Ross 2003). Because the structures of the axial skeleton are covered by thick muscles, they are not as readily palpable as the bony structures in the limbs, making intra-articular injections difficult. Therefore, ultrasound-guided injection techniques are potentially very useful in this region in order to improve accuracy of deposition and thus avoid potential errors of deposition such as penetration of the vertebral canal (Denoix and Jacquet 2008). In human medicine, intra-articular injections of the spine for both diagnostic and therapeutic purposes are performed routinely (Kinard 1996; Murtagh 2000) using fluoroscopic-, CT- as well as ultrasound-guided techniques (Küllmer *et al.* 1997; Murtagh 2000; Galiano *et al.* 2007). In a recent study, Galiano *et al.* (2007) demonstrated ultrasound-guided injections to be of equal accuracy to CT-controlled injections, when there was a clear image of the APJ. Despite the routine nature of the procedure in man, there is still some disagreement about the clinical effect in the lumbar facets (Slipman *et al.* 2003; Sehgal *et al.* 2005).

In horses, a method of injecting the cervical APJs using ultrasound guidance has been described by Grisel *et al.* (1996) and Snyder and Spier (2001). The method was evaluated by Nielsen *et al.* (2003), who found that there was a high degree of accuracy when using this approach. Periarticular injection of the sacroiliac area using ultrasound guidance was also described by David *et al.* (2007) and Denoix and Jacquet (2008); however, the literature available on injection of the caudal thoracolumbar APJs is very limited (Denoix 1999b; P.H. Benoit, personal communication).

The objective of this study was to evaluate factors affecting the accuracy of intra-articular injection of the APJs in the caudal thoracolumbar region in the horse.

*Author to whom correspondence should be addressed.
[Paper received for publication 27.02.09; Accepted 15.04.09]

Materials and methods

Samples

The thoracolumbar region of 12 backs from horses subjected to euthanasia for reasons unrelated to back problems were used. The region, from approximately T14–L6, was included and the backs were separated from the cadavers leaving 15–20 cm of the ribs attached to the vertebrae on both sides and the skin intact. The backs were numbered in chronological order from 1–12. Backs 1–3 were refrigerated for 1–2 days before the injections were performed and Backs 4–12 were frozen and thawed in warm water immediately before the injections were performed.

Operators

Operator 1 (V.F.) was a veterinary student inexperienced in ultrasound and joint injection techniques. *Operator 2* (J.V.N.) was a veterinary surgeon with 6 years of experience from equine practice and extensive experience in ultrasonography, joint medication and ultrasound guided injection of cervical APJs.

Injection procedure

The injections were performed during 4 two-day sessions with injections on Day 1 and dissections on Day 2. There was a gap of 2 weeks between Backs 4 and 5, 3 weeks between Backs 6 and 7 and 2 weeks between Backs 9 and 10. The backs were placed in a horizontal plane to resemble the *in situ* position and preparation for ultrasound included shaving, washing and application of scanning gel to the backs. The APJs were located ultrasonographically using the Vivid 3, GE Medical System[1] and a 5 MHz curved linear array transducer. A fixed set-up of 34 frames/s. was used and the depth was set at 15 cm. The focus was set according to the depth of the APJ. A solution of 0.25% bromophenol blue dye[2] in 4% agarose[3] was used (Schydlowsky *et al*. 1998; Nielsen *et al*. 2003; Vandeweerd *et al*. 2007); 1 ml solution was deposited in the area of the APJs between vertebrae T14/15 and L5/6. A 16 cm 14 gauge (2 mm) needle was used for Backs 1–4 and 9–10, and a 15.2 cm 18 gauge (1.2 mm) spinal needle was used for Backs 5–8 and 11–12. The choice of 14 gauge needle was based on a previous study using a dye solution of high viscosity (Nielsen *et al*. 2003), and the 18 gauge needle was chosen to represent a potentially more realistic choice in a clinical setting while still enabling the injection of the highly viscous solution.

The injections were performed using 2 different approaches; a lateral approach (LA: applied to backs with uneven numbers) and a medial approach (MA: applied to backs with even numbers). In the LA, the transducer was placed in a transverse plane across the spinous processes. In cases where the spinous processes were protruding above the musculature the transducer was placed next to the spinous process axis (Fig 1). The needle was placed lateral to the transducer almost perpendicular to the skin. In the MA, the transducer was placed in a transverse-paramedian plane 2–3 cm lateral to the spinous process axis. The needle was placed perpendicular to the skin between the transducer and the spinous process (Fig 2).

