# Assessment of Acupuncture Point Sensitivity Scanning Method for Localizing and Evaluating Lesions in Horses

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**ABSTRACT**
In traditional Chinese veterinary medicine, palpation of sensitive acupuncture points (scan diagnosis) is part of the equine clinical exam and is routinely used to locate pain and/or structural disease. The objective of this double-blinded study was to evaluate the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of scan diagnosis and its correlation with conventional diagnostic methods. In addition, the diagnostic acupoint's reactivity grade was compared to lesion severity to evaluate any correlation between the 2 methods of disease diagnosis. Fifty-nine client-owned horses randomly chosen and presented for a variety of equine clinical diseases were included in the study. Performance statistics (sensitivity, specificity, PPV, NPV) of the scan diagnosis were calculated by comparison with the conventional exam outcomes. Study findings for scan diagnosis demonstrated a sensitivity of 88.7% (true positive rate), a specificity of 86.9% (true negative rate), NPV value of 98.1% (percentage of non-lesions determined by the scan diagnosis also shown negative in the conventional examination) and positive predictive value of 50.6% (percentage of lesions determined by the scan diagnosis also shown from conventional examination). In addition, a statistically significant correlation ($p$-value < 0.001) between acupuncture point reactivity grade and lesion severity was demonstrated. This study showed that the scan diagnosis might be a reliable and complementary tool when diagnosing equine pain and/or structural diseases.

**Key words:** traditional Chinese veterinary medicine, horse, scan diagnosis, acupuncture, acupoint reactivity, acupoint diagnosis, lameness

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**ABBREVIATIONS**

| | |
|---|---|
| **CE** | Conventional exam |
| **EGUS** | Equine gastric ulcer syndrome |
| **GRF** | Ground reaction force |
| **NSAID** | Non-steroidal anti-inflammatory drug |
| **NPV** | Negative predictive value |
| **PPV** | Positive predictive value |
| **SD** | Scan diagnosis |
| **TCVM** | Traditional Chinese veterinary medicine |
| **TMJ** | Temporomandibular joint |

Current equine veterinary medicine needs efficient and accurate diagnostic methods. The basic clinical exam and orthopedic investigation of a patient allows identification of systemic and musculoskeletal diseases in most patients. For additional lesion identification in more complex cases, diagnostic imaging techniques are often needed to make a more accurate diagnosis and prognosis and may include one or several of the following techniques: radiography, thermography, endoscopy, ultrasound, scintigraphy, computer tomography (CT) and magnetic resonance imaging (MRI). In addition to the plethora of conventional diagnostics, interest in acupuncture and traditional Chinese veterinary medicine (TCVM) and its ability to detect organ and musculoskeletal abnormalities has been increasing in modern equine management.[1-5] Systematic palpation of reactive acupuncture points (scan diagnosis) can be used to augment a conventional medical exam and is part of the TCVM examination in every horse. This unique diagnostic method allows the TCVM practitioner to locate single or multiple lesions on a horse's body by palpating acupoints, which correlate to specific body locations.[6-15]

Research in this area has given encouraging results supporting the scan's reliability.[6-15] These studies have provided an excellent first attempt to validate the clinical importance of scanning and corroborate results by imaging. The next step to validate the use of this promising technique is investigate whether statistical analysis would verify its reliability when compared to conventional diagnosis. The aims of this study, therefore,

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were to provide a research protocol with investigators blinded to history, primary complaint and scan diagnosis to provide an unbiased study that could withstand the rigors of statistical evaluation.

The objective of this double blinded comparative study was to demonstrate scan diagnosis could be reliably used to localize pain and/or structural disease in horses when compared to conventional diagnostic methods and that the severity grade of acupoint sensitivity was comparable to the conventional severity grade. The hypothesis was that the scan's sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) would not be inferior to conventional diagnosis (achieve 90%) and that the scan's severity grade would be comparable to conventional diagnosis severity of disease.

## MATERIALS AND METHODS

All horses admitted at the Areda Equine Clinic in Bex, Switzerland, regardless of their breed, age, and sex were included in the study after informed owner consent was provided. The patients were presented for pre-purchase examination, poor performance, lameness, internal medicine, skin disease, dental examination or for further investigations such as endoscopic, ultrasonographic and radiologic examination. Patients whose history was known by the author or who had been treated with NSAIDs (non-steroidal anti-inflammatory drugs), corticosteroids or omeprazole in the two previous weeks were excluded.

All horses underwent the scan diagnosis first so that the acupoint sensitivity would not be influenced by the warming up of the musculature from the orthopedic examination. It was performed by the author, an experienced TCVM trained veterinarian, who did not know the patient from previous examinations nor the main complaint for actual presentation. The patient was not evaluated clinically nor in movement by the author.

The conventional veterinarian, an experienced equine orthopedist, internist and surgeon in charge of the clinical part of the study was not present during the scan diagnosis. This veterinarian remained blinded to the scan diagnosis outcomes while performing the conventional examination of patients.

