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Management of hindlimb proximal suspensory desmopathy by neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy: 155 horses (2003–2008)

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Summary

Reasons for performing study: Neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy have become accepted as methods of treatment of proximal suspensory desmopathy (PSD), but there are limited long-term studies documenting the outcome.
Objectives: To describe long-term follow-up in horses with PSD alone or with other injuries contributing to lameness and poor performance, including complications, following neurectomy and fasciotomy.
Methods: Follow-up information was acquired for 155 horses that had undergone neurectomy and fasciotomy for treatment of PSD between 2003 and 2008. Success was classified as a horse having been in full work for >1 year post operatively. Horses were divided into 3 groups on the basis of the results of clinical assessment and diagnostic analgesia. Horses in *Group 1* had primary PSD and no other musculoskeletal problem. Horses in *Group 2* had primary PSD in association with straight hock conformation and/or hyperextension of the metatarsophalangeal joint. Horses in *Group 3* had PSD and other problems contributing to lameness or poor performance.
Results: In *Group 1*, 70 of 90 horses (77.8%) had a successful outcome, whereas in *Group 3*, 23 of 52 horses (44.2%) returned to full function for >1 year. Complications included iatrogenic damage to the plantar aspect of the suspensory ligament, seroma formation, residual curb-like swellings and the development of white hairs. All horses in *Group 2* remained lame.
Conclusions and clinical relevance: There is a role for neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy for long-term management of hindlimb PSD, but a prerequisite for successful management requires recognition of risk factors for poor outcome including conformation features of straight hock or fetlock hyperextension.

Keywords: horse; lameness; suspensory ligament; interosseous muscle; enthesopathy

Introduction

Proximal suspensory desmitis (affecting the proximal third of the suspensory ligament [SL]) is a common condition in horses from all types of disciplines, with dressage horses being particularly at risk (Murray *et al*. 2006). Successful management is dependent on accurate diagnosis (Dyson 1994, 1995a, 2007; Dyson and Genovese 2010). Clinical manifestations vary widely from an overt unilateral hindlimb lameness to a subtle performance problem, such as inability to perform canter pirouette in one or both directions, generalised stiffness, altered head carriage or behavioural changes such as bolting or resisting. Proximal suspensory desmopathy (PSD) might be a more appropriate term in some horses in view of the degenerative histological characteristics of injured ligaments (Dyson 1995b) and absence of signs of inflammation in the majority (Dyson 1994, 2007). There is growing evidence that, at least in some horses, this is a progressive degenerative condition on which work trauma may be superimposed (Mero and Pool 2002; Halper *et al*. 2006; Schenkman *et al*. 2009). Pain causing lameness may originate from the SL itself or be associated with compression of the adjacent nerves (Dyson 1995b; Toth *et al*. 2008). The SL is effectively within a compartment bounded by the plantar aspect of the third metatarsal bone (MtIII), the second and fourth metatarsal bones (MtII and MtIV) and the deep fascia running between the plantar aspects of the MtII and MtIV (Ross 2010).

Diagnosis of PSD is based on exclusion of pain arising from both the distal aspect of the limb and the tarsometatarsal joint, confirmation of pain in the proximal plantar metatarsal region and identification of ultrasonographic abnormalities including alterations in shape, size, echogenicity and fibre pattern. Local analgesic techniques potentially lack specificity (Dyson and Romero 1993; Hughes *et al*. 2007; Dyson and Genovese 2010; Ross 2010), therefore radiographic examination of the hock and proximal metatarsal region is recommended. Magnetic resonance imaging (MRI) may be required for definitive diagnosis in some horses (Dyson and Genovese 2010; Labens *et al*. 2010; Dyson 2011a).

The response to conservative management of PSD is poor. Only 6/42 horses (14%) seen in a referral practice were able to resume full work without detectable lameness for at least one year, all of which had been lame for less than 5 weeks (Dyson 1994). Two additional horses resumed full work but suffered lameness in another limb. Seven horses improved markedly and were able to work, despite persistent mild lameness.

Radial pressure wave therapy of 43 horses with hindlimb PSD and lameness of ≥3 months' duration resulted in 41% being in full work 6 months after treatment (Crowe *et al*. 2004). Similar results were achieved using focused shockwave therapy (Boening *et al*. 2000; Lischer *et al*. 2006).

