

## Clinical Studies

# Evaluating the Diagnostic Accuracy of Three Traditional Chinese Medicine Eye-based Diagnostic Systems and Clinical Disease in Horses

Allison Marshall\*, Huisheng Xie, Aituan Ma, Deng-Shan Shiao

**ABSTRACT**

This study investigated the diagnostic accuracy of three traditional Chinese medicine (TCM) eye-based diagnostic systems (*Wu Lun*, *Ba Kuo*, *Ba Gua*) and equine clinical disease. An ocular exam was performed on 103 horses which included photo documentation of both eyes. Findings from the exam, using each of the different TCM diagnostic systems, were compared to known medical history of a subject horse and the clinical presentation during the enrollment visit. An overall diagnosis accuracy score of each TCM eye assessment system was evaluated against the chance level, and the differences among the three systems were compared. Based on a subject horse's past medical history, all three eye diagnostic systems had overall diagnostic scores significantly greater than 0 (null hypothesis), demonstrating better than chance diagnostic accuracy:  $p=5.8 \times 10^{-13}$ ,  $1.9 \times 10^{-13}$ ,  $9.4 \times 10^{-11}$  for *Ba Gua*, *Ba Kuo* and *Wu Lun* respectively. Statistically significant findings for diagnostic accuracy were also obtained based on a subject's clinical presentation at study enrollment:  $p=8.2 \times 10^{-15}$ ,  $3.0 \times 10^{-14}$ ,  $5.3 \times 10^{-13}$  for *Ba Kuo*, *Ba Gua*, *Wu Lun* respectively; all with smaller  $p$ -values (more significant) than the results for past medical history. Comparison of diagnostic score outcomes did not reveal significant differences among the three eye-based diagnostic systems ( $p=1.000$  and  $0.243$ , based on past medical history and clinical presentation, respectively). This study provides early evidence-based findings that the three TCM ocular assessments could prove helpful in diagnosing clinical disease and *Zang-fu* organ imbalance in the horse and should be considered as a useful adjunct to equine clinical TCVM examinations.

**Keywords:** *Ba Gua*, *Ba Kuo*, Chinese eye diagnostics, equine, ophthalmology, *Wu Lun*

**ABBREVIATIONS:** TCM: traditional Chinese medicine; TCVM: traditional Chinese veterinary medicine

In all medical systems, whether ancient or modern, diagnosis is paramount and indispensable for optimal treatment. According to *Wang Zhen Zun Jing*, "if one wants to treat it, one must diagnose it; if one does not diagnose it, one cannot know the disease; and if one does not diagnose it, one cannot establish the treatment".<sup>1</sup> The diagnostic system used, therefore, and its ability to establish the best treatment is an important part of medical practice. A conventional Western medicine approach relies heavily on a battery of technology (e.g. bloodwork, imaging), with less emphasis on clinical observation. In contrast, traditional Chinese medicine (TCM), uses a system of diagnosis based on observation of subtle changes of the external body. Over generations, the *Si-zhen* (4 diagnostic methods) was developed by TCM practitioners to diagnose patterns of disease that could be correctly treated.<sup>1,2</sup> The underlying theoretical principle when using *Si-zhen* (inquiry, inspection, hearing/smelling, palpation) was that Interior changes of the body will be evident when examining the Exterior due to the connection to the *Zang-fu* organs.<sup>2</sup>

The TCM inspection of the whole body gathers even greater detail by progressing to observation of local parts of the body.<sup>1,2</sup> Examination of the eye belongs to inspection of local anatomic parts. The first record of TCM eye examination is recorded in *Spiritual Pivot (Ling Shu Jing)*, one of the foundational texts of the *Yellow Emperor's Classic of Internal Medicine* written close to 2000 years ago.<sup>1,3</sup> The text discussed the relationship between physiology and pathology of the eyes and *Zang-fu* organ health.<sup>3</sup> Physicians could judge the condition of the *Zang-fu* organs by looking at the expression, color, shape,

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and state of the eyes.<sup>1</sup> The eyes were considered the bridge between the *Zang-fu* organs and the outside world, with the whole eye associated with the Liver, but various parts of the eye associated with all five *Zang* organs and six *Fu* organs.<sup>2-4</sup> Based on these early writings, inspection of the eyes was an important part of *Si-zhen*.