The TCVM scan diagnostic exam was performed with a standard 40 × 25 mm plastic acupuncture needle cap from head to hindquarters first on the left side, then on the right side in haircoat direction. Constant pressure was used to evaluate the reactivity of diagnostic acupuncture points. The scan always began with palpation of ST-7, then went on in order with GB-20, BL-10, TH-16, SI-16, *Jing-jia-ji*, LI-18, PC-1, BL-13, TH-15, GB-21, LI-16, LI-17, ST-10, LI-15, TH-14, SI-9, SI-10, SP-20, *Yan-zhou*, *Cheng-deng*, then from BL-13 to BL-25 including *Qi-hai-shu*, *Bai-hui*, *Shen-shu*, *Shen-peng*, *Shen-jiao*, BL-26 to BL-28, *Ba-jiao*, GB-27, SP-13, SP-12, SP-11, ST-31, BL-35 to BL-39, BL-53, BL-54, *Lu-gu*, *Huan-zhong*, *Huan-tiao*, *Huan-hou*, *Yang-ling*, CV-12, GB-25, LIV-13, GB-24 and LIV-14. For each scanned acupoint, the sensitivity of the horse's response was graded with a score from 0 to 3 as described in the literature (Table 1).[14] Anatomic sites associated with sensitive acupoints during the scan were recorded for each study horse and previously cited literature was used to define the corresponding disease location (Table 2).[6,14] In order to be able to compare the scan and conventional exam results, a capital letter was attributed to each specific lesion or disease location (Table 2).

Shortly after the scan, the horses underwent conventional medical exams. Depending on the primary complaint, a general examination as well as an orthopedic exam with or without nerve blocks, radiographic, ultrasonographic, thermographic, gastroscopic and/or dental examination were performed to reach a diagnosis. Once all the investigations necessary to get a diagnosis were completed, all the procedures, their results and the lesion grades were reported on forms and transmitted to the author for scoring.

First, the reactivity (0-3) of each diagnostic acupoint was recorded. Then the overall scan sensitivity of each detected lesion was calculated as the average positive sensitivity for the involved scan acupoints. As an example, a scanned shoulder acupoint reactivity of SI-9++, LI-16+, LI-15++, TH-14+++, GB-21++ would provide an overall lesion grade by adding the scores (2+1+2+3+2=10), divided by the number of scanned acupoints (5), which gives grade 2 (total of 10 divided by 5 acupoints). For each horse, outcome of the scan diagnosis was the presence of lesions based on the associated criteria described in Table 2.

**Table 1:** Criteria for grading acupoint sensitivity during scan diagnosis.

| Grade | Criteria |
|---|---|
| 0 | No response |
| 1 | Mild consistent localized flinch |
| 2 | Moderate to Severe consistent localized flinch |
| 3 | Severe flinching with evasion, kicking or biting |

**Table 2:** Diagnostic acupoints and associated anatomic lesions.[6,14,15]

| | Location | Necessary Acupoints for Diagnosis | Supportive Acupoints for Diagnosis |
|---|---|---|---|
| Lesion A | TMJ/Teeth | ST-7 | |
| Lesion B | Cervical | *Jing-jia-ji* | GB-20/21, BL-10, BL-18 |
| Lesion C | Front foot | PC-1, LI-18 | BL-13/25, BL-14, BL-15/27 |
| Lesion D | Front fetlock | TH-16, LI-16 | SI-16, LI-17, BL-13, Contralateral BL-25 |
| Lesion E | Carpus | *Jing-jia-ji*, C4/C5, LI-17 | BL-13/14/22, SP-20, Contralateral BL-25 |
| Lesion F | Shoulder | SI-9, LI-16, LI-15, TH-14 | SI-10, GB-21, *Yan-zhou*, *Cheng-deng* |
| Lesion Ga | Primary Back Pain | BL back points | |
| Lesion Gd | Back pain secondary to gastric pain | BL back points, CV-12, BL-20/21, ST-7, *Qi-hai-shu* | |
| Lesion H | Hip/Sacrum | Soft tissue: BL-53/54, *Lu-gu*, *Ba-jiao*<br>Bony: *Huan-tiao*, *Huan-hou*, *Huan-zhong*, GB-30 | *Shen-shu*, *Shen-peng*, *Shen-jiao*, BL-23 to BL-26, *Ba-jiao*<br>Contralateral GB-20/21 |
| Lesion I | Hock | BL-35/39, GB-27, SP-13 | BL-16/17, 18/19, SP-12, BL-27/28<br>Contralateral BL-10, GB-20 |
| Lesion J | Stifle | SP-11/12, ST-31, *Yang-ling*, BL-36/37/38 | BL-20/21/22, *Qi-hai-shu*<br>Contralateral BL-10, GB-20 |
| Lesion K | Tendons/Ligaments | TH-15, SI-16 | BL-14/15/18/19 |
| Lesion L | Distal hock area | No diagnostic points | No diagnostic points |
| Lesion M | Internal Organ/Liver | BL-18, LIV-13/14 | |