Local infiltration with porcine urinary bladder matrix (A-Cell)[1] resulted in 84% of 77 of horses with either fore- or hindlimb PSD returning to full work. However, horses with hindlimb injuries were also treated by fasciotomy (Mitchell 2006). Desmoplasty and focal fasciotomy achieved similar results with 87% of 23 horses with hindlimb PSD resuming work (Hewes and White 2006). However, in both of these studies, the duration of follow-up was poorly defined. Tibial neurectomy performed in 8 horses enabled 6 (75%) to return to full athletic function (showjumping and eventing) for at least 2 years after surgery, with no post operative complications (Dyson and Genovese 2003).

Neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy was first described by Bathe (2006a,b) and has subsequently been reported by Bathe (2008), Kelly (2007) and Toth *et al*. (2008), with success ranging from 62 to 91%. However, there are limited long-term studies documenting the outcome of horses with PSD treated by neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy. The purpose of this report is to describe long-term outcome and complications in horses with PSD alone or with other injuries contributing to lameness and poor performance, treated by neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy.

Materials and methods

Case selection

All horses were examined by one experienced clinician (S.J.D.) at the Animal Health Trust (AHT) between January 2003 and December 2008 and underwent surgical management of PSD by neurectomy of the deep branch

TABLE 1: Summary of diagnoses for horses in *Group 3* (n = 58) with proximal suspensory desmopathy and concurrent problems; some horses had more than one additional problem

Sacroiliac joint region pain	n = 17
Distal hock joint osteoarthritis	n = 10
Forelimb proximal suspensory desmitis	n = 18
Forelimb foot pain	n = 9
Other lameness	n = 7
Impinging/overriding spinous processes	n = 15
Osteoarthritis of caudal thoracic synovial intervertebral articulations	n = 5

of the lateral plantar nerve and plantar fasciotomy. Horses were divided into 3 groups on the basis of the results of clinical assessment and diagnostic analgesia. Horses in *Group 1* had primary PSD and no other musculoskeletal problem. Horses in *Group 2* also had primary PSD in association with excessively straight hock conformation (a dorsal hock angle of ≥150°) and/or hyperextension of the hind fetlocks (dorsal fetlock angle ≤130°). Angles were measured from digital photographs acquired with the horse standing squarely behind on a horizontal surface, with the metatarsal regions vertical. Horses in *Group 3* had PSD and other problems contributing to lameness or poor performance (Table 1).

A diagnosis of PSD was dependent on both the response to diagnostic analgesia and identification of PSD using ultrasonography (Dyson and Genovese 2010) or MRI (Dyson 2011a). Horses that had been in full work for <1 year at the time of follow-up were excluded.

All horses underwent a comprehensive clinical examination including assessment moving in hand on a hard surface and lunged on soft and firm surfaces; the majority of horses were also examined ridden. Lameness was graded on a scale of 0–8 (0 = sound, 2 = mild, 4 = moderate, 6 = severe, 8 = nonweightbearing) (Dyson 2011b). Proximal and distal limb flexion tests were performed. Horses included in *Group 1* showed a negative response to both perineural analgesia of the plantar nerves (at the junction of the proximal three-quarters and distal one-quarter of the metatarsal region or proximal to a distended digital flexor tendon sheath [DFTS]) and plantar metatarsal nerves (a 'low 4 point' block) and to intra-articular analgesia of the tarsometatarsal (TMT) joint (3 ml mepivacaine; response assessed 10 min after injection). Perineural analgesia of the deep branch of the lateral plantar nerve (3 ml mepivacaine; response assessed 10 min after injection) resulted in ≥80% improvement in the baseline lameness. In horses with symmetrically restricted hindlimb impulsion bilateral perineural analgesia of the deep branch of the lateral plantar nerve was often performed at the same time (Dyson 2007; Dyson and Genovese 2010). Improvement was seen as increased hindlimb impulsion and engagement, longer stride length, increased swing through the back, better balance, improved quality and consistency of contact with the bit and increased willingness. All horses were reassessed after nerve blocks under the circumstances in which the gait abnormality appeared worst, often ridden. Horses in *Group 3* underwent multiple local analgesic techniques (Bassage and Ross 2010) until all lameness was abolished and the horse performed satisfactorily under saddle. A significant improvement (>50%) was observed after perineural analgesia of the deep branch of the lateral plantar nerve.