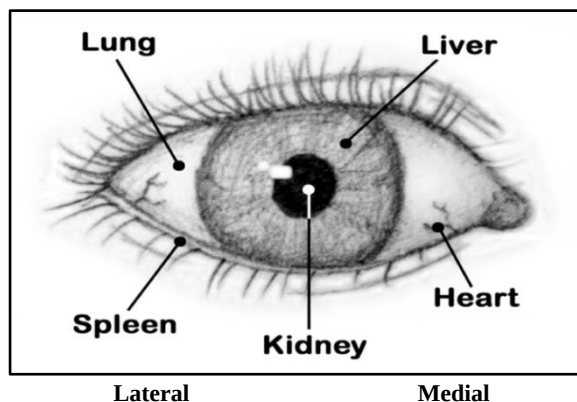
Historically, three methods of eye-based diagnosis evolved in China, each different from the other. Ancient eye examination systems centered on either changes to anatomic parts of the eye (*Wu Lun*), observation of changes to surface boundaries of the eye (*Ba Kuo*) or in each of 8 areas of the eye derived from dividing the eye into sections (*Ba Gua*). The *Wu Lun* (otherwise known as the Five Spheres system) was first introduced in *General Discourse on the Five Spheres and the Eight Boundaries of Essential Subtleties on the Silver Sea* (Sun Si Miao, 682 BC).<sup>3,5</sup> Sun correlated the five *Zang-fu* organs with Five Spheres (anatomic parts) of the eye (Figure 1). The iris of the eye was associated with the Liver/Wood element, and called the Wind-sphere. The Heart was associated with the scleral vessels, conjunctiva, medial canthus and reflected the Fire element (Blood-sphere).<sup>2</sup> The upper and lower lids were associated with the Spleen and reflected the Earth element (Flesh-sphere). The visible sclera was associated with Lung and reflected Metal element health, with its respective sphere called the Qi-sphere. The pupil of the eye was associated with Kidney *Jing* and the Water element.

The *Ba Kuo* (Eight Boundaries/Regions) system is also described in Sun's book.<sup>3,5</sup> The tissue peripheral to parts of the eye were divided into 8 diagnostic areas, each of which related to a particular organ. The names were derived from the 8 external phenomena: sky/heaven (Lung), earth (Spleen), wind (Gall Bladder), fire (Heart), water (Kidney), thunder (Liver), marshes/lakes (Small and Large Intestines), mountains (Stomach). Different organs did not occupy clearly defined positions, but had more general designations (Figure 2). This system does not extend into the center of the pupil but rather associates the general areas of the eye's perimeter which correlates with each *Zang-fu* organ system. Although contradictory in some ways, these two systems can be used in a complimentary

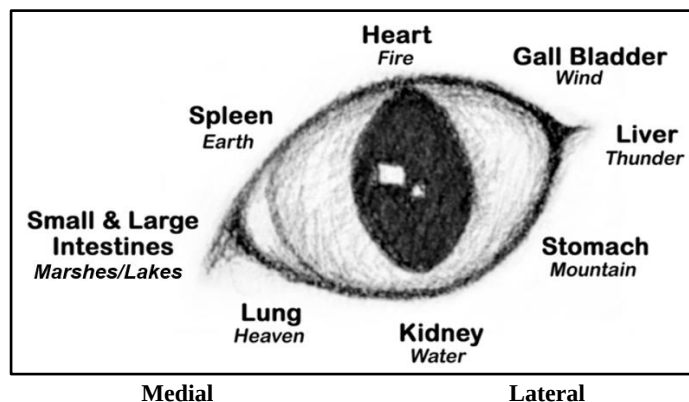
fashion, for example noting an affected eye part in the *Wu Lun* system (i.e. sclera, Lung/Metal) showing abnormalities along the thunder boundary (i.e. Liver/Wood).