When the joint space could be visualised ultrasonographically, the needle was directed towards it. If the joint space could not be visualised, the needle was directed towards the middle of the horizontal plateau described by the articular processes in a latero-medial orientation. Ultrasound images or film clips were recorded for all injections performed.

Both operators performed an equal number of injections with *operator 1* performing injections on one side, followed by *operator 2* injecting the other side alternating between the left and

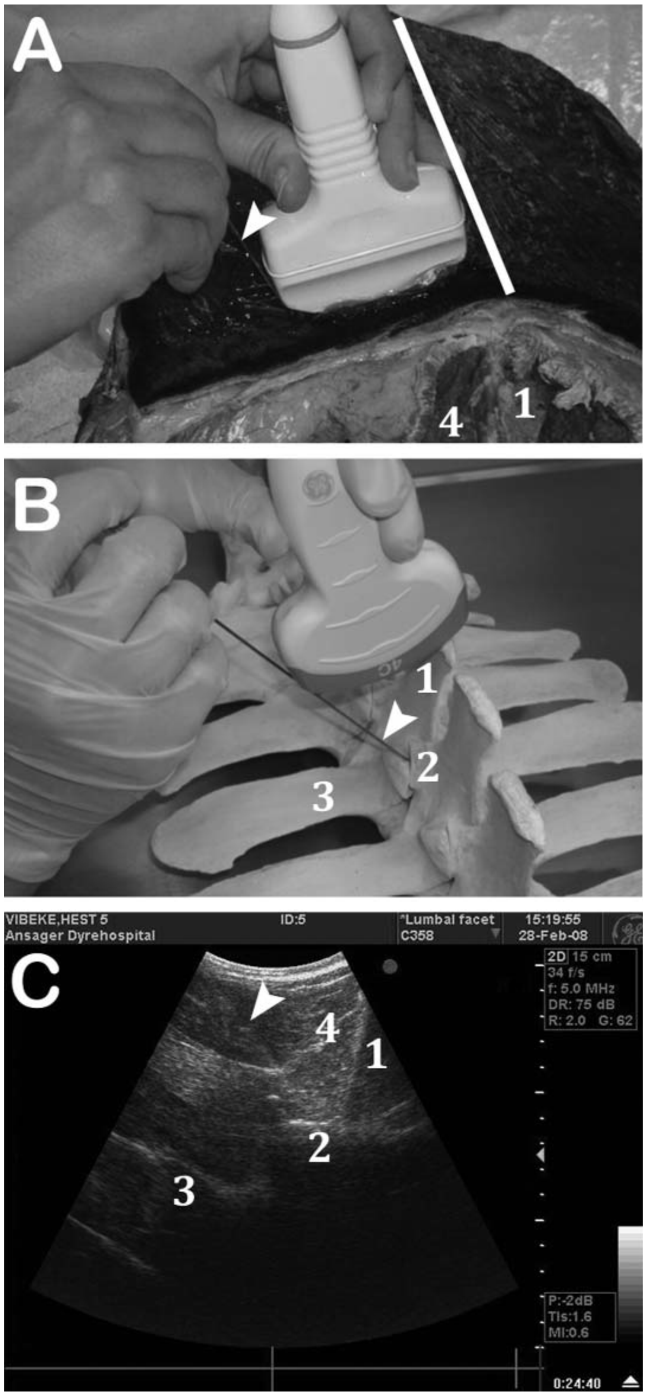

Fig 1: Injection technique using the lateral approach (LA). A) Craniocaudal view of the lateral injection procedure (white line indicates longitudinal axis of the spinous processes). B) Bone specimen of the axial skeleton showing the position of the transducer and needle used. Note that the probe in this picture was not the one used for the injections. C) Ultrasound image of an intra-articular injection; 1: proc. spinosus*; 2: articular process joint space; 3:* proc. transversus*; 4:* mm. multifidi*; white arrow indicates needle.*

right side and alternating between the 2 approaches for every 2 backs. The epaxial musculature was subsequently dissected to expose the articular facets and to identify the location of the injectate. The distance of the injectate from the APJ margin was measured (Fig 3).