The plantar metatarsal regions of both hindlimbs were evaluated ultrasonographically using an 8–10 MHz variable frequency linear ± virtual convex transducer usually without a stand-off, from plantaromedial and plantar aspects. If lesions were identified bilaterally, surgery was performed bilaterally even if lameness was unilateral. Horses in which the results of ultrasonography were negative or equivocal underwent MRI of the distal hock and proximal metatarsal regions (Brokken and Tucker 2011; Werpy 2011) under standing sedation using a 0.27 T magnet (Hallmarq)[2]. All horses underwent radiological assessment of the hock and proximal metatarsal region of the lame limb(s) using dorsoplantar (DPl), lateromedial, dorsolateral-plantaromedial oblique and dorsomedial-plantarolateral oblique images (Butler *et al*. 2008). One-hundred-and-thirty-five horses in *Groups 1* and *3* underwent nuclear scintigraphic assessment of the hocks (plantar and lateral images) or the thoracolumbar and pelvic regions and hindlimbs (Dyson *et al*. 2003). All horses in *Group 2* underwent scintigraphic assessment of the hocks. All scintigraphic images were reviewed retrospectively by S.J.D. and increased radiopharmaceutical uptake (IRU) was subjectively graded as mild, moderate or intense.

It was recommended that horses in *Group 2* should not undergo neurectomy and fasciotomy because of previous experience of deterioration in lameness post operatively in horses with such conformational features (Dyson 2010). However, contrary to recommendations, these 5 horses did undergo surgery elsewhere but were subsequently re-evaluated at the AHT. The results for these horses are recorded separately.

Surgical technique

Surgery at the AHT was performed by one of 2 surgeons (R.P. and A.B.) with horses in dorsal recumbency under general anaesthesia. A 4–6 cm vertical incision on the plantar aspect of the limb, extending distally from the TMT joint, was made with a No. 20 blade. The superficial fascia was dissected using straight Metzenbaum scissors. The skin and flexor tendons were retracted medially and proximally using Langenbeck retractors. The fascia and connective tissue were dissected using straight Metzenbaum scissors, to reveal the deep branch of the lateral plantar nerve. The nerve, which sometimes (5%) had a bifurcation, was isolated and elevated using a hook, a modified small ligature needle (150 mm Aesculap)[3]. The area was infused with 10 ml mepivacaine and the nerve(s) was (were) transected distally and 4 cm further proximally using a No. 20 scalpel blade. The deep metatarsal fascia on the plantar aspect of the SL, clearly identifiable proximally by its transverse fibres, was incised blindly proximally to distally using Metzenbaum scissors (R.P.) or a fasciotome[4] (A.B.). Tension in the fascia was assessed using the hook before and after its transection and if tension persisted the incision was continued distally. The superficial fascia was closed in a simple continuous suture pattern with polyglactin 910 (3 m Vicryl)[5]. The skin was apposed using a simple continuous subcuticular suture pattern with 2 m Vicryl, with (R.P.) or without (A.B.) skin staples.

Perioperative management and follow-up

Phenylbutazone (4.4 mg/kg bwt b.i.d. reducing to 2.2 mg/kg bwt b.i.d.) was administered for 3–5 days perioperatively, together with trimethoprim and sulphadiazine (30 mg/kg bwt b.i.d. *per os*) for 3 days. Horses were trimmed and reshod at the AHT to correct any mediolateral or dorsoplantar foot imbalance. Wide web shoes with generous length at the heel were applied. Horses were restricted to box rest for 2 weeks post operatively, until staple removal. Thereafter horses walked for 45 min daily for 6 weeks in hand, on a horse walker (unless there was concurrent forelimb foot pain) or ridden.

Horses in *Groups 1* and *3* were reassessed clinically and ultrasonographically at the AHT 2 months post operatively. If lameness had resolved and there was satisfactory improvement in the ultrasonographic appearance of the SL, horses progressively resumed normal ridden work. Advice was given concerning physiotherapy to improve core muscle strength (in conjunction with a chartered animal physiotherapist), work programmes and work surfaces. If large hypoechogenic areas in the SL persisted, suggesting that the SL may not have sufficient strength to withstand increased loading, or the horse showed residual lameness the convalescence period was prolonged and horses underwent serial re-examinations at 2 monthly intervals. Horses in *Group 3* underwent appropriate management of concurrent problems, which often resulted in a longer convalescent time than horses in *Group 1*. Horses in *Group 2* followed a similar rehabilitation programme under the guidance of the attending surgeon and were not reassessed at the AHT until 4–6 months post operatively.

Follow-up information was obtained by re-examinations by S.J.D., discussions with the referring veterinary surgeon and a telephone questionnaire to all owners and/or riders.

Data analysis

Descriptive statistics were undertaken on data from the 3 groups. Effect of group on lameness outcome was investigated using a Chi-square test. Effect of scintigraphy grade and presence or absence of IRU on lameness outcome were investigated using a Chi-square test. However, a power analysis indicated that numbers were insufficient to detect minor effects of scintigraphic information.

