# Quantitative Sonographic Assessment in the Clinical Management of Superficial Digital Flexor Injuries in Thoroughbred Racehorses

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This study demonstrates that a quantitative sonographic assessment using a systematic, routine evaluation can provide objectivity for clinical information and improve the ability to render an accurate prognosis. Categorization of tendon injuries can assist the practitioner in determining the potential for continued racing and the risk of additional tendon injury. Authors' address: Randall Veterinary Hospital, 20600 Miles Parkway, Warrensville Heights, OH 44128-5504. © 1997 AAEP.

## 1. Introduction

Diagnostic ultrasonography has been established as the imaging technique of choice to confirm the presence or absence of an injured superficial digital flexor tendon (SDFT) by qualitatively identifying hypoechoic fiber bundles.[1–5] There are few reports that graded the injuries of the SDFT at the weak link and included the proximal to distal extent of the lesion. One report of Thoroughbred and Standardbred racehorses proposed sonographic objectivity by a severity rating for grading the extent of the injury and correlating the severity rating to future racing capability.[6] This method of quantitation has been modified and the severity rating was abandoned because it was not practical for clinical use.

The concept of a uniform classification of SDFT injury has considerable impact in the clinical management of SDFT injuries in racehorses. Objective sonographic data have the potential to categorize tendon injuries when the prognosis is given for future racing. A similar quantitative objectivity may be applicable during rehabilitation to guide exercise management.

In 1991, a clinical trial was started to evaluate the effectiveness of intralesional β-aminopropionitrile-fumarate (βAPN-F),[a] combined with controlled exercise.[7] Seven basic quantitative evaluations were used in that study. These assessments appear to have clinical value for the practitioner in routine sonographic evaluations of SDFT injuries. Basic methods of sonographic quantitation used in the βAPN-F clinical field studies were modified quantitative sonographic assessments to objectively categorize various degrees of SDFT injury.[8] The severity of injury in 164 Thoroughbred and Standardbred racehorses and the ultimate return to racing were reported.[8] Tendon injuries were classified as slight, moderate, or severe based on quantitative sonographic criteria. A successful return to racing was determined for various treatments and severities of SDFT injury. Using quantitative sonographic evaluations, the study reported that with long-term treat-

**NOTES**

ment, horses with a slight SDFT injury had a 67% chance to return to compete in at least one race; horses with a moderate SDFT injury had a 51% chance; and those with a severe SDFT injury had only a 40% chance to return to racing for at least one start. Quantitative sonographic criteria were developed in this study to categorize the severity of the tendon injury.

The present study was undertaken by using a similar quantitative assessment to (a) increase the accuracy of detecting a SDFT injury before hypoechoic fiber bundles are detected, and (b) determine the statistical chances of racing success or failure in cases in which long-term therapy is not an option.

Clinical cases were limited to Thoroughbred racehorses that continued training or racing after injury. Horses with metacarpal swelling suggesting potential SDFT injury, or those with clinical evidence of SDFT injury with sufficient sonographic data to be categorized, were evaluated and their outcome determined. Horses in this study were all treated symptomatically and continued some form of modified training and racing. This trainer management decision to continue athletic use, as opposed to long-term treatment and rehabilitation, is referred to here as symptomatic treatment and continued exercise. The reduced exercise group of horses was not taken completely out of training for a period of longer than 1 month postsonographic evaluation. Many had modified training programs, such as a reduced training schedule, a reduction in the number of racing events, and a reduction in the level of competition. Most horses continued or attempted to continue their present athletic use. The goal here is to provide practitioners with objective sonographic criteria to determine the following: Is there an injury to the SDFT? Can this horse continue to race? Will this horse further injure itself if it does race? How many races can one expect? Finally, what does that black hole mean?

Trainers make athletic management decisions for injured horses based on the medical information provided by the veterinarian. One of the most critical decisions is whether to stop training (racing) and institute long-term therapy or to continue present training and racing programs with a favorable response to symptomatic treatment. A major part of that decision rests with the veterinarian's sonographic evaluation and interpretation. There are critical financial, medical, and animal care decisions based on this sonographic evaluation. The authors believe that qualitative serial sonographic assessments can be erroneous in horses with SDFT injuries in which there are minor abnormalities and that a quantitative evaluation may provide additional information useful to predict future injury.