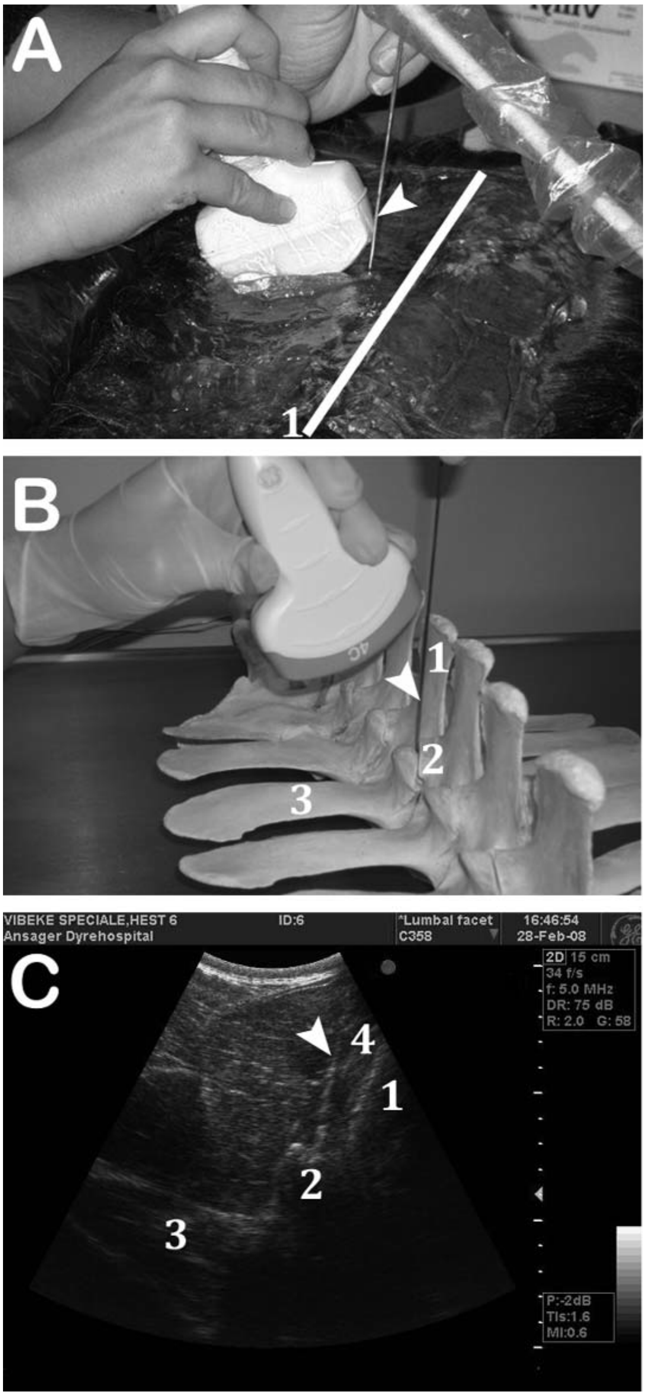

Fig 2: Injection technique using the medial approach (MA). A) Craniocaudal view of the medial injection procedure (white line indicates longitudinal axis of the spinous processes). B) Bone specimen of the axial skeleton showing the position of the transducer and needle used. C) Ultrasound image of an intra-articular injection; 1: proc. spinosus*; 2: articular process joint space; 3:* proc. transversus*; 4:* mm. multifidi*; white arrow indicates needle.*

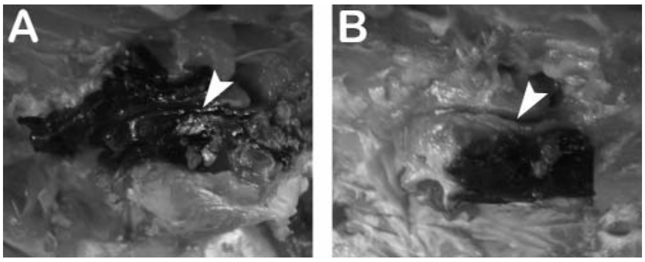

Fig 3: Location of blue dye deposits in or around a thoracolumbar APJ. A) Intra-articular deposition; B) periarticular deposition. White arrow indicates joint space.

