Medical management of superficial digital flexor tendonitis: a comparative study in 219 horses (1992–2000)

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Summary

Reasons for performing study: **There is a lack of long-term follow-up data for outcome of medical treatment of superficial digital flexor (SDF) tendonitis.**

Objectives: **To determine whether intralesional injection of hyaluronan, beta aminoproprionitrile fumarate (BAPN) or polysulphated glycosaminoglycans (PSGAG) or systemic administration of PSGAG yielded better results than a controlled exercise programme alone in the management of SDF tendonitis, with a minimum follow-up period of 2 years after resumption of full work; and to determine whether reinjury rate was related to sports discipline and whether fibre alignment score (FAS) at 4 months could predict outcome.**

Methods: **In *Study 1*, 50 horses were managed by controlled exercise alone (*Group A*), 50 were treated with intralesional injection of hyaluronan (*Group B*), 20 received intralesional and systemic treatment with PSGAG (*Group Ci*) and 30 received systemic treatment with PSGAG (*Group Cii*). Horses in *Groups B, Ci* and *Cii* followed the same controlled exercise programme as *Group A*. In *Study 2*, 69 horses (*Group D*) were treated by intralesional injection of BAPN and followed a modified controlled exercise programme. Horses were re-examined clinically and ultrasonographically at intervals. Follow-up data were obtained for horses 2 years after resuming full work and for up to 6 years.**

Results: **There was no significant difference in reinjury rate of the treated limb(s) between *Groups A, B, Ci* and *Cii* (42.5–44.4%) (P>0.9). The reinjury rate (16%) in the treated limb(s) in *Group D* was significantly lower than in the other groups (P<0.001). However, when injury rate of the uninjured limb was considered, the results were similar to *Study 1*. In *Study 2*, the FAS at 4 months after treatment was a good predictor of outcome (P<0.001). Reinjury rates for different disciplines were similar in the 2 studies, with the risk of reinjury ascending from showjumpers to event horses to National Hunt and flat racehorses.**

Conclusions: **Treatment with BAPN reduced the risk of reinjury in the treated limb, although the overall rate of subsequent injury was not affected. FAS at 4 months after treatment is a good predictor of outcome in the treated limb(s).**

Potential relevance: **This study provides long-term follow-up data in horses from a variety of sports disciplines that can be used to provide prognostic information.**

Introduction

Superficial digital flexor (SDF) tendonitis is a potentially career-limiting injury, with a high incidence of reinjury (Genovese *et al.* 1996; Palmer *et al.* 1994; Yovich *et al.* 1995). Most of the published data relating to SDF tendonitis relate to Thoroughbred flat (Genovese *et al.* 1996; Gibson *et al.* 1997) and National Hunt (Marr *et al.* 1993; Ordidge 1996) racehorses and Standardbred racehorses (Hawkins and Ross 1995). There are limited data concerning other disciplines (Palmer *et al.* 1994; van den Belt *et al.* 1994; Dyson 1998). However, SDF tendonitis is important in other sports horses, especially event horses (Palmer *et al.* 1994; Gibson *et al.* 2002; Bathe 2003; Dyson 2003) and Grand Prix showjumpers (Palmer *et al.* 1994; Boswell *et al.* 2003; Dyson 2003). Long-term follow-up information for nonracing sports disciplines is lacking.

Experimental studies using a collagenase-induced tendonitis model have investigated the effects of intralesional injection of hyaluronan (Spurlock *et al.* 1989; Gaughan *et al.* 1991, 1995) or beta aminoproprionitrile fumarate (BAPN) (Alves *et al.* 2001), or systemically administered polysulphated glycosaminoglycan (PSGAG) (Redding *et al.* 1992). There are limited published data relating to treatment of clinical cases of SDF tendonitis with hyaluronan (Hertsch *et al.* 1989) or PSGAG (Marr *et al.* 1993; Dow *et al.* 1996). More recently, the clinical use of intralesional BAPN was described (Genovese *et al.* 1996; Reef *et al.* 1996, 1997). The importance of controlled exercise in the management of tendonitis has also been emphasised (Genovese *et al.* 1996; Gillis 1997).

This paper reports 2 consecutive related studies, the first (Dyson 1997) comparing results of treatment with intralesional hyaluronan or PSGAG and systemic administration of PSGAG with controlled exercise alone. The second study compares the results of treatment with beta aminoproprionitrile fumarate (BAPN) in 69 horses with those of the previous study.