Results

The study included 155 horses: 92 horses in *Group 1*, 5 in *Group 2* and 58 in *Group 3*. Mean age was 8.4 years (range 4–16 years, median 8 years). Breeds comprised Warmblood (n = 81), Thoroughbred (TB) (n = 22), TB cross (n = 34), Pony (n = 2), Other (n = 16). There were 118 geldings, 10 stallions and 27 mares. Work discipline included dressage (n = 45), showjumping (n = 35), eventing (n = 28), racing (n = 3) and general purposes, including unaffiliated competition (n = 44). The reasons for clinical assessment included overt lameness (n = 75), lack of hindlimb power (n = 35), difficulties in performing specific movements, e.g. canter pirouette often to one particular side (n = 10), evasions or resistances (n = 25), bolting (n = 2) and unwillingness to perform (n = 8). Sixty-eight horses had unilateral lameness and 87 horses were lame bilaterally. The maximum lameness grade in each horse ranged from 1 to 6 (on a scale of 0–8). The mean duration of lameness or poor performance was 4.9 months (range 1–12 months).

Fifty-one lame limbs (21.1%) had a spur on the dorsoproximal aspect of the third metatarsal bone (MtIII). Seventy-three lame limbs (30.2%) had mild diffuse increased radiopacity proximolaterally in the DPl image of the MtIII and 4 horses had more focal areas of more intense increased opacity (Fig 1). Radiological abnormalities consistent with low-grade osteoarthritis of the TMT and centrodistal joints were seen in 15 lame limbs (6.2%) (5 in *Group 1* [5.4%] and 10 in *Group 3* [17.2%]). There was IRU in the proximoplantar aspect of the MtIII, unilaterally or bilaterally, in 24 horses in *Groups 1* and *3*. Sixteen of 270 limbs (5.9%) in *Groups 1* and *3* had mild IRU in the proximoplantar aspect of the MtIII and 10/270 limbs (3.7%) had moderate or intense IRU (Fig 2). Six of 10 limbs (60%) in *Group 2* had mild or moderate IRU. There was no significant difference in outcome for horses in *Group 1* with or without IRU. Ultrasonographic abnormalities (alteration in size, shape, echogenicity and fibre pattern) of the SL were identified in 152 horses (Fig 3a); MRI was required for definitive diagnosis of PSD in 3 horses (Fig 4).

Surgery was performed by RP (n = 113) or AB (n = 37) (left hind n = 48, right hind n = 10, bilateral n = 92). If there was an unusual amount of haemorrhage at the time of surgery, this usually resulted in seroma formation (n = 8, 5.3%) and resultant prolonged antimicrobial treatment. Several horses (n = 4, 2.7%) with skin apposition by subcuticular sutures alone required skin closure at the dressing change on the first post operative day because the skin edges were not apposed. At the 2-month follow-up examination there was a small residual curb-like swelling (n = 83, 55.3%) ± white hairs (n = 48, 32%). In most horses (n = 142, 94.7%) ultrasonographic examination revealed that the SL was smaller and of more uniform echogenicity compared with preoperatively but was not considered normal. In 7 horses (3.1%), there was focal decreased echogenicity in the plantar aspect of the SL that had not been present preoperatively and was believed to reflect iatrogenic damage (Fig 3b). Sixty-four of 92 horses (69.6%) in *Group 1* returned to work after 2 months;

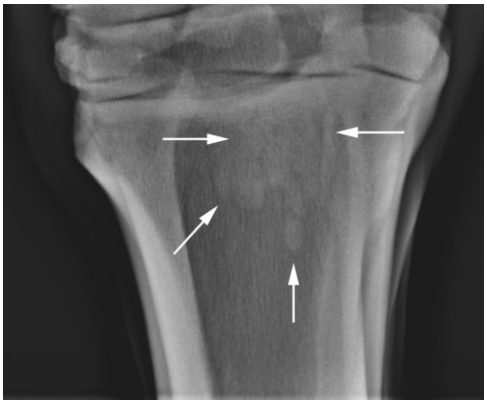

Fig 1: Dorsoplantar radiographic image of the proximal metatarsal region. Medial is to the left. There are multiple focal areas of increased radiopacity in the proximal aspect of the third metatarsal bone, mostly laterally (arrows). This is likely to reflect entheseous new bone.

a)

b)

c)