Statistical methods

Descriptive statistics: The distance from the joint capsule to the injectate was measured and scored 1–5 with 1 = intra-articular (identification of blue dye within the joint), 2 = periarticular ≤2 mm, 3 = periarticular 2–5 mm, 4 = periarticular >5 mm and 5 = negative. The following independent variables were applied to each injectate: operator, facet, needle size (14 gauge/18 gauge), approach (LA/MA) and back number. The variable back number was used as an indicator of time. The score frequency, cumulated score frequency and 95% confidence intervals were calculated.

Analytical statistics: A 2-sided Chi-squared test was applied to examine the association between the independent variables and the likelihood of intra-articular deposition of the injectate. The location of the injectate was dichotomised and coded either as failure = 0 (extra-articular, score 2–5) or success = 1 (intra-articular). When evaluating a possible effect of gained experience, the backs were categorised as the first 6 vs. the last 6. $P<0.05$ was considered significant.

Secondly, a multivariable analysis of variance (ANOVA) was performed using a general linear model. A full model including the variables operator, facet, needle size (14 gauge/18 gauge), approach (LA/MA), ± cutis and back number was fitted using the MANOVA procedure in Minitab 15[4]. Variables were left in the model if associated significantly with the response variable ($P<0.05$). The change in P value was ascribed to multicollinearity (high correlation between 2 or more variables) if the interaction term was nonsignificant ($P>0.05$).

Results

A total of 154 joints were injected in 12 backs, including the APJs of vertebrae T14/15 to L5/6. The depth of the facets varied from 4–9 cm. Four vertebral levels had APJs that were injected 10 times or less (Table 1), but as these joints were not significantly different to the other joints ($P>0.05$), they were included in the analysis. The cutis of Back 3 was removed due to cutaneous emphysema, but the results of injections on this back did not differ significantly ($P>0.05$) from the other backs and thus Back 3 was included in the analysis.

Score frequencies were calculated, and 27% (CI: 20–34%) of injections were found to be intra-articular (*score 1*), 51% to be periarticular within 2 mm of the joint capsule (*score 2*), 17% periarticular 2–5 mm (*score 3*), 4% periarticular >5 mm (*score 4*) and 2% were undetectable upon dissection and recorded as negative (*score 5*). The cumulated score frequency of making a deposit within the joint or less than 2 mm from the joint capsule was 77%

TABLE 1: Effect of back number, articular process joint (APJ), operator, approach and needle size on accuracy of APJ injections

Variable	Level	Number of intra-articular injections (%)	Total number of injections	P value*
Back number	Back 1–6	19 (26%)	74	0.80
	Back 7–12	22 (28%)	80	
APJ	T14-15	1 (25%)	4	0.68
	T15-16	2 (25%)	8	
	T16-17	6 (33%)	18	
	T17-18	5 (25%)	20	
	T18-L1	9 (38%)	24	
	L1-2	7 (29%)	24	
	L2-3	6 (27%)	22	
	L3-4	4 (20%)	20	
	L4-5	1 (10%)	10	
	L5-6	0 (0%)	4	
Operator	1	20 (26%)	77	0.86
	2	21 (27%)	77	
Approach	Lateral	13 (17%)	76	0.008
	Medial	28 (36%)	78	
Needle size	14 gauge	11 (14%)	78	<0.001
	18 gauge	30 (39%)	76	

Results of univariate analysis of factors in relation to intra-articular vs. extra-articular injections. *The association between an independent variable and the location of the injectate was considered significant if P<0.05.

(CI: 70–84%) (Table 2). The score frequency of injections according to the number of back injected is shown in Figure 4.

In the univariable analysis (2-sided Chi-squared test) a significant association was found between an intra-articular deposition and approach and needle size (P<0.05) (Table 1). No effect of gained experience (increase in intra-articular deposits with higher back number) was seen. Neither operator identity nor the APJ location were associated significantly with an intra-articular deposition.