## 2. Materials and Methods

The horses in this study were Thoroughbred racehorse seen in northeastern Ohio from April 1983 to October 1996. All horses had initial sonographic examinations for the clinical complaints of metacarpal swelling (focal or diffuse) or swelling of the SDFT (focal or diffuse). No horses with injury of the deep digital flexor tendon (DDFT), accessory ligament of the DDFT (inferior check ligament), or interosseous muscle (suspensory ligament) were included. All horses were in training or racing, and the client's request for examination was based on the discovery of recent heat or swelling, with or without associated lameness. This initial examination data served as the baseline. In all horses in this group, the trainer management decision was to treat the swelling symptomatically and pursue continued training or racing. There were no horses that completely ceased training for more that 4 weeks. Many horses did not race or breeze for at least 30 days after the initial examination and had their exercise level reduced to swimming or ponying. These horses were designated as reduced exercise. Other horses continued normal racing or slightly modified racing and training, and these were designated as continued exercise.

A sonographic evaluation was performed with either an ATL 4600 scanner or Pie Data 200 scanner, using either a 7.5-Mhz sector or linear array transducer. Quantitative information was obtained by utilizing a computer and digitizing pad for cross-sectional surface area (CSA). A computer and digitizing pad is not necessary in clinical practice. A hand-held caliper and the scale on the print can be used for measuring tendons. The CSA of the SDFT and the lesion was determined for six or seven levels (zones) of the palmar metacarpus.

For the average-sized Thoroughbred, the zone or level designations are as follows: zone 1A, 0–4 cm distal to the accessory carpal bone (DACB); zone 1B, 4–8 cm DACB; zone 2A, 8–12 cm DACB; zone 2B, 12–16 cm DACB; zone 3A, 16–20 cm DACB; zone 3B, 20–24 cm DACB; and zone 3C, 24–26 cm DACB.

The maximum injury zone (MIZ) was the level with the greatest percent of hypoechoic fiber bundles. If there were no identifiable hypoechoic fiber bundles at any level, the MIZ would be the level of the SDFT that showed the largest percent increase in CSA when compared with the contralateral normal zone. For example, if zone 1A had a CSA of 110 $mm^2$ and the CSA of the normal tendon is 100 $mm^2$, then the increased zone would be 10%. If zone 1B was 120 $mm^2$ and the normal limb was 100 $mm^2$, the increase would be 20%; then zone 1B would be the MIZ.

The total CSA's of the six or seven levels were summed, which provided the total CSA (T-CSA). The hypoechoic cross-sectional areas were similarly summed to provide the total hypoechoic fiber bundle (T-HYP). Dividing the T-HYP by the T-CSA and multiplying by 100 provided the percent total hypoechoic (% T-HYP). The %T-HYP serves as the basis of categorizing the extent of the injury. If there was a lesion, the echogenicity of that lesion was determined for each abnormal level. The echogenicity scores are referred to as lesion type. The

density or type scores are 0 for isoechogenic, 1 for slightly hypoechoic, 2 for mixed echogenicity, and 3 for mostly anechoic. The scores were totaled in multiple level injuries, and this score is the total type score. For example, if there is a type 1 lesion at zones 1B and 2A, and a type 3 lesion at zone 2B and a type 2 lesion at Zone 3A, then the total type score would be 7. If there were no identifiable hypoechoic fiber bundles, the T-CSA of the SDFT was summed and the percent increase compared with that obtained from the opposite normal limb. This was designated the total percent increase. For example, if the seven-level sum of the normal tendon is 600 $mm^2$ and the seven-level sum of the injured SDFT is 750 $mm^2$, then the total increase was 25%.

In this study the quantitative assessments that can be used, though not every one may be utilized, are as follows: (a) MIZ–CSA, (b) MIZ–CSA increase, (c) MIZ–%HYP, (d) T-CSA, (e) T-CSA increase, and (f) %T-HYP. It is hoped that the addition of quantitative information will improve clinical case management.

The tendons were categorized as follows, with normal referring to the contralateral normal limb: Category I: (a) new swelling (no reinjured tendons included), (b) %T-HYP was <1%, (c) T-CSA was <15% normal, and (d) no single zone MIZ–CSA was >40% of normal. Category II: (a) new swelling (no reinjured tendons included), (b) %T-HYP was <1%, (c) T-CSA >15% of normal, or (d) MIZ–CSA was >40% normal. Category III: (a) new or reinjured tendons, and (b) %T-HYP of 1–25%, *but the total lesion type score was <3.* Category IV: (a) new or reinjured tendons, and (b) %T-HYP of 1–15% and a *total type score of ≥3.* Category V: (a) new or reinjured tendons, and (b) %T-HYP of 16–25%. Category VI: (a) new or reinjured tendons, and (b) %T-HYP of >25%.