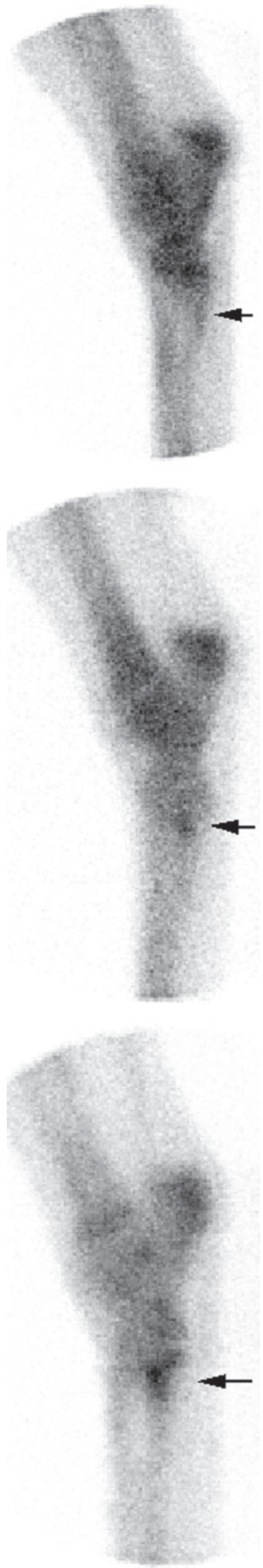

Fig 2: Lateral scintigraphic images of 3 limbs showing a) mild linear increased radiopharmaceutical uptake (IRU) (arrow), b) moderate focal IRU (arrow) and c) intense focal IRU (arrow) in the proximoplantar aspect of the third metatarsal bone.

a)

b)

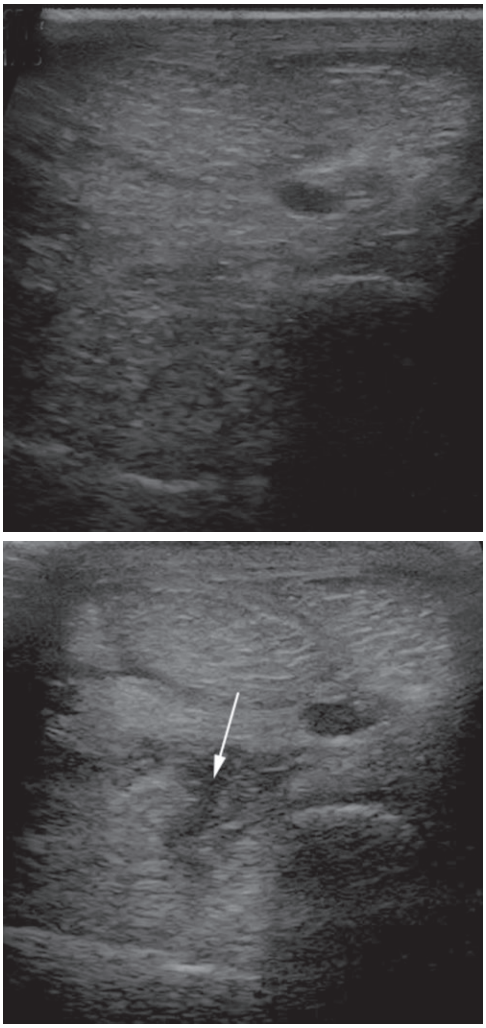

Fig 3: Transverse ultrasonographic images obtained 4 cm distal to the tarsometatarsal joint of the left hindlimb of a 7-year-old Warmblood a) preoperatively and b) 2 months post operatively. Medial is to the left. Before treatment, the suspensory ligament (SL) had a diffuse decrease in echogenicity and was enlarged. Note that there is no space between the SL and its accessory ligament and the accessory ligament of the deep digital flexor tendon. Two months after surgery the dorsal and medial parts of the SL have increased in echogenicity and are now more similar to that of the deep digital flexor tendon. However, there is an almost anechogenic area in the accessory ligament of the SL and the plantar aspect of the SL (arrow) which is likely to be the result of iatrogenic damage during fasciotomy.

the remainder had up to 6 months of controlled exercise. The duration of convalescence for horses in *Group 3* was more variable and depended on resolution of the other clinical problems.

There was a significant effect of group on follow-up outcome (P<0.0001), with good outcome most likely in *Group 1* and least likely in *Group 2*. Follow-up information was available for ≤6 years after horses had been back in full function for a minimum of one year. In *Group 1*, 2 horses developed unrelated problems. Seventy of the remaining 90 horses (77.8%) returned to full athletic function at their previous level for >1 year. Fifteen horses in *Group 1* had unilateral or bilateral IRU in the proximoplantar aspect of the MtIII (mild n = 11; moderate or intense n = 4). Two of these 15 horses developed unrelated problems; 9 of the remaining 13 horses (69.2%) had a successful outcome. Six horses required medication of the TMT joint because of subsequent low-grade lameness improved by IA analgesia. Two horses had ipsilateral hindlimb lameness associated with foot pain that was abolished by correction of foot imbalance. All owners considered that the cosmetic outcome was satisfactory.