In the multi-variable analysis, a transformation of the outcome (ln[distance + 0.5]) was applied to the model as it was a better fit. The results from the univariable analysis were confirmed as there was no significant association between the location of the deposit and operator identity (P = 0.94), location of the APJ (P = 0.83) or back number (P = 0.57). Approach and needle size both showed significant association with the location of the deposit (P<0.05). The medial approach and 18 gauge needle were superior to the lateral approach and 14 gauge needle, and the differences in score frequency in relation to back number depicted in Figure 4 could therefore be ascribed to approach and size of needle used. The interaction between the last 2 variables (approach and needle size) was nonsignificant (P = 0.19), and all other interactions were nonsignificant (P>0.05). The changes seen can be ascribed therefore to multicollinearity (high correlation between 2 or more variables.

TABLE 2: Injection scores according to location of injectate

Score	Number of injections	Prevalence (%) (95% confidence interval)	Cumulative prevalence (%) (95% confidence interval)
Intra-articular	41	27 (20–34)	27 (20–34)
≤2 mm	78	51 (42–59)	77 (70–84)
2–5 mm	26	17 (11–24)	94 (89–97)
>5 mm	6	4 (1–8)	98 (94–100)
Non-detected	3	2 (0–6)	100 (98–100)
Total	154	100	

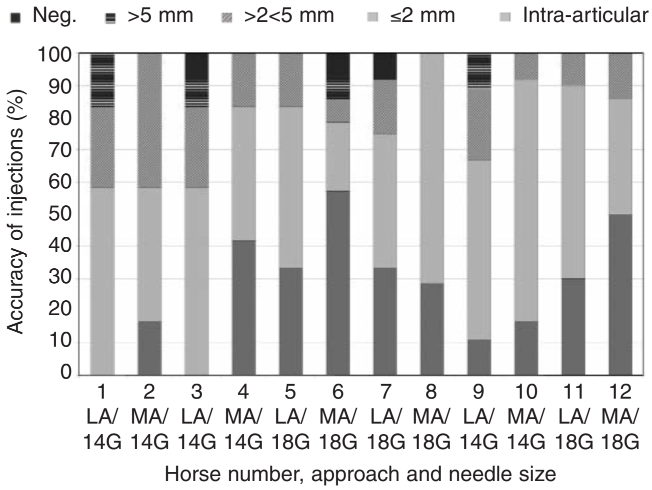

Fig 4: Score frequencies of injections in Backs 1–12 (chronological order). LA: Lateral approach; MA: Medial approach; 14G: 14 gauge needle; 18G: 18 gauge needle.

Discussion

The aim of this study was to evaluate factors affecting the accuracy of intra-articular injections of APJs in the caudal thoracolumbar region. Only 27% of the injections were found to be intra-articular, however a total of 77% (CI: 70–84%) of the injections were found to be within 2 mm of the joint capsule including the intra-articular deposits. These results suggest that it is difficult to inject directly into the APJ, but the application of an ultrasound modality makes a deposition close to the joint possible. Benoit (personal communication) has stated that true intra-articular injections of the lumbar facets are difficult, which has been confirmed in this study. However, diffusion of both analgesics and corticosteroids has been demonstrated between adjacent synovial structures within the hoof, carpus, tarsus and stifle (Gough *et al*. 2002a,b; Serena *et al*. 2005), and periarticular injection of the sacroiliac joint (SIJ) with a mixture of corticosteroids and local anaesthetic has been shown to diffuse into the SIJ with an observable clinical effect (Engeli and Haussler 2004). The specificity of the injection for diagnostic purposes is obviously decreased when the deposit is not placed intra-articularly (Denoix and Dyson 2003; Engeli *et al*. 2004), but the literature suggests that a periarticular injection of the facets may be valuable for therapeutic purposes even if it is of less value as a diagnostic tool.

In this study only 2 factors had a significant effect on the accuracy of the deposition of the injectate: approach and needle size. The medial approach yielded the highest proportion of successful intra-articular injections compared to the lateral approach. This may be explained by the MA ensuring better alignment of the needle with the more vertical orientation of the joint space in the region caudal to T16 or T17. This explanation is, however, to some extent discounted by the finding that location of APJ did not significantly affect the accuracy. A possible explanation may be that the position of the mamillary process craniolateral on the cranial articular process could favour the MA in the region cranial to T16 or T17 as well, where this process is more prominent and makes intra-articular needle positioning with the LA difficult. In order to evaluate the difference of needle positioning cranial and caudal to T16 or T17 statistically, a larger number of joints cranial to T16 or T17 would have had to be injected; but some horses may exhibit bony changes to the APJs, which is likely to make the intra-articular injections more difficult.