**Table 3:** Criteria for grading lesions diagnosed by conventional exam.

| Grade | Criteria |
|---|---|
| N | No abnormality |
| L | Mild abnormality with no radiographic/ultrasound findings; mild dental lesions; mild gastroscopic lesions/equine gastric ulcer syndrome (EGUS) grade I[17] |
| M | Moderate abnormality with visible tissue lesion; radiographic/ultrasound findings and/or gastroscopic findings (EGUS grade II-III)[17] |
| S | Severe abnormality with visible tissue lesions; radiographic/ultrasound findings and/or gastroscopic findings (EGUS grade IV)[17] |

Lesion identification for the conventional exam was reported as either "positive", "negative", or "not assessable". The conventional exam recorded a lesion as positive when a lesion could be identified that agreed with the primary owner complaint. It was negative when no diagnostic method could identify or locate a lesion and not assessable when there was no diagnostic method that could be used to identify whether there was a lesion present or not. Lesions were graded into normal (N), light (L), moderate (M) or severe (S) by the orthopedist according to criteria detailed in Table 3. Results of the conventional examination were used as the "gold standard" for evaluation of the acupuncture scan diagnosis.

Lesion identification for the scan diagnosis was also reported as either positive, negative or not assessable. The lesions were considered positive when all corresponding acupoints listed in Table 1 for lesion determination were reactive when stimulated. A negative value was assigned when all corresponding acupoints needed for diagnosis were not reactive when stimulated. Not assessable was assigned when the scan was not able to locate a lesion due to lack of corresponding acupoints (e.g. Table 4, Lesion L) or when the lesion was not investigated in the conventional exam.

The endpoints of this study were to evaluate scan diagnosis sensitivity (percentage of lesions determined by the conventional examination and also detected by the scan diagnosis), specificity (percentage of non-lesions determined by the conventional examination and not

detected by the scan diagnosis), positive predictive value (percentage of lesions determined by the scan diagnosis and also from conventional examination), negative predictive value (percentage of non-lesions determined by the scan diagnosis and also shown negative from conventional examination) and correlation between the grading of the scan and the disease severity in the conventional exam.

To test the noninferiority hypothesis (at least 90%) regarding the scan diagnosis sensitivity, specificity, PPV and NPV, respectively, 95% confidence interval (95% CI) based on bootstrap re-sampling method was used, since lesions within each patient were not independent. If the lower bound of the 95% CI was greater than the (90% - δ), where, δ = noninferiority margin, then the null hypothesis could be rejected (i.e., noninferiority established). The noninferiority margin δ was set to be 0.09, which was 10% of the desired performance (90%). The null hypothesis ($H_0$), therefore, was rejected when the lower limit of the 95 CI was greater than 81% (preset noninferiority threshold). To test whether there existed association between the scan point sensitivity grade and the disease severity, a test on Kappa statistic using normal approximation (Z-statistic) was applied. A *p*-value less than 0.05 was considered statistical significance (rejection of $H_0$).

The inclusion of 60 horses offered the desired 90% power to reject the null hypothesis for testing sensitivity and specificity, assuming that both the scan diagnosis sensitivity and specificity were 90% and each patient had

**Table 4:** Specific lesion reactivity diagnosed during the scan and in the conventional exam on 59 study horses.

| | **Scan Diagnosis (59 horses)** | | | **Conventional Exam (59 horses)** | | |
|---|---|---|---|---|---|---|
| | Positive | Negative | Not assessable | Positive | Negative | Not assessable |
| Lesion A TMJ/Teeth | 44 | 15 | 0 | 7 | 14 | 38 |
| Lesion B Cervical | 5 | 54 | 0 | 4 | 54 | 1 |
| Lesion C Front foot | 40 | 19 | 0 | 14 | 42 | 3 |
| Lesion D Front fetlock | 17 | 42 | 0 | 5 | 52 | 2 |
| Lesion E Carpus | 2 | 57 | 0 | 0 | 58 | 1 |
| Lesion F Shoulder | 5 | 54 | 0 | 1 | 57 | 1 |
| Lesion Gd* Back pain secondary to gastric pain | 20 | 39 | 0 | 8 | 38 | 13 |
| Lesion Ga Primary Back Pain | 43 | 16 | 0 | 19 | 35 | 5 |
| Lesion H Hip/Sacrum | 2 | 57 | 0 | 1 | 57 | 1 |
| Lesion I Hock | 11 | 48 | 0 | 3 | 54 | 2 |
| Lesion J Stifle | 24 | 35 | 0 | 19 | 40 | 0 |
| Lesion K Tendons/Ligaments | 25 | 34 | 0 | 12 | 39 | 8 |
| Lesion L Distal hock area | 0 | 50 | 9 | 12 | 46 | 1 |
| Lesion M Internal Organ/Liver | 2 | 57 | 0 | 1 | 56 | 2 |
| Total | 240 | 577 | 9 | 106 | 642 | 78 |

2 – 3 lesions. The median of the observed lesion numbers over all study subjects was 2. With this sample size, according to Bujang and Baharum, the test for Cohen's Kappa statistic would have over 90% power to reject the null hypothesis with a significance level of 0.05 (with a true kappa statistic at least 0.4).[16] All statistical analyses were performed using a commercial statistical software[a].