The results of continued exercise management were based on race performance records provided by The Jockey Club Information Systems[b] and the attending veterinarians and trainers or owners.

Horses were classified as successful, partially successful, or failures based on data obtained until the end of the study or until the horse was unable to race and train as a result of the tendon injury. The classification was as follows: (a) failure, unable to complete three races; (b) partial success, four to six races completed; (c) successful, seven to ten races completed; and (d) highly successful, more than ten races completed.

### 3. Results

Results are arranged in tabular form, in Tables 1–5.

### 4. Discussion

The distribution of cases reflected the clinical experience trend on the racetrack. There are a high number of horses in category I because the majority of this group have palmar metacarpal swelling without SDFT swelling. Accidental liniment blister, malpositioned bandages, and distal SDFT sheath effusion would all fall into this category. Category II is a small group because this most likely includes SDFT strain. This category is a SDFT injury with no obvious hypoechoic fiber bundles. This is a group difficult to identify without quantitative CSA data.

Category III is likewise a small group simply because these SDFT abnormalities are most likely chronic lesions recently recognized by the attendant, an incidental finding, possible scanning technique artifact, or possibly an interpretive artifact. Serial quantitative sonographic measurements allow these tendons to be categorized and managed clinically (with caution), and lesion stability can be determined during exercise.

Category IV injuries are all slight SDFT injuries. The group is large because clinically, these horses usually have slight swelling and no lameness. They train well, are bright and alert, and compete reasonably well. This is the group that is identified sonographically that grossly does not seem to have much of a problem externally.

Category V and VI tendon injury levels are for clinically abnormal horses when examined by both the trainer and the veterinarian. Many of this group have transient lameness, heat, SDFT swelling, and most likely have a painful response to digital pressure. The basic decision to continue exercise is mostly economical. Trainers may feel the horse is fit and ready to race again. It may be that there is a possibility the horse will be claimed in the next few races. The trainer may have had poor experience with long-term treatment and views this stage as career ending and desires to exploit what little production may remain from this horse. There are fewer horses in category V and VI for continued exercise management because they are obviously

**Table 1. Limb Distribution for Continued Exercise Horses**

| Category | No. of Tendons | No. of Horses | Right | Left |
|---|---|---|---|---|
| I | 49 | 48 | 20 (41%) | 29 (59%) |
| II | 14 | 14 | 09 (64%) | 05 (36%) |
| III | 17 | 17 | 07 (41%) | 10 (59%) |
| IV | 65 | 64 | 27 (42%) | 38 (58%) |
| V | 27 | 27 | 12 (44%) | 15 (56%) |
| VI | 37 | 37 | 12 (32%) | 25 (68%) |
| Total | 209 | 207 | 87 (42%) | 122 (58%) |
| I/III | 66 (38%) | 65 | 27 (41%) | 39 (59%) |
| II/IV/V/VI | 143 (62%) | 142 | 60 (42%) | 83 (58%) |

**Table 2. Month of Year for First Ultrasonographic Exam**

| Month | Number |
|---|---|
| Spring (Feb., Mar., Apr., May) | 77 (37%) |
| Summer (June, July, Aug.) | 101 (48%) |
| Fall (Sept., Oct., Nov., Dec.) | 31 (15%) |

**Table 3. Distribution of MIZ for Each Category**

| Zone | Cat. I | Cat. II | Cat. III | Cat. IV | Cat. V | Cat. VI | Total |
|---|---|---|---|---|---|---|---|
| 1A | 9 (18%) | 2 (14%) | 0 (0%) | 5 (8%) | 1 (4%) | 0 (0%) | 17 (8%) |
| 1B | 7 (14%) | 0 (0%) | 1 (2%) | 1 (6%) | 5 (19%) | 5 (14%) | 19 (9%) |
| 2A | 6 (12%) | 3 (21%) | 4 (24%) | 9 (14%) | 1 (4%) | 7 (19%) | 30 (14%) |
| 2B | 5 (10%) | 4 (29%) | 4 (24%) | 22 (34%) | 1 (4%) | 7 (19%) | 43 (21%) |
| 3A | 11 (22%) | 3 (21%) | 5 (29%) | 16 (25%) | 9 (33%) | 13 (35%) | 57 (27%) |
| 3B | 10 (20%) | 2 (14%) | 3 (18%) | 11 (17%) | 9 (33%) | 5 (14%) | 40 (19%) |
| 3C | 1 (2%) | 0 (0%) | 0 (0%) | 1 (2%) | 1 (4%) | 0 (0%) | 3 (1%) |
| Total | 49 | 14 | 17 | 65 | 27 | 37 | 209 |