As seen in this study, the 18 gauge needle improves intra-articular needle positioning compared to the 14 gauge needle. This may be because the joint spaces of the caudal thoracolumbar APJs are very narrow. When choosing needle size it has to be considered that a needle with a small diameter i.e. 21 gauge described by Benoit (personal communication) may benefit from the stabilising effect of a stilet as it could bend when penetrating the thick muscles and fascia covering the APJs.

The 2 operators in the present study had different levels of experience in intra-articular injections. This difference had no effect on the accuracy of deposition in the thoraco-lumbar APJs and it also seems to have no effect on the learning curve. Both these findings are somewhat surprising as a previous study on intra-articular injections of the cervical APJs showed that gained experience significantly influenced the accuracy of injections (Nielsen *et al*. 2003). It is possible that the low success rate in this study compared to the earlier study (27% and 72% respectively) is due to the narrow joint space of the facets in this region of the back compared to the cervical region, and this could have made it difficult to detect any improvements due to experience.

In conclusion, injection of the equine APJ in the thoracolumbar region using ultrasound guidance is a reliable method as most of the injections were either in or within 2 mm of the joint. Based on the findings of this cadaver study, the medial approach is expected to be the most accurate in live horses. Further investigations are required to evaluate the diagnostic and therapeutic potential of this method in clinical practice.

Acknowledgements

The authors would like to thank the technical staff at Ansager Veterinary Hospital for invaluable assistance throughout the study, and Anders Tolver Jensen for advice on the statistical analysis.

Manufacturers' addresses

[1]GE Healthcare Diagnostic Imaging, Brøndby, Denmark.
[2]Bio-Rad Laboratories, Copenhagen, Denmark.
[3]Invitrogen A/S, Taastrup, Denmark.
[4]Minitab, State College, Pennsylvania, USA.

References

Bassage, L.H. and Ross, M.W. (2003) Diagnostic analgesia. In: *Diagnosis and Management of Lameness in the Horse*, Eds: M.W. Ross and S.J. Dyson, Saunders, Philadelphia. pp 93-124.

David, F., Cousty, M. and Rossier, Y. (2007) How to do ultrasound-guided injection of the sacroiliac region in horses. *Proc. Am. Ass. equine Practnrs.* **55**, 430-432.

Denoix, J.M. (1998) Diagnosis of the cause of back pain in horses. In: *Proceedings of the Conference on Equine Sports Medicine and Science,* Cordoba. pp 97-110.

Denoix, J.M. (1999a) Spinal biomechanics and functional anatomy. *Vet. Clin. N. Am.: Equine Pract.* **15**, 27-60.

Denoix, J.M. (1999b) Ultrasonographic evaluation of back lesions. *Vet. Clin. N. Am.: Equine Pract.* **15**, 131-159.

Denoix, J.M. and Dyson, S.J. (2003) Thoracolumbar spine. In: *Diagnosis and Management of Lameness in the Horse*, Eds: M.W. Ross and S.J. Dyson, W.B. Saunders, Philadelphia. pp 509-521.

Denoix, J.M. and Jacquet, S. (2008) Ultrasound-guided injection of the sacroiliac area in horses. *Equine vet. Educ.* **20,** 203-207.

Engeli, E. and Haussler, K.K. (2004) Review of sacroiliac injection techniques. *Proc. Am. Ass. equine Practnrs.* **50**, 372-378.

Engeli, E., Haussler, K.K. and Erb, H.N. (2004) Development and validation of a periarticular injection technique of the sacroiliac joint in horses. *Equine vet. J.* **36**, 324-330.

Galiano, K., Obwegeser, A.A., Walch, C., Schatzer, R., Ploner, F. and Gruber, H. (2007) Ultrasound-guided versus computed tomography-controlled facet joint injections in the lumbar spine: A prospective randomized clinical trial. *Reg. Anesth. Pain Med.* **32**, 317-322.

Gibson, K.T. and Stashak, T.S. (1989) Employing intra-articular anesthesia to detect joint lesions in lame horses. *Vet. Med.* **84**, 1088-1092.