## RESULTS

A total of 60 horses started the study, however, 1 horse was removed due to inability to be scanned entirely because of massive hyperreactivity and dangerous behavior. The study, therefore, had a total of 59 horses which included: 30 (50%) geldings, 23 (38.3%) mares, and 7 (11.7%) stallions. Their age ranged from 1 to 28 years. Eleven breeds were represented: 35 (58.3%) Warmbloods, 5 (8.3%) Pura Raza Espanola, 4 (6.7%) Franche-Montagne, 4 (6.7%) no specific breed, 3 (5%) Trotter, 3 (5%) ponies, 2 (3.3%) Quarter horses, 2 Pura Raza Lusitano, 1 (1.7%) Thoroughbred and 1 (1.7%) Irish Cob.

The majority of horses (45/59, 75%) were presented for lameness. Conventional diagnostic methods identified 27/45 (45%) with osteoarthritic lesions, 12/45 (20%) tendon or ligament lesions and the remaining 6/45 (10%) were lame without radiographic or ultrasonographic lesions. The remaining 14/59 horses had a variety of primary complaints that included: 13/59 (22%) back pain, 9/59 (15%) gastrointestinal disease, 6/59 (10%) dental disease, 6/59 (10%) wounds or surgery, 5/59 (8.3%) skin disease, 3/59 (5%) respiratory disease, 3/59 (5%) urogenital disease and 1/59 (1.67 %) liver disease.

Conventional diagnostic methods used on the 59 study horses included: radiographs for 36 (61%) patients, 30 (50.8%) patients had an orthopedic exam without nerve blocks, 28 (47.4%) had ultrasound, 7 (11.7%) had gastroscopy, 5 (8.5%) had undergone orthopedic examination with nerve blocks, 3 (5.1%) had thermography and 3 (5.1%) had a complete blood analysis. Due to costs for the owners, it was not possible to undergo the same clinical investigations in all horses and therefore only mandatory investigations for each case were made to reach a diagnosis.

Fourteen groups of lesions labeled from A to M were evaluated in each of the 59 horses which yielded a total of 826 potential lesion locations (Table 4). The scan diagnosis was positive in 58/59 (98.3%) tested horses. One horse had a complete negative scan. The scan identified 240/826 (29.1%) positive lesions, 577/826 (69.9%) negative lesions and 9/826 (1%) not assessable lesions (lesions distal to hock). The conventional exam was positive in 60/60 (100%) horses. It identified 106/826 (12.8%) positive lesions, 642/826 (77.7%) negative lesions and 78/826 (9.4%) not assessable lesions (Table 4).

There were 16.27% more positive outcomes (identification of lesions) for scan diagnosis (SD) when compared to conventional diagnostic methods (CE). The biggest differences among positive lesions identified by the scan diagnosis and not identified by the conventional exam were for lesions A (TMJ/teeth), C (front foot), Ga (back pain), K (tendons/ligaments), D (front fetlock), Gd (stomach associated back pain), J (hock) and F (shoulder) (Table 4). Conventional and scan diagnosis were similar for positive lesion identification for lesions E (carpus), B (cervical area), H (hip/sacropelvic area), and M (internal organs) (Table 4).

Lesions reported as negative were 7.7% higher for the conventional exam when compared to scan diagnosis. The biggest differences for negative assignment between CE and SD were for lesions C (front foot), Ga (back pain), I (Stifle), D (front fetlock), J (hock), K (tendon/ligament) and F (shoulder). Lesions A (TMJ/teeth), B (cervical area), E (carpus), Gd (stomach associated back pain), H (hip/sacropelvic), L (distal hock area), and M (internal organs) had more similar negative findings when SD and CE were compared.

Dental and gastroscopic exams were only performed on horses with a primary owner complaint or suspected disease. This was therefore associated with lesions A (TMJ/teeth) and Gd (stomach associated back pain) being assigned not assessable for the conventional exam (78 lesions) when compared to SD. The not assessable lesion for scan was lesion L (9 lesions) because no specific diagnostic acupoints are known for lesions located distal to the hock.

To investigate the correlation/agreement between the SD and CE diagnostic systems, tables with counts of concordance (same diagnosis outcome) and discordance (different diagnosis outcome) were generated (Table 5). Comparing positive lesions for the CE (106 total) and positive lesions for SD (240 total), there were 86 lesions that were identical between the 2 diagnostic methods.