The purposes of these studies were to: 1) compare the reinjury rate in horses treated by controlled exercise alone, or in combination with either intralesional treatment with hyaluronan, PSGAG or BAPN or systemic administration of PSGAG, with a minimum follow-up period of 2 years after return to full work; 2) determine whether outcome could be predicted by ultrasonographic

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TABLE 1: Guidelines for the controlled exercise programme in *Study 1* (progress was guided by ultrasonographic appearance of the tendons whenever possible)

Weeks	Duration and nature of exercise
0–4	15 mins walking exercise in hand twice daily
4–8	45 mins walking in hand, on horse-walker or ridden
8–12	60 mins walking in hand, on horse-walker or ridden
16–24	Turn-out in small paddock and ridden walking exercise with short periods of trot, for 60 mins
24–48	Turn-out in large paddock and ridden walking and trotting exercise, with progressive increase in duration of trot
48–52	Flat work; walk and trot
52	Ridden walk, trot and canter

Table from Dyson (1997).

determination of fibre alignment grade; and 3) compare reinjury rates in horses from different disciplines.

Materials and methods

Horses were selected for inclusion in the study by clinical and ultrasonographic evidence of forelimb SDF tendonitis, either unilaterally or bilaterally. Horses with first-time or recurrent injuries were included. All horses were examined ultrasonographically bilaterally using a 7.5 or 10 MHz transducer. The cross-sectional area (CSA) of the SDFT was measured at 4 cm intervals distal to the accessory carpal bone (ACB), and an echogenicity score (0–3) assigned (Rantanen *et al.* 2003). Fibre alignment score (FAS) (Rantanen *et al.* 2003) was assessed in longitudinal images and the grade (0–3) refers to the score at the maximum injury zone (MIZ) in the more severely injured limb.

Study 1

Horses in *Study 1* (n = 150) were examined over 2 years from 1992 to 1994 (Dyson 1997). Fifty horses (*Group A*) were treated conservatively and owners were advised to follow a controlled exercise programme (Table 1). Fifty horses (*Group B*) were treated by intralesional injection of high molecular weight hyaluronan (Hylartil Vet)[1]. Twenty horses (*Group Ci*) received intralesional PSGAG (Adequan)[2] (500 mg) and 7 i.m. injections of PSGAG at 5 day intervals. Thirty horses (*Group Cii*) received 7 i.m. injections of PSGAG at 5 day intervals. Both limbs were treated in *Groups B* and *Ci* if lesions had been identified, even if asymptomatic. Horses in *Groups B, Ci* and *Cii* followed the same controlled exercise programme as horses in *Group A*. It was recommended that horses should not start cantering exercise until 12 to 16 months after injury, depending on the ultrasonographic appearance of the tendons.

It was not possible to assign all horses randomly to treatment groups due to lack of client compliance. The population of each group was mixed, given the variability of lesion severity, number of limbs affected and discipline for which each horse was used. An attempt was made to have similar proportions of horses from each discipline in each treatment group, and to assign horses to treatment groups irrespective of the severity of injury.

Horses were examined clinically and ultrasonographically at approximately 3 month intervals after treatment, until 12 to 15 months after treatment. Follow-up information was obtained at 2 years after each horse started cantering, or sooner if re-injury had already occurred. The results are based only on those horses (135) that returned to their former athletic function.

TABLE 2: Distribution of horses for which follow-up was available among treatment groups in *Study 1*

	Group A (n = 46)		*Group B* (n = 47)		*Group Ci* (n = 18)		*Group Cii* (n = 29)	
Discipline*	No.	%	No.	%	No.	%	No.	%
R(F)	2	4.3	2	4.3	0	0	0	0
R(NH)	13	28.2	7	14.9	4	22.2	4	13.8
E	23	50.0	25	53.2	12	66.7	20	69.0
SJ	4	8.7	5	10.6	2	11.1	2	6.9
End	2	4.3	5	10.6	0	0	1	3.4
Dr	2	4.3	3	6.4	0	0	2	6.9

*R(F) = Flat racing; R(NH) = National Hunt racing; E = Eventing; SJ = Showjumping; End = Endurance; Dr = Dressage. Table modified from Dyson (1997).

Study 2

Horses in *Study 2* (n = 69) were examined between July 1996 and May 2000 (the study is still ongoing, but results are presented only for horses for which follow-up information for at least 2 years after resuming full work was available). Horses were selected based upon ultrasonographic evidence of SDF tendonitis with a CSA of the tendon at maximum injury site of >1.5 cm^2 and/or a hypoechoic region occupying >50% of the CSA of the tendon and extending more than 1.5 cm proximodistally. Treatment was not performed until at least 4 weeks after injury.