The *Ba Gua* is independent of the other 2 eye diagnostic systems dividing the eye like a pinwheel with extension centrally into the pupil.<sup>3</sup> Areas of the eye are designated by using the 8 trigram figures. Each trigram is a series of solid and dashed lines representing lesser and greater Yin/Yang. This diagnostic system adds the *San Jiao* (i.e. Triple Burner/ Triple Heater), known for important functions such as distributing Body Fluid and Qi, as well as metabolic coordination and immune support. It consists of 3 functional regions/burners (i.e. Upper, Middle, Lower Burners) affecting organs of the Upper, Middle, and Lower *Jiaos*. Along with the 3 burners, the *Zang-fu* organs also have designated areas on the 8 sections of the pinwheel (Figure 3). This system provides ocular topography for 13 organs divided into the 8 areas, divided equally by the 4 pupil-centered lines.<sup>6</sup> The Upper Burner (regions above the horizontal line) also include the upper limbs/front legs, the Lower Burner is located in regions below the horizontal line, and Middle Burner includes the lower lateral area of the eye.<sup>6</sup>

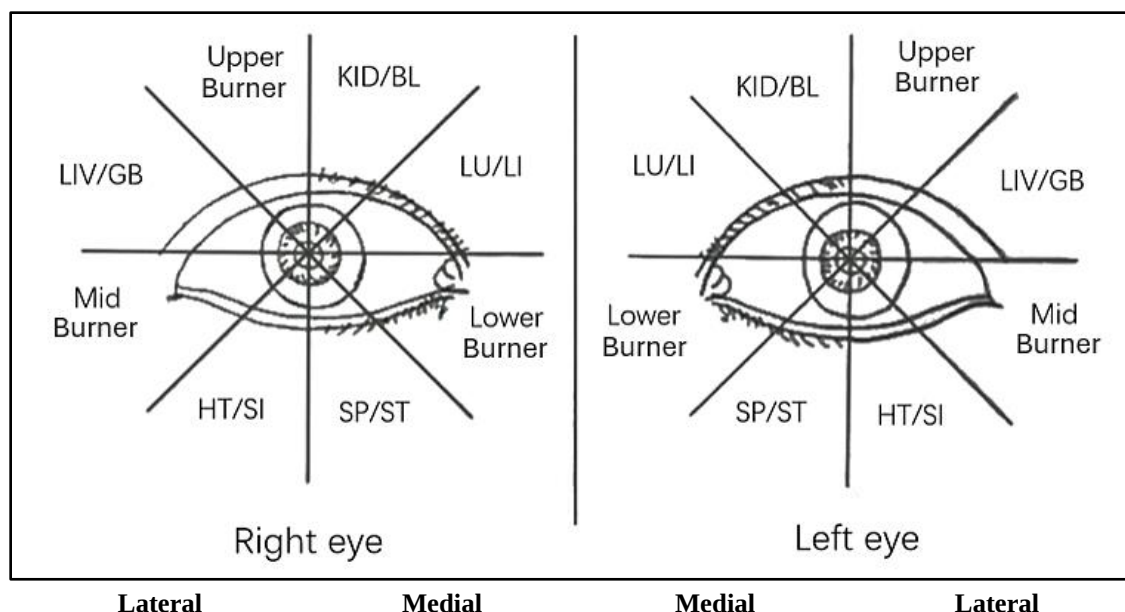
One or more of the three eye-based diagnostic systems are used in human TCM to augment clinical diagnosis.<sup>1,6,7</sup> The physiological and pathological state of the body is closely related to changes in the eyes, as the eyes are regarded as exposed *Zang* organs of the body. Traditional Chinese medicine eye diagnosis is increasingly valued for its simplicity and intuitiveness.<sup>1</sup> If a TCM diagnostic eye system could prove relevant and viable for use in animals, this information could be used as an adjunct diagnostic method to support traditional "Tongue and Pulse" diagnosis. Immediate information could be provided during physical exam when the clinician first observes a patient and also provide data for animals that cannot be easily examined during the physical to obtain a tongue and pulse diagnosis. It is also common for different diagnostics to either be unavailable, unclear, or not agree with respect to diagnosis. It would make sense that the more aspects of a patient's body that can be used to aid in making a proper diagnosis, the better and more accurate the diagnosis will be.