When looking for correlation between negative lesions for CE (642 total) and SD (577 total), there were 558 lesions that matched between the 2 methods. There were 9 not assessable lesions for SD, all of which were positive for CE. The 78 not assessable lesions for CE were all assigned lesions by scan (70 positive, 8 negative) (Table 5). Based on this table, sensitivity, specificity, PPV, NPV as well as the correlation of the lesion grade were evaluated (only for outcomes that were assessable in both SD and CE). When compared against the CE outcomes, the scan diagnosis had a sensitivity of 88.7% (86/97), a specificity of 86.9% (558/642), a PPV of 50.6% (86/170) and a NPV of 98.1% (558/569). To reject null hypothesis ($H_0$), the 95% lower limit of the tested parameter should be greater than the preset noninferiority threshold (81%). The observed sensitivity, specificity and NPV were able to reject the respective null hypothesis and achieve statistical significance of noninferiority to 90%. The null hypothesis for the PPV could not be rejected (Table 6). Despite the exclusion of 1 horse, the power for each of the aforementioned statistical tests remained above 90% under the same assumptions and statistical considerations.

**Table 5:** Incidence table showing positive, negative and not assessable lesions for scan diagnosis and those that match conventional exam findings (bolded).

| All lesions | Scan diagnosis (SD) | | | | |
|---|---|---|---|---|---|
| | | Positive (240 total) | Negative (577 total) | NA (9 total) | Total |
| Conventional Exam (CE) | Positive (106 total) | **86** | 11 | 9 | 106 |
| | Negative (642 total) | 84 | **558** | 0 | 642 |
| | Not Assessable (78 total) | 70 | 8 | **0** | 78 |
| | Total | 240 | 577 | 9 | |

NA = Not Assessable, CE = Conventional Exam, SD = Scan Diagnosis

**Table 6:** Analysis to determine the accuracy of scan diagnosis based on conventional diagnosis as the gold standard to determine sensitivity (true positive rate), specificity (true negative rate), PPV (horses that are positive that actually have a lesion), NPV (horses that are negative that actually do not have a lesion).

| Statistics | Mean (s.e) | 95% lower limit | Reject $H_0$* |
|---|---|---|---|
| Sensitivity | 88.7% (3.7%) | 82.1% | Yes |
| Specificity | 86.9% (1.7%) | 83.7% | Yes |
| PPV | 50.6% (3.2%) | 44.0% | No |
| NPV | 98.1% (0.7%) | 96.8% | Yes |

* Reject null hypothesis ($H_0$) when 95% lower limit > 81%; s.e = standard error of the percentage

The scan and conventional diagnosis correlation were determined for individual lesions (A-M), sensitivity, specificity, NPV and PPV values. Seven and 2 lesions achieved sensitivity and PPV, respectively, greater than 90%; however, due to small sample size of positive diagnosis by CE in individual lesions, only sensitivity of lesion Ga can be statistically claimed to be at least 90%. On the other hand, negative diagnosis (specificity) had 8 of the 14 lesions achieving greater than 90% and 7 can be claimed statistically at least 90%. With respect to NPV, all lesions were over 90%, with 12 of them having sufficient statistical evidence to claim noninferiority to 90% (Table 7).

Acupuncture point reactivity (0-3) was graded and compared to conventional lesion severity (normal to severe) assigned during the exam (Tables 1, 3). Only lesions assessable in both exams (739) were included and then correlated: N (CE)= 0 (SD), L (CE)= 1 (SD), M (CE)= 2 (SD), S (CE)= 3 (SD). In the scan, 569/739 (77%) were graded 0, 48/739 (6.5%) lesions were graded 1, 101/739 (13.7%) lesions were graded 2, and 21/739 (2.8%) lesions were graded 3.

In the conventional exam, 642/739 (86.9%) lesions were negative (graded N), 23/739 (3.1%) lesions were graded L, 53/739 (7.2%) lesions were graded M, and 21/739 (2.8%) lesions were graded S. Comparison of lesion grading between conventional and scan diagnosis demonstrated an association between the two lesion grade systems that was statistically significant at $p$ <0.001 (based on Cohen's kappa coefficient) (Tables 8, 9). Findings for individual lesion grading demonstrated high percentage of match (>90%) for lesions H, M, E, L, F and Gd (Table 10), however, most tables contained too little information about the non-negative diagnosis and made statistical analysis less meaningful (Table 11).

## DISCUSSION

The systematic palpation of reactive acupuncture point patterns to localize disease to anatomic sites (scan diagnosis) is an important part of a complete equine TCVM exam. The objective of this double-blinded study was to investigate whether the scan diagnosis was a reliable diagnostic method based on its comparison with conventional exam (considered the gold standard). The

results of this study supported the hypothesis that the scan's sensitivity (88.7%), specificity (86.9%) and negative predictive value (98.1%) when compared to the gold standard would achieve statistical significance (95% lower limit > 81%). In addition, assigned lesion grade scores had good correlation between the 2 diagnostic methods and achieved statistical significance at $p<0.001$.