Information was also available for many horses in *Group 1* for considerably longer than one year after resumption of full work. Two horses had recurrent hindlimb PSD after 3 and 5 years, respectively. One horse developed PSD in the contralateral hindlimb and one horse had an injury of a SL branch in the ipsilateral hindlimb. One horse had desmitis of the ipsilateral hindlimb accessory ligament of the deep digital flexor tendon (DDFT). One horse developed bilateral DDFT lesions in the DFTS, was treated by implantation of bone marrow-derived cultured mesenchymal progenitor cells (MPCs) and subsequently resumed full work. Three horses developed forelimb PSD, 6 horses front foot pain, 4 horses other lameness and 5 horses thoracolumbar or sacroiliac joint region pain.

Twenty horses (21.7%) in *Group 1* had persistent or recurrent lameness, 14 of which underwent repeated diagnostic analgesia. Lameness in these horses was not altered by a 'low 4 point' block but was abolished by subtarsal infiltration of local anaesthetic solution. Intra-articular analgesia of the TMT joint did not influence lameness in these 14 horses. Low-grade structural abnormalities of the SLs were identified on ultrasonographic examination but these were considered unlikely to be consistent with the degree of persistent lameness. One of the 20 horses had moderate IRU in the proximoplantar aspect of the MtIII and 3 horses had mild IRU at the time of initial diagnosis. The proportion of failures for each surgeon was similar.

All 5 horses in *Group 2* had persistent or recurrent lameness. This was associated with deterioration in the ultrasonographic appearance of the SL.

Six of the horses in *Group 3* (n = 58) did not return to work due to unrelated reasons. Of the remainder, 23/52 horses (44%) returned to full work for minimum of one year and up to 4 years. Performance was limited by concurrent problem(s) in 29/52 horses (56%), especially associated with thoracolumbar and/or sacroiliac joint region pain (n = 18) or front foot pain (n = 6). Ten horses had recurrent pain associated with the sacroiliac joint region that was verified by local analgesia.

Discussion

This is the first long-term (>1 year after resumption of full work) follow-up report documenting the results of treatment of PSD by neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy. Seventy-eight percent of horses with primary PSD without major conformational abnormalities were managed successfully. Similar shorter-term results were achieved following desmoplasty and fasciotomy (Hewes and White 2006): 20/23 horses (87%) with hindlimb PSD returned to full function (jumping, dressage, hacking), 2 of which subsequently incurred reinjury. The interval between surgery and return to full athletic function was

Fig 4: Transverse T2-weighted motion-insensitive low-field magnetic resonance image of the proximal metatarsal region. Medial is to the left. The medial lobe of the suspensory ligament (SL) (arrows) has diffuse increased signal intensity in the collagenous tissue. The shape of the proximoplantar aspect of the limb had prevented acquisition of diagnostic quality ultrasonographic images of the SL. The plantar cortex of the third metatarsal bone is also thickened, especially medially.

generally longer, when recorded, in the study by Hewes and White (2006) (n = 8: 5–18 months [mean 7.5 months]) than for horses in *Group 1* in the current study. Plantar fasciotomy using a medial approach and injection of a 'biological preparation' (bone marrow, porcine urinary bladder matrix, fat-derived MPCs, bone marrow-derived cultured MPCs, platelet rich plasma) resulted in 184/225 Warmblood, Warmblood-cross and Thoroughbred sports (dressage, showjumping and eventing) horses (82%) returning to work without reinjury at one year post operatively (Judy 2009). Neurectomy of the deep branch of the lateral plantar nerve and fasciotomy was performed alone (n = 271) or in conjunction with the injection of either porcine urinary bladder matrix or autologous bone marrow (n = 25), or osteostixis (n = 35), resulting in 79, 84 and 55% respectively resuming work for an undocumented period (Bathe 2008). Kelly (2007) (neurectomy alone) and Toth *et al*. (2008) (neurectomy and fasciotomy) reported success in 91% of 89 horses and 62.5% of 16 horses respectively but the duration of follow-up was not defined. The similar short-term success rates reported for fasciotomy without neurectomy (Judy 2009) and desmoplasty (Hewes and White 2006) compared with the current study suggest that decompression of the SL alone may be sufficient to relieve pain.