**Figure 1:** Illustration of the Five Spheres/Rings (*Wu Lun*) concept for TCM eye diagnosis; the five *Zang-fu* organs are correlated with the Five Spheres (anatomic parts) of the eye.<sup>4</sup>



**Figure 2:** Illustration of *Ba Kuo* (Eight Boundaries/Regions) TCM eye diagnostic system; tissue peripheral to parts of the eye is divided into 8 diagnostic areas, each of which is related to a particular *Zang-fu* organ and the regional name derived from the 8 external phenomena. This system does not extend into the center of the pupil but rather associates general regions along the eye's perimeter with disease assessment.<sup>4</sup>



**Figure 3:** The *Ba Gua* TCM eye assessment system divides the eye like a pinwheel with extension of regions centrally into the pupil. Areas of the eye are designated by 8 trigrams and it adds the Upper, Middle, Lower Burners along with designations for the *Zang-fu* organs.

There are limited publications explaining and outlining the ancient eye-based systems in TCM.<sup>8</sup> Additionally, there has been limited research in humans and no veterinary clinical research comparing or evaluating reliability of these three eye-based diagnostic systems in animals.<sup>1,3,4,6,7</sup> The primary objective of this study was to determine whether there exists correlation between the TCM eye-based diagnostic systems and clinically manifested equine disease. The hypothesis was that the TCM eye-based diagnostic systems would correspond with clinical disease diagnoses (current or past) in a study horse, and diagnostic accuracy scoring of the TCM systems would produce scores that significantly exceed those expected by random chance.

## MATERIALS AND METHODS

### Animals

A total of 103 horses were enrolled, and all study subjects were sport and pleasure horses in the mid-Atlantic region of the United States. Horses of any age, breed, sex, and health history were included. Recruited candidates were excluded from the study if they did not allow each eye to be photographed in good detail, or if a complete medical history of at least 1 year was not provided by the client. Each owner was provided information on study experimental objectives and protocol. Horse owner consent was required for participation of a horse in the study.

### Study Design

For each horse, both eyes were examined and photographed. Each horse was assigned a number according to its entrance into the study. Each eye was analyzed separately and independently of the collection, thereby blinded to the researcher, using the horse's number instead of name. The evaluations were cumulatively documented.

A single examiner (AM), blinded to the horse's medical history, made all of the assessments. These were recorded on a medical record form developed for this study. A digital camera<sup>a</sup> with a 2532-by-1170-pixel resolution at 460 ppi was used to photodocument each eye of each subject, creating a data base for the left eye and right eye for each horse.