The positive predictive value (50.6%) was the only part of the investigation that did not achieve statistical significance. It is worth looking into why the positive predictive value of the scan diagnosis did not achieve the desired performance.

The scan showed 16.27% more positive outcomes than the conventional exam. It has been demonstrated in biomechanics that a lame horse will attempt to reduce pain in the stance phase by decreasing the peak vertical ground reaction forces (GRF) on the lame limb.[18-20] Ground reaction forces are the forces generated when the hoof pushes against the ground. When the lameness is mild, the horse will only demonstrate less bouncy movement, but when the lameness becomes more severe, the reduced GRF will be compensated by other limbs.[21] This creates mechanical stress on the whole body through the interstitial connective tissue which surrounds and connects all body structures.[22] Knowing this, it appears clear that every abnormal movement created by pain, poor shoeing/saddle adjustment or riding has an impact on a horse's structural balance. This will not only create a localized lesion but also compensatory reactivity or pain at other anatomic sites distant from the actual lesion which would be difficult to locate with conventional diagnostic methods. Langevin and Yandow suggested a high correlation between intermuscular/intramuscular connective cleavage planes and acupuncture points along

**Table 7:** Analysis of scan diagnosis accuracy when compared to conventional diagnosis findings for individual lesions.

| Area | Sensitivity | Specificity | PPV | NPV |
|---|---|---|---|---|
| A<br>TMJ/Teeth | 6/7 = 85.7% | 14/14 = 100% | 6/6 = 100% | 14/15 = 93.3% |
| B<br>Cervical | 3/4 = 75.0% | 52/54 = 96.3% | 3/5 = 60.0% | 52/53 = 98.1% |
| C<br>Front foot | 14/14 = 100% | 18/42 = 42.9% | 14/38 = 36.8% | 18/18 = 100% |
| D<br>Front fetlock | 5/5 = 100% | 42/52 = 80.8% | 5/15 = 33.3% | 42/42 = 100% |
| E<br>Carpus | N/A (0/0) | 56/58 = 96.6% | 0/2 = 0% | 56/56 = 100% |
| F<br>Shoulder | 1/1 = 100% | 53/57 = 93.0% | 1/5 = 20% | 53/53 = 100% |
| Gd<br>Back pain secondary to gastric pain | 7/8 = 87.5% | 37/38 = 97.4% | 7/8 = 87.5% | 37/38 = 97.4% |
| Ga<br>Primary Back Pain | 19/19 = 100% | 16/35 = 45.7% | 19/38 = 50.0% | 16/16 = 100% |
| H<br>Hip/Sacrum | 0/1 = 0% | 55/57 = 96.5% | 0/2 = 0% | 55/56 = 98.2% |
| I<br>Hock | 0/3 = 0% | 45/54 = 83.3% | 0/9 = 0% | 45/48 = 93.8% |
| J<br>Stifle | 18/19 = 94.7% | 34/40 = 85% | 18/24 = 75.0% | 34/35 = 97.1% |
| K<br>Tendons/Ligaments | 12/12 = 100% | 34/39 = 87.2% | 12/17 = 70.6% | 34/34 = 100% |
| L<br>Distal hock area | 0/3 = 0% | 46/46 = 100% | N/A (0/0) | 46/49 = 93.9% |
| M<br>Internal Organ/Liver | 1/1 = 100% | 56/56 = 100% | 1/1 = 100% | 56/56 = 100% |

**Table 8:** Lesion grades for all assessable lesions determined through scan diagnosis and conventional exam with percent correlation between the 2 lesion diagnostic methods.

| Grade SD | Scan Diagnosis (739 lesions) | | Grade CE | Conventional Exam (739 lesions) | | Lesions with Same Grade Scan and Conventional |
|---|---|---|---|---|---|---|
| 0 | 569 | | N | 642 | | 558 (86.9%) |
| 1 | 48 | | L | 23 | | 9 (39.1%) |
| 2 | 101 | | M | 53 | | 37 (69.8%) |
| 3 | 21 | | S | 21 | | 1 (4.8%) |

SD= Scan diagnosis; CE= Conventional exam

**Table 9:** Summary of matching lesion grade (bolded number) when comparing conventional diagnosis to scan diagnosis and non-matching lesion grades for all study lesions.

| All lesions | | Acupoint Scan* | | | |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 |
| Conventional Diagnosis* | N | **558** | 30 | 43 | 11 |
| | L | 3 | **9** | 9 | 2 |
| | M | 3 | 6 | **37** | 7 |
| | S | 5 | 3 | 12 | **1** |

*See Tables 1 and 3 for grading criteria; numbers bolded = matching grade diagnosis for acupoint scan when compared to conventional diagnosis