The improvement in ultrasonographic appearance of the SL at 2 months after surgery is probably in part due to neurogenic muscle atrophy. The SL contains variable amounts of muscular tissue (Bischofberger *et al*. 2006) and it has been demonstrated experimentally (Pauwels *et al*. 2009) that there was a significant reduction in mean cross-sectional area (CSA) of muscle tissue after neurectomy (control CSA: $3.01 \pm 1.65\ mm^2$, neurectomy CSA: $0.49 \pm 0.33\ mm^2$), with a 6:1 muscle fibre ratio in the control limb vs. the treated limb; skeletal muscle fibre diameter was also decreased in the treated limb. The biomechanical consequences of neurogenic muscle atrophy are currently unknown. It is also possible that there was some repair of the SL, perhaps facilitated by decompression, resulting in improved echogenicity. The presumed iatrogenic lesions on the plantar aspect of the SL did not appear to influence the long-term outcome.

Other factors that we suggest should be considered in the post operative period are correction of foot imbalance, the training regime and work surfaces, the natural paces of the horse potentially leading to overuse, musculoskeletal strength and coordination and the rider's ability and balance. We have previously shown an association between arena surface variables and lameness in dressage horses (Murray *et al*. 2010a,b). Pilot data has demonstrated the influence of collection and extension in trot on metatarsophalangeal joint angles and thus potential strain on the suspensory apparatus (Murray and Dyson, unpublished data).

Six horses in *Group 1* required medication of a TMT joint because of recurrence of low-grade lameness after resumption of full work. The accessory ligament of the SL originates on the plantar aspect of the calcaneus and fourth tarsal bone and merges with the SL in the proximal metatarsal region (Schulze and Budras 2008). It is possible that altered biomechanical function of the suspensory apparatus following neurogenic muscle atrophy may have some influence on the biomechanics of the distal hock joints and may predispose to the development of distal hock joint pain.

The number of horses in *Group 1* with IRU was too small to assess objectively its influence on the time for resolution of lameness post operatively. There were other variable factors influencing the length of convalescence, such as improvement in echogenicity of the SL. There was no significant difference in outcome for horses in *Group 1* with or without IRU, but this may reflect the small number of horses with IRU; 69% of horses with IRU had a successful outcome compared with 78% of all horses in *Group 1* (excluding those which developed unrelated problems). The proportion of horses with IRU may not be representative of the general population of horses with PSD and was substantially higher in *Group 2*, with no successful outcomes, than in *Groups 1* and *3*.

Although many horses had mild increased opacity of the proximolateral aspect of the MtIII seen in DPl radiographic images, such radiological abnormalities can be seen in horses free from lameness (Butler *et al*. 2008). The frequency of occurrence of more severe osseous abnormalities (entheseous or endosteal new bone) was small and may also not be representative of the general population of horses with PSD, especially those with more chronic lesions. Radiology may underestimate the presence of endosteal and entheseous new bone, which may be more reliably detected using computed tomography (Launois *et al*. 2009) or MRI (Labens *et al*. 2010; Brokken *et al*. 2011; Dyson 2011a).

In *Group 1* 22% of horses had persistent lameness or recurrent lameness soon after resumption of work. In all horses that underwent further investigation, pain was relocalised to the proximoplantar aspect of the metatarsal region but no definitive explanation for persistent pain could be reached. The possibility of adhesions between the SL and the second metacarpal bone, the third or the fourth metacarpal bone, reaction to entheseous new bone, endosteal bone pain, pain associated with the accessory branch of the SL, additional innervation and unrelated osseous injuries remain possibilities. The ease with which the proximal aspect of the SL can be assessed ultrasonographically depends, in part, on the conformation of the proximoplantar aspect of the limb; it is difficult to evaluate in its entirety from medially to laterally. A recent study questioned the sensitivity and specificity of ultrasonography for detection of SL lesions compared with MRI (Labens *et al*. 2010). Magnetic resonance imaging may also be superior for detection of osseous pathology in the distal tarsal and proximal metatarsal regions and adhesion formation (Brokken *et al*. 2007; Sampson and Tucker 2007; Labens *et al*. 2010; Dyson 2011a). Computed tomography may also give information about the SL and entheseous new bone (Launois *et al*. 2009). We do not currently have sufficient information about reasons for failure in order to predict which horses might be most likely to respond successfully to surgery.