Girodroux, M., Dyson, S. and Murray, R. (2009) Osteoarthritis of the thoracolumbar synovial intervertebral articulations: Clinical and radiographic features in 77 horses with poor performance and back pain. *Equine vet. J.* **41**, 130-138.

Gough, M.R., Mayhew, G. and Munroe, G.A. (2002a) Diffusion of mepivacaine between adjacent synovial structures in the horse. Part 1: Forelimb foot and carpus. *Equine vet. J.* **34**, 80-84.

Gough, M.R., Munroe, G.A. and Mayhew, G. (2002b) Diffusion of mepivacaine between adjacent synovial structures in the horse. Part 2: Tarsus and stifle. *Equine vet. J.* **34**, 85-90.

Grisel, G.R., Grant, B.D. and Rantanen, N.W. (1996) Arthrocentesis of the equine cervical facets. *Proc. Am. Ass. equine Practnrs.* **42**, 197-198.

Gundel, M. and Schatzmann, U. (1997) Ruckenprobleme beim Pferd: 3.Vorschlag eines klinischen Unterschungspuotokolls zur Abklarung einer Ruckenproblematik beim Reitpferd. *Pferdeheilkunde* **13**, 213-221.

Jeffcott, L.B. (1975) Symposium on back problems in the horse. (2) The diagnosis of diseases of the horse's back. *Equine vet. J.* **7**, 69-78.

Jeffcott, L.B. (1985) The examination of a horse with a potential back problem. *Proc. Am. Ass. equine Practnrs.* **31**, 271-284.

Kinard, R.E. (1996) Diagnostic spinal injection procedures. *Neurosurg. Clin. N. Am.* **7**, 151-165.

Küllmer, K., Rompe, J.D., Lowe, A., Herbsthofer, B. and Eysel, P. (1997) Die Sonographie der Lendenwirbelsaule und des lumbosakralen Uberganges. Sonoanatomie und Moglichkeiten der sonographisch gesteuerten Facettengelenksinfiltration. *Z. Orthop. Ihre Grenzgeb.* **135**, 310-314.

Murtagh, R. (2000) The art and science of nerve root and facet blocks. *Neuroimaging Clin. N. Am.* **10**, 465-477.

Nielsen, J.V., Berg, L.C., Thoefnert, M.B. and Thomsen, P.D. (2003) Accuracy of ultrasound-guided intra-articular injection of cervical facet joints in horses: A cadaveric study. *Equine vet. J.* **35**, 657-661.

Schydlowsky, P., Strandberg, C., Tranum-Jensen, J., Bojsen-Moller, F., Jorgensen, U. and Galbo, H. (1998) *Post-mortem* ultrasonographic assessment of the anterior glenoid labrum. *Eur. J. Ultrasound* **8**, 129-133.

Sehgal, N., Shah, R.V., Kenzie-Brown, A.M. and Everett, C.R. (2005) Diagnostic utility of facet (zygapophysial) joint injections in chronic spinal pain: A systematic review of evidence. *Pain Physician* **8**, 211-224.

Serena, A., Schumacher, J., Schramme, M.C., Degraves, F., Bell, E. and Ravis, W. (2005) Concentration of methylprednisolone in the centrodistal joint after administration of methylprednisolone acetate in the tarsometatarsal joint. *Equine vet. J.* **37**, 172-174.

Slipman, C.W., Bhat, A.L., Gilchrist, R.V., Issac, Z., Chou, L. and Lenrow, D.A. (2003) A critical review of the evidence for the use of zygapophysial injections and radiofrequency denervation in the treatment of low back pain. *Spine J.* **3**, 310-316.

Snyder, J.R. and Spier, S. (2001) Selected intra-articular injections in the horse. In: *Proceedings of the 7th Geneva Congress of Equine Medicine and Surgery*. Geneva. pp 115-123.

Vandeweerd, J.M., Desbrosse, F., Clegg, P., Hougardy, V., Brock, L., Welch, A. and Cripps, P. (2007) Innervation and nerve injections of the lumbar spine of the horse: a cadaveric study. *Equine vet. J.* **39**, 59-63.

Author contributions All authors contributed to the initiation, conception, planning and writing of this paper. The pathology and execution were by J.V.N. and V.F., and the statistics by V.F.