**Table 10:** Grading system percentage of match for individual lesions (scan diagnosis versus conventional exam) beginning with lesions highly correlated (>90%) between the 2 methods of diagnosis.

| Lesion | | Correlation between Scan Diagnosis and Conventional Exam |
|---|---|---|
| H | Hip/Sacrum | 98.2% |
| M | Internal Organ/Liver | 98.2% |
| E | Carpus | 96.5% |
| L | Distal hock area | 93.9% |
| F | Shoulder | 91.4% |
| Gd | Back pain secondary to gastric pain | 91.3% |
| B | Cervical | 89.7% |
| A | TMJ/Teeth | 85.7% |
| K | Tendons/Ligaments | 80.4% |
| I | Hock | 78.9% |
| J | Stifle | 76.3% |
| D | Front fetlock | 77.2% |
| Ga | Primary Back Pain | 48.1% |
| C | Front foot | 46.4% |

meridians in humans.[22] The additional positive outcomes (reactive acupoints) from scan diagnosis associated with the distant compensatory effects through the connective tissue network would certainly substantiate increased SD positive findings.

Another explanation for higher incidence of positive outcomes in the scan compared to the conventional exam may be associated with lack of conventional evaluation for all positive lesions identified by the scan. Patients were only evaluated conventionally for the primary complaint given by the owner. For instance, if a horse was announced to be lame by the owner, it underwent an orthopedic exam, but his teeth or stomach were not evaluated. Similarly, a horse suffering from chronic weight loss and poor appetite underwent a blood analysis, oral exam and/or gastroscopy, but no lameness evaluation was performed. This is a limitation for the present study. All lesions diagnosed during the scan should have been investigated by conventional methods in order to compare all study findings. Unfortunately, due to the costs for the owner, only mandatory conventional exams were performed.

A third hypothesis deals with the validity of the scan diagnosis and raises the following questions: (a) Is the reliability of the positive outcomes of the scan questionable, (b) Is it a threshold issue, or (c) Does the scanning method show more lesions than the conventional exam? For an experienced acupuncturist, compensation reactivity of the scan is easily recognized and interpreted accurately. Similarly, overreactive patients are common and the results of the scan are interpreted accordingly. Some locations, however, are positive without any explanation. According to the investigator's experience, repeatable reactivity of specific locations (when the horse is seen several weeks apart and rescanned) might indicate an area of *Qi* and/or Blood Stagnation which without treatment will probably develop structural change but which has limited clinical relevance at the time of the scan and not readily diagnosable by conventional methods. It could also represent a lesion which has healed, for example a tendinitis, but which is still reactive on the tendon-ligament points. Considering the additional diagnostic capabilities, the acupoint scanning method would be a very valuable tool for the monitoring of sports horses.

Regarding the correspondence of the lesion grades, it was interesting to discover that the correlation between the scan's grading and the conventional exam's grading was statistically significant. The highest correlation was found for negative lesions (86.9%) and for moderate lesions (69.8%). A few lesions were graded as severe in both exams, however, a number of severe lesions were not. This finding could indicate that diagnostic acupoints might not react as strongly as expected for some severe lesions. One older horse in this study had a complete negative scan although he was chronically lame with severe lesions. The acupoints should have been very reactive. It is hypothesized that the connective tissue network could be affected by chronic tensions and imbalances making it less reactive by acupuncture point stimulation. This might also explain why chronically ill or older patients need more treatments to respond to acupuncture treatment than patients that have acute lesions or younger age.

**Table 11:** Grading incidence table for individual lesions (correlating lesions bolded).

| **Lesion A[1]** | **Acupoint Scan** | | | | | **Lesion Ga[8]** | **Acupoint Scan** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **14** | 0 | 0 | 0 | Conventional | N | **16** | 4 | 13 | 2 |
| Diagnosis | L | 0 | **1** | 0 | 1 | Diagnosis | L | 0 | **3** | 3 | 0 |
| | M | 0 | 0 | **3** | 0 | | M | 0 | 2 | **7** | 1 |
| | S | 1 | 0 | 1 | **0** | | S | 0 | 0 | 3 | **0** |
| **Lesion B[2]** | **Acupoint Scan** | | | | | **Lesion H[9]** | **Acupoint Scan** | | | | |
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **52** | 0 | 0 | 2 | Conventional | N | **55** | 0 | 2 | 0 |
| Diagnosis | L | 1 | **0** | 0 | 0 | Diagnosis | L | 0 | **0** | 0 | 0 |
| | M | 0 | 1 | **0** | 1 | | M | 0 | 0 | **0** | 0 |
| | S | 0 | 0 | 1 | **0** | | S | 1 | 0 | 0 | **0** |