In the current study, there were no objective measurements of hindlimb conformation at the time of clinical assessment in the majority of horses. However, 5 horses with what were considered to be marked straightness of the hock and/or hyperextension of the fetlock underwent neurectomy and fasciotomy elsewhere contrary to recommendations and all experienced progressive deterioration of the infrastructure of the SL and persistent lameness. It is, therefore, possible that horses with this type of conformation may have increased strains experienced by the SL. Alternatively, increased fetlock extension may be a marker of already progressive deterioration of the infrastructure of the SL. Either of these factors could explain why surgical outcome was poor for these horses. There is evidence that in some horses there may be progressive degeneration of the SL (Mero and Pool 2002; Mero and Scarlett 2005; Halper *et al*. 2006; Schenkman *et al*. 2009; Miller and Juzwiak 2010; Dyson 2010). Anecdotally, there are also reports of horses experiencing catastrophic breakdowns of the SL after neurectomy and fasciotomy, usually in association with conformational abnormalities. It is, therefore, suggested that hock and fetlock conformation should be critically assessed preoperatively. However, one of a further 39 horses with normal conformation treated subsequent to this study (until December 2010) experienced acute, severe lameness when in light work 4 months' post operatively, in association with marked deterioration in the ultrasonographic appearance of the SL (Dyson, unpublished data).

It is currently unknown if there is a genetic predisposition for SL injury. In the current study, 3 horses in *Group 1* subsequently developed forelimb PSD and in *Group 3*, 18 of 58 horses (34%) had fore- and hindlimb PSD at the time of initial injury recognition. During the period of this study, there were an additional 43 horses that had concurrent fore- and hindlimb PSD that fulfilled inclusion criteria but did not undergo surgery (Dyson, unpublished data). Injury of the SL in several limbs could also reflect the exercise history and other environmental factors such as work surfaces, thus multiple SL injuries may be a representation of overall environmental features either alone or in association with genetic factors.

In the current study, the success rate was considerably less in *Group 3* (44%) compared with *Group 1* and failure was generally attributable to other injuries. This highlights the need for very careful preoperative assessment and owners contemplating neurectomy and fasciotomy should be aware of the poorer results particularly for horses with associated chronic sacroiliac and/or thoracolumbar region pain.

In the horses in the current study, neurectomy and fasciotomy was performed unilaterally in those with unilateral lameness and no detectable ultrasonographic abnormality of the contralateral limb. One of 58 horses (1.7%) treated unilaterally subsequently developed injury in the contralateral limb. Whether surgery should routinely be performed bilaterally remains open to debate. The number of post surgical complications was small. None of the horses in the current study with seroma formation developed breakdown of the incision wound, although one horse which underwent surgery subsequent to the study has done so (Dyson, unpublished data).

The degree of response to local analgesia and accurate diagnosis of PSD are considered important for case selection for neurectomy and fasciotomy. Prior to the initiation of this study, 2 horses in which PSD was the only detectable abnormality showed only 50% improvement after perineural analgesia of the deep branch of the lateral plantar nerve. Lameness was abolished by perineural analgesia of the tibial nerve but intra-articular analgesia of each tarsal joint produced no change. Both horses underwent neurectomy and fasciotomy but remained lame (Dyson, unpublished data). It is also important to exclude pain arising from the distal aspect of the limb because perineural analgesia of the deep branch of the lateral plantar nerve has the potential to improve fetlock region pain.

This study had some limitations. There was no control group of horses, although the prognosis with other nonsurgical management techniques has been reported (Dyson 1994; Boening *et al*. 2000; Crowe *et al*. 2004; Lischer *et al*. 2006). We were ultimately reliant on owner assessment of the horses' performances. Conformation was not assessed objectively in all horses. There were only a limited number of horses that underwent both ultrasonography and MRI and the possibility of false positive results of ultrasonography must be recognised (Labens *et al*. 2010). The number of horses was considered too small to perform multivariate analysis of variance to determine risk factors for outcome including objective assessment of conformation, age, breed and work discipline, duration and severity of lameness, lesion severity and evidence of coexistent osseous pathology and gait variables such as advanced diagonal placement and recognition of thickening of the plantar fascia or gross nerve pathology intraoperatively.

It is concluded that there is a role for neurectomy of the deep branch of the lateral plantar nerve and plantar fasciotomy for long-term management of hindlimb PSD but horses should be selected carefully based on conformation and other sources of pain contributing to lameness or poor performance. The recognition of a curb-like swelling or white hairs on the proximoplantar aspect of the metatarsal region should alert a clinician at a prepurchase examination to the possibility of previous surgery.

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No conflicts of interest have been declared.

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Manufacturers' addresses

[1]A-Cell Vet, Columbia, Maryland, USA.
[2]Hallmarq Veterinary Imaging, Guildford, UK.
[3]Animalcare Ltd, York, UK.
[4]Dr Fritz Gmbh, Germany.
[5]Ethicon, Johnson and Johnson, St. Stevens-Woluwe, Belgium.

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