**Table 4. Racing Results of Continued Exercise Management**

| Category | Failed (<4 Starts) | Partial Success (4–7 Starts) | Successful (7–10 Starts) | Highly Successful (>10 Starts) | Total |
|---|---|---|---|---|---|
| I ($n$ = 43) | 3 (7%) | 6 (14%) | 12 (28%) | 22 (51%) | 34 (79%) |
| II ($n$ = 13) | 4 (31%) | 3 (23%) | 2 (15%) | 4 (31%) | 6 (46%) |
| III ($n$ = 17) | 4 (24%) | 1 (6%) | 3 (18%) | 9 (54%) | 12 (71%) |
| IV ($n$ = 64) | 42 (66%) | 10 (16%) | 7 (11%) | 5 (8%) | 12 (19%) |
| V ($n$ = 27) | 18 (67%) | 6 (22%) | 1 (4%) | 2 (7%) | 3 (11%) |
| VI ($n$ = 37) | 27 (73%) | 5 (14%) | 3 (14%) | 3 (8%) | 2 (5%) |
| Total ($n$ = 201) | 98 (49%) | 31 (15%) | 28 (14%) | 44 (22%) | 72 (36%) |

**Table 5. Distribution of Benefit of Reduced Exercise Group by Category**

| | Failed (<4 Races) | | Successful (>4 Races) | |
|---|---|---|---|---|
| Category | Did Reduce Exercise | Did Not Reduce Exercise | Did Reduce Exercise | Did Not Reduce Exercise |
| I | 2 | 2 | 9 | 30 |
| II | 4 | 0 | 4 | 5 |
| III | 1 | 3 | 6 | 7 |
| IV | 17 | 25 | 9 | 13 |
| V | 7 | 11 | 3 | 5 |
| VI | 13 | 14 | 4 | 6 |
| Total | 44 | 55 | 35 | 66 |
| I/III | 3 | 5 | 15 | 37 |
| I/II/IV/V/VI | 41 | 50 | 20 | 29 |

clinically abnormal. Trainers tend to consider longer-term treatment or retirement to alternative use in these instances.

In American flat racing, the left forelimb has a higher SDFT injury incidence (right forelimb, 42%; left forelimb, 58%). Interestingly, the left forelimb, category I incidence (no clinically or sonographically confirmed SDFT injuries) is similar to true SDFT injuries found in category IV. Category II had a higher right limb incidence, but that may be due to the small number of tendons in the group. The severe SDFT injuries (category VI) were more frequent in this left fore.

The month of the initial examination was included to correlate the initial SDFT evaluation relative to the racing surface and climatic conditions. Horsemen for years have equated bowed tendons with mud. It has also been suggested that fatigue from improper training may contribute to SDFT injuries. Category I injuries, which had no clinically or sonographically confirmed SDFT injuries, were evenly distributed from mid-March to mid-December. However, category V and category VI injuries were found more frequently in the summer. When divided into spring, summer and fall, it appears that in the spring, when cold climate and muddy tracks predominate, 37% of the horses were examined. This is a time period when the previous year's long-term treated, SDFT injured horses would be ready for their first works and races. Therefore, one would expect a slight increase in examinations to detect those horses that were starting to show evidence of failure. The summer months (drier, faster tracks) had the highest number of initial examinations (48%). This would be a time when horses were at their fittest and the least leg weary; they would be asked to perform at their fastest capability. The fall has the lowest request (15%) for initial sonographic examinations during the time of year in northeastern Ohio, when there tends to be more rain and muddy tracks are common. So, with these criteria, muddy tracks do not increase injury.