Horses were treated by intralesional administration of 7–18 mg BAPN[3], depending on the length of the lesion. Multiple injections were performed using a 27 gauge needle on 5 occasions on alternate days. Injections were performed with the limb bearing weight and with the horse sedated using detomidine and butorphanol. Injections extended proximal and distal to the region of tendon which appeared abnormal ultrasonographically. Seventeen horses were treated bilaterally and 52 unilaterally. Horses were walked for 30 mins daily on a horse-walker throughout the treatment period and, for the following 4 months, walking exercise was continued for up to 45 mins in hand, on a walker or ridden. In the early phase of the trial, short periods of trotting exercise were introduced after 8 weeks, but this appeared to be detrimental (resulting in swelling and lameness in some cases).

Horses were re-examined clinically and ultrasonographically 4 months after treatment and at variable intervals thereafter, depending on clinical progress. Subsequent exercise management was dependent on the ultrasonographic appearance of the tendon. Most horses were back in moderate cantering exercise by 12 months after injury. In *Study 2*, follow-up data were assessed for 68 horses that had been back in full work for at least 2 years and up to 6 years (to May 2003).

Statistical analysis

Chi-squared analysis was used to assess differences in reinjury rates between treatment groups in *Study 1* and between *Studies 1* and *2*. The effect of discipline and fibre alignment score on reinjury were tested using Fisher's Exact test.

Results

In both studies, the injections were well tolerated. No adverse reactions to injection were seen. In *Study 2*, injections extended proximal and distal to the site of lesions detected

TABLE 3: Incidence of recurrent injury in horses which returned to their former athletic function related to treatment group and discipline in *Study 1*

Discipline	*Group A* No.	%	*Group B* No.	%	*Group Ci* No.	%	*Group Cii* No.	%
R(F)	1/1	100	1/2	50	0/0	0	0/0	0
R(NH)	5/10	50	4/7	57	2/4	50	3/4	75
E	10/23	43	11/25	44	5/12	42	8/19	42
SJ	1/ 4	25	1/5	20	1/2	50	0/2	0
End	0/2	2	2/5	40	0/0	0	0/1	0
Dr	1/2	50	1/3	33	0/0	0	1/2	50

For abbreviations, see Table 2.

TABLE 4: Incidence of reinjury related to discipline in *Study 1*. Differences between disciplines were not significant (P = 0.35)

Discipline	Total No. horses	No. horses with recurrent injury	% Reinjury
R(F)	3	2	66.7
R(NH)	25	14	56.0
E	79	34	43.0
SJ	13	3	23.0
End	8	2	25.0
Dr	7	3	42.8

For abbreviations, see Table 2.

ultrasonographically. It was easy to discern whether the tendon was normal by the force of resistance to injection. Injection was easy into damaged tendon, which almost invariably extended at least 2 cm proximal and distal to the lesion detected ultrasonographically. In *Study 1*, client compliance with the exercise programme was less good than in *Study 2*. Eight horses in *Study 1* started cantering exercise earlier than recommended, between 10 and 12 months after treatment. The majority of horses in *Study 1* (n = 118) started cantering between 12 and 14 months after treatment, whereas in *Study 2* most horses (n = 66) were in moderate canter work by 12 months after treatment.

Study 1

Follow-up information was available for 140 horses (*Group A*, 46; *Group B*, 47; *Group Ci*, 18 and *Group Cii*, 29) (Table 2). Five of these horses (1 flat racehorse, 3 National Hunt racehorses and 1 event horse) did not return to their former athletic function, but were used for hunting or pleasure riding. None of these horses had recurrent injury, but they were excluded from further analysis. In the remaining 135 horses the incidence of reinjury to the treated limb(s) between groups ranged from 42.5 to 44.4% (Table 3). There was no significant difference between treatment groups (P>0.90). There was no significant effect of discipline (P = 0.35), but there was a trend for higher incidence of reinjury in racehorses (flat and National Hunt) than in eventers and dressage horses (Table 4). Reinjury rate was lowest in showjumpers and endurance horses. The data for subsequent injury to nontreated limbs are not available.