**Table 11** cont.

| **Lesion C[3]** | **Acupoint Scan** | | | | | **Lesion I[10]** | **Acupoint Scan** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **18** | 15 | 8 | 1 | Conventional | N | **45** | 2 | 6 | 1 |
| Diagnosis | L | 0 | **3** | 1 | 1 | Diagnosis | L | 1 | **0** | 0 | 0 |
| | M | 0 | 1 | **5** | 1 | | M | 2 | 0 | **0** | 0 |
| | S | 0 | 0 | 2 | **0** | | S | 0 | 0 | 0 | **0** |
| **Lesion D[4]** | **Acupoint Scan** | | | | | **Lesion J[11]** | **Acupoint Scan** | | | | |
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **42** | 4 | 5 | 1 | Conventional | N | **34** | 2 | 3 | 1 |
| Diagnosis | L | 0 | **0** | 0 | 0 | Diagnosis | L | 0 | **2** | 2 | 0 |
| | M | 0 | 1 | **2** | 1 | | M | 0 | 1 | **9** | 2 |
| | S | 0 | 1 | 0 | **0** | | S | 1 | 0 | 2 | **0** |
| **Lesion E[5]** | **Acupoint Scan** | | | | | **Lesion K[12]** | **Acupoint Scan** | | | | |
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **56** | 0 | 0 | 2 | Conventional | N | **34** | 2 | 2 | 1 |
| Diagnosis | L | 0 | **0** | 0 | 0 | Diagnosis | L | 0 | **0** | 1 | 0 |
| | M | 0 | 0 | **0** | 0 | | M | 0 | 0 | **7** | 1 |
| | S | 0 | 0 | 0 | **0** | | S | 0 | 1 | 2 | **0** |
| **Lesion F[6]** | **Acupoint Scan** | | | | | **Lesion L[13]** | **Acupoint Scan** | | | | |
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **53** | 1 | 3 | 0 | Conventional | N | **46** | 0 | 0 | 0 |
| Diagnosis | L | 0 | **0** | 0 | 0 | Diagnosis | L | 1 | **0** | 0 | 0 |
| | M | 0 | 0 | **0** | 0 | | M | 1 | 0 | **0** | 0 |
| | S | 0 | 0 | 1 | **0** | | S | 1 | 0 | 0 | **0** |
| **Lesion Gd[7]** | **Acupoint Scan** | | | | | **Lesion M[14]** | **Acupoint Scan** | | | | |
| | | 0 | 1 | 2 | 3 | | | 0 | 1 | 2 | 3 |
| Conventional | N | **37** | 0 | 1 | 0 | Conventional | N | **56** | 0 | 0 | 0 |
| Diagnosis | L | 0 | **0** | 1 | 0 | Diagnosis | L | 0 | **0** | 1 | 0 |
| | M | 0 | 0 | **4** | 0 | | M | 0 | 0 | **0** | 0 |
| | S | 1 | 1 | 0 | **1** | | S | 0 | 0 | 0 | **0** |

[1]TMJ/Teeth, [2]Cervical, [3]Front foot, [4]Front fetlock, [5]Carpus, [6]Shoulder, [7]Back pain secondary to gastric pain, [8]Primary back pain, [9]Hip/Sacrum, [10]Hock, [11]Stifle, [12]Tendons/Ligaments, [13]Distal hock area, [14]Internal organ/Liver.

Individual lesion results were also compared in this study. Nine lesions achieved sensitivity (positive diagnosis) at greater than 81% (TMJ/teeth, front feet, front fetlock, shoulder, back pain-primary/gastric associated, hock, tendon/ligament, internal organ) with 3 PPV lesions (TMJ/teeth, back pain-gastric associated, internal organ) achieving this level. Negative diagnosis (specificity) had larger numbers with 11 of the 14 lesions achieving greater than 81% and NPV with 14 of 14 lesions achieving this level. In general, most tables contained too little information about the non-negative diagnosis and made statistical analysis less meaningful for this area of investigation. A larger sample size would be necessary to investigate individual lesion positive outcomes properly.

Literature review of previous research has shown good sensitivity, specificity and correlation between sensitive acupoints and lesion location.[14-15] Similar to the current study, more lesions were documented in the scan than with the conventional exam.[12] None of these studies, however, used investigators that were blinded to history, primary complaint and scan results. In addition, to the best of the current investigators' knowledge, the grade of the acupuncture point reactivity and the severity of the lesion in the conventional exam has not been investigated before.

In conclusion, the present double blinded study was able to demonstrate that scan diagnosis when compared to the gold standard of conventional exam has a sensitivity of 88.7%, a specificity of 86.9% and a negative predictive value of 98.1%. Scan diagnosis also demonstrated a statistically significant correlation between acupoint sensitivity grade and conventional lesion grading. These study results showed that the scan diagnosis might be a reliable and complementary tool for conventional diagnostic methods when diagnosing equine pain and/or structural diseases.

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**Declaration of Interest**

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this paper.

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**FOOTNOTES**

[a.] The R Foundation for Statistical Computing; R version 3.4.1 https://wwww.r-project.org/

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