Zone 3A was the most common MIZ (the junction of the middle and distal thirds of the tendon). Categories I and II had more involvement of zones 1A and 1B. The authors believe that this may be due to 2-year olds starting their racing careers and having adaptive enlargement as reported by Gillis[5] or developing sonographic evidence of tendon strain. These zones are often the MIZ in tendons where hypoechoic fiber bundles are not immediately identifiable. Two horses had the MIZ in zone 3A and one in zone 2A. Eleven horses had the MIZ in zones 1A or 1B and none developed clinical tendinitis. In Category II,

three of the four horses that eventually sustained clinical tendinitis had the MIZ, at the time of the initial examination, in zones 2B, 3B, and 3A, respectively. Only one horse in both categories that eventually developed clinical tendinitis has an upper third MIZ (1A). Therefore, especially in category II, when the MIZ tends to be around the junction of the middle and distal thirds of the SDFT (2B or 3A), more caution is advised when training or racing continues.

We believe that despite the lack of identifiable hypoechoic fiber bundles of at least 1%T-HYP, category II horses most likely represent SDFT injury in the form of a strain. In our experiences, these horses do well with 2–3 months out of training, which should be considered in the decision process. Two to three months completely out of training is not a lot of lost time, and this is the level of tendon injury that requires the least long-term time off and therapy (mostly rest).

Categories IV, V, and VI represent confirmed slight, moderate, and severely injured or reinjured tendons. The eventual clinical tendinitis necessitating either retirement to an alternative career or long-term treatment is basically the same for categories IV, V, and VI. There is a slight increase in clinical failure with increasing severity. We believe that most trainers anticipate this end result with categories V and VI; but it is interesting that category IV has an eventual 80% failure rate. Our belief is that clinically, at the time of the initial examination, these horses are slightly hurt and long-term therapy may be the more appropriate choice. It is a difficult trainer decision for the aforementioned reasons, but the eventual failure rate with continued exercise (80%) does raise an extremely important point for consideration. In this study, in which the sonographic data were available at the time of clinical failure, all horses in category IV had more severely injured tendons. Therefore, once continued exercise fails, there is a new long-term starting point and most likely the SDFT further injury will move into category V or VI. This will reduce the prognosis for successful long-term treatment.

These data are most interesting in that we have proposed fine sonographic quantitative differences among categories II, III, and IV, yet there is a dramatically different expected end result of continued exercise management. Categories II and III clinically rebow at approximately the same 29% rate, yet they step over into quantitative category IV and rebowing escalates to an 80% eventual clinical failure rate. We do not believe that clinical examination and qualitative assessment of the sonogram can consistently distinguish these groups. Only by objectively categorizing these groups would one be able to render this information to the trainer at the time of deciding how to manage any given horse.

When we look at simplifying the overall data of continued exercise management by using failure of productivity as zero to three starts or successful productivity defined as three or more starts, categories I and III are the categories least likely to result in loss of productivity and eventual clinical tendinitis. When combined, there is an 88% chance to start more than three times and only a 12% chance of clinical bow. In contrast, combining categories II, IV, V, and VI, there is a 35% chance to complete three or more races and an 82% chance to experience clinical tendinitis.

We attempted to determine if continued exercise at a reduced rate was of benefit. It did not seem that this made any difference in the failure of category I. In fact, the only message here was that most horses in category I that were successful did not reduce exercise. It was interesting to note that all horses in category II that failed did reduce exercise. This adds substance to our point of view that this group should be laid up for a few months, because it doesn't seem advantageous to reduce exercise in category II horses. Category III horses, however, did seem to fail more often when exercise was not reduced. Therefore, this group may well be advised to downscale exercise for a while and be sonographically monitored as a means to improve continued exercise success. In categories IV, V and VI, there did not seem to be any advantage or disadvantage to exercise changes. However, we as clinicians would make this decision on an individual basis and tend to be more persuasive toward reduced exercise if continued exercise was the only management option available.

## 5. Conclusion

This study suggests that additional and useful sonographic information can be made available for clinical decision making in horses with metacarpal or SDFT swelling. The use of systematic quantitative measurements is practical and adds objectivity to clinical and qualitative assessments. This helps to segregate metacarpal swellings and SDFT injuries into meaningful categories. These concepts can be used in everyday practice. Furthermore, consistently comparing the contralateral limb in all horses increases the information available for analysis. These assessments are relatively easy to do and will improve sonographic information for your clients. These data approaches can improve case conclusions and establish a sonographic routine that can increase diagnostic information.

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