Study 2

One racehorse was retired as a breeding stallion; data are presented for the remaining 68 horses (34 event horses, 26 racehorses, 7 showjumpers and 1 cross-country horse). The reinjury rate was significantly less (P<0.001) than in *Study 1*, with only 11 of 68 horses (16%) sustaining recurrent injury to a treated limb (Table 5). However, when injuries to the contralateral limb were considered in horses treated unilaterally, the injury rate was similar to *Study 1*, with 45.6% of horses experiencing injury. The reinjury rate for different disciplines was very similar to that in *Study 1*, with the risk of reinjury ascending from showjumpers to event horses to flat and National Hunt racehorses.

Event horses formed the largest discipline group (*Study 1*, 79 horses; *Study 2*, 34 horses). In *Study 2* there was a higher proportion (*Study 1* 24/79 [30%]; *Study 2* 22/34 [65%]) of Advanced level event horses, competing at 3-day events up to Federation Equestre Internationale (FEI) 4-star level. In *Study 1*, no horse completed more than two 3-day events without recurrent injury. Fourteen horses in *Study 2* completed from 2 to six 3-day events without injury. Nine of these horses completed 3 or more FEI 4-star events. A further 5 horses completed from 2 to five 3-day events before injuring the contralateral limb; 3 of these horses have since completed 2 further 4-star 3-day events.

There were significant differences between fibre alignment scores and reinjury (P<0.001). All 4 horses with a FAS at the MIZ of 2 or 3 at 4 months after treatment had recurrent injury of the treated limb. Seven of 30 horses with a FAS of 1 suffered reinjury, whereas no horse (n = 34) with a FAS of 0 reinjured the treated limb.

Discussion

In *Study 1* there appeared to be no benefit of treatment with either hyaluronan or PSGAG compared with controlled exercise alone. In *Study 2* there was a significant reduction in reinjury rate of the treated limb compared to *Study 1*, but when reinjury of the untreated limb was considered, the overall results were similar. However, data for injury of the untreated limb were not available

TABLE 5: Incidence of reinjury to a treated limb or new injury of an untreated limb related to discipline in *Study 2* in 68 horses for which follow-up data was available

Discipline	Total No. horses	No. horses with recurrent injury	% Reinjury	New injury to untreated limb	Total injury	% Total injury
R(F)	16	2	12.5	8	10	62.5
R(NH)	10	4	40.0	2	6	60.0
E	34	5	14.7	9	14*	41.2
SJ	7	0	0	1	1	14.3
Cross country	1	0	0	0	0	0
Total	**68**	**11**	-	-	**31**	-

*One additional horse sustained desmitis of the accessory ligament of the deep digital flexor tendon in 1 of 2 treated limbs. For abbreviations, see Table 2.

for *Study 1*. In both studies, reinjury was highest in racehorses; event horses were at medium risk of reinjury and showjumpers at low risk. Horses treated with BAPN returned to cantering exercise and competition earlier than the horses in *Study 1*, apparently without detrimental results. In *Study 2*, FAS at 4 months after treatment was a good predictor of outcome.

These combined studies had a number of limitations. The studies were sequential and not concurrent. The overall clinic case load did not alter with respect to discipline during the study periods, although the proportion of Warmblood breeds slowly increased, reflecting the growing use of these breeds, especially for dressage and showjumping. Treatments were neither randomised nor blinded. There was not a control group. The studies depended on client compliance with the exercise regime, which was less good in *Study 1* than *Study 2*. Interpretation of the results is also confounded by the variety of athletic sports in which the horses were involved, severity of the initial injury, whether it was a first-time injury or reinjury, whether the injury was unilateral or bilateral, and the age of the horse. Some horses in *Study 1* would not have met the lesion severity inclusion criteria for *Study 2*. These were selected because, in a previous study (Reef *et al.* 1997), there was no demonstrable benefit of BAPN treatment in mild lesions compared with controlled exercise alone. In the current studies, the horses in the treatment groups were otherwise comparable, except that there was a greater proportion of high level event horses in *Study 2*. However, in *Study 1* data were available only for reinjury of the treated limb(s), whereas in *Study 2* data were available for both reinjury and new injury of untreated limbs.

When reinjury of the treated limb is considered, there were superior results with treatment using BAPN. This is contrary to experimental data in a collagenase-induced tendonitis model in rabbit Achilles tendons *in vivo* (Yamamoto *et al.* 2002) in which BAPN appeared to inhibit healing, whereas hyaluronan promoted healing. It is also conflicts with an *in vitro* study investigating the effects of BAPN on normal equine tenocyte metabolism (Dahlgren *et al.* 2001). However, these experimental studies focused on the short-term effects of BAPN, whereas the current study investigated long-term outcome. In the current study, there appeared to be no benefit for preventing reinjury by treatment with either hyaluronan or PSGAG compared with controlled exercise. Previous experimental studies using hyaluronan have shown conflicting results (Spurlock *et al.* 1989; Gaughan *et al.* 1991; Foland *et al.* 1992; Gift *et al.* 1992; Yamamoto *et al.* 2002). The only other documented clinical study (Hertsch *et al.* 1989) had extremely short-term (3 to 10 months) follow-up data. There are 2 documented clinical trials investigating the effect of PSGAG (Marr *et al.* 1993; Dow *et al.* 1996), but the study of Dow *et al.* (1996) lacked reliable follow-up information. Marr *et al.* (1993) compared conservative management with laser treatment or intralesional or i.m. PSGAG in National Hunt racehorses with a follow-up period of 9 to 30 months. There was no significant difference in the proportion of horses returning to training in the 3 groups, but horses treated with PSGAG had a higher risk of reinjury.

This is the first documented long-term study on a large number (n = 113) of event horses and also permits comparisons with reinjury rates in horses from other disciplines. The highest reinjury rate was in flat and National Hunt racehorses. The high incidence of tendon injury and reinjury in National Hunt racehorses is well recognised (Dyson *et al.* 2003). Serious tendon injury in young flat racehorses in the UK is generally not regarded as a major problem (Pilsworth 2003). It is possible that the treated horses were inherently susceptible to injury, with a high proportion injuring the contralateral limb in *Study 2*. The new or recurrent injury rate in flat racehorses was similar to that reported in New Zealand in horses treated either conservatively or by desmotomy of the accessory ligament of the SDFT (Gibson *et al.* 1997). All the showjumpers were competing at Grand Prix level and in both studies had a comparatively low reinjury rate, despite being a group of higher mean age (13 years) than in any other discipline. Degenerative changes in the equine SDFT develop with age and are thought to predispose to injury (Smith 2003). The high rate of reinjury in dressage horses in *Study 1* was surprising because SDF tendonitis is not a major problem in this discipline (Kold and Dyson 2003). This may also reflect an inherent susceptibility to tendon injury in these individuals. The use of BAPN enhanced the likelihood of event horses being able to complete more than two 3-day events compared to other treatment methods. Nonetheless, when injuries to the nontreated limb were considered, the overall injury rate in the follow-up period was similar in both studies, irrespective of treatment.

During the BAPN injection procedure it was clear that areas of damaged tendon extended proximal and distal to the sites identified as abnormal using ultrasonography. This highlights the potential limitations of ultrasonography. It is therefore possible in horses with unilateral injury that regions of damaged tendon in the contralateral asymptomatic limb were missed. Experience comparing ultrasonography with magnetic resonance imaging (MRI) in the distal metacarpal and pastern regions has demonstrated that tendon lesions detectable using MRI are often either not detectable or considerably smaller when assessed ultrasonographically (S. Dyson and R. Murray, unpublished data). Consideration should be given to assessment of the tendon architecture in the apparently normal limb by attempting injection into the tendon.

In *Study 2*, FAS at 4 months after treatment was a good predictor of final outcome, in accordance with a previous study (Reef *et al.* 1997). Regular ultrasonographic monitoring during the rehabilitation period was used to control changes in the exercise regime. The work programme for individual horses was based on the stability of the CSA of the tendon and its echogenicity score and FAS.

One event horse in *Study 2* with bilateral injury returned to competition, but subsequently developed desmitis of the accessory ligament of the deep digital flexor tendon, a comparatively unusual injury in event horses. No horse in either study developed suspensory desmitis.

In conclusion, BAPN reduced the reinjury rate in the treated limb compared with other medical treatments; however, long-term injury rate in the untreated limb remained high. Injection of mesenchymal stem cells may result in enhanced healing (Smith *et al.* 2003), but requires long-term validation. Based on the results of the current study, consideration may have to be given to treatment of both limbs, even if lesions are detected in only one limb using ultrasonography.

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Manufacturers' addresses

[1]Pharmacia & Upjohn Animal Health, Corby, Northamptonshire, UK.
[2]Janssen Animal Health, High Wycombe, Buckinghamshire, UK.
[3]Sigma Pharmaceuticals, Poole, Dorset, UK.

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