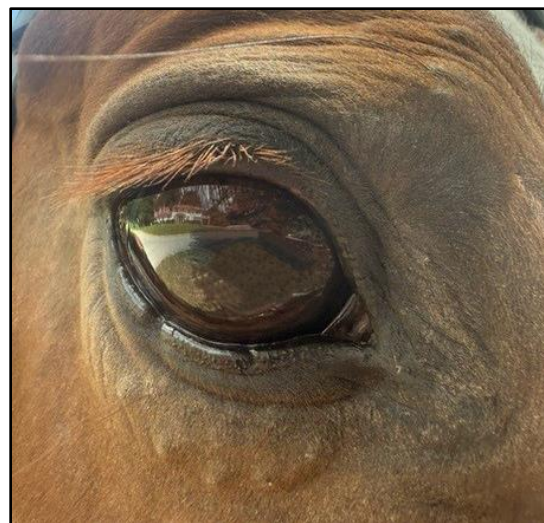
The diagnosis for each area included the general pupil area, external visible structures of the eye (e.g. iris, sclera, third eyelid, cornea) and the periocular tissue. Any change observed in normal eye structure or color was included in the "abnormal" category. These included eyelid swelling or droopiness, changes in iris coloration, corpora nigra formation, redness, inflammation, unusual blood vessel formation, and third eyelid abnormalities (Figures 4 and 5). It also included any structural abnormality deemed congenital. The outcome for each area was either "normal" or "abnormal". The results were applied to diagnoses made based on each of the traditional TCM eye-based systems: (1) *Wu Lun*, (2) *Ba Kuo*, and (3) *Ba Gua*.

### Data Extraction and Analysis

Clinical findings derived from the traditional Chinese veterinary medicine (TCVM) exam at the time of enrollment (i.e. initial clinical exam) and the findings gathered from past medical history, were converted to TCVM diseases based on the most likely Five Element Theory association. For example, kidney disorders were assigned to the Kidney element. Tendons and ligaments are governed by the Wood element in TCVM theory, so known injuries to those structures were assigned to the Wood element, or Liver/Gall Bladder. Feet are also governed by the Wood element, so a foot problem would be assigned accordingly. Weight loss would be attributed to the Spleen or Earth element. Respiratory disease would be assigned to the Lung or Metal element.



**Figure 4** (Left eye lesion documented): There is redness of the sclera located at and extending dorsal to the medial canthus. *Wu Lun* system would diagnose involvement of the Metal element (Lung-sclera) and Fire element (Heart-medial canthus, blood vessels). With location at the medial canthus, the *Ba Kuo* system would diagnose Small Intestine and Large Intestine which again involves the Fire and Metal elements. With the lesion located at and extension dorsal to the medial canthus, the *Ba Gua* system would diagnose involvement of the Metal element (Lung-Large Intestine). All three TCM eye-based diagnostic systems agree on involvement of the Metal element and 2 of the systems also included Fire element.



**Figure 5** (Right eye lesion documented): There are 2 defects in the lower eyelid. *Wu Lun* system would interpret these as involving Earth element (Spleen). In the *Ba Kuo* system, the caudal notch would involve Earth element (Stomach) and the notch located closest to the medial canthus would involve the Metal element (Lung). In the *Ba Gua* system, the cranial notch would be Earth element (Spleen-Stomach), and the caudal notch Fire (Heart-Small Intestine). All three TCM eye-based diagnostic systems agree on involvement of the Earth element. In addition, consideration of Metal or Fire elements would be added for *Ba Kuo* or *Ba Gua* respectively.

Assessment of the three TCM eye-based diagnostic systems was based on a scoring system. Each horse with a correct diagnosis of an internal disease would score “1” and incorrect diagnosis scored a “-1”. Therefore, for *Ba Kuo* and *Ba Gua*, each horse would have a diagnosis score ranging from -8 to 8 (eight areas of the orbit to evaluate), and for *Wu Lun* system would be from -5 to 5 (five anatomic structures to evaluate). If the eye system under assessment had no diagnostic value, then it was expected that the mean diagnosis score among the study subjects would be equal to 0.

Based on the diagnostic scores, the study aimed to determine whether: (1) the mean diagnosis score of the tested TCM eye-based diagnostic system is greater than 0 [null hypothesis ( $H_0$ ): mean score=0]; and (2) there exists a difference in diagnosis scores among the three eye-based diagnostic systems ( $H_0$ : All three system have the same diagnosis scores). The first hypothesis was tested using the nonparametric Wilcoxon Signed Rank test, given the ordinal nature of the diagnosis score. The comparison of the three diagnostic systems was made through a mixed logistic model for analysis of binary repeated measures data. Pair-wise comparison tests were carried out following the significance finding (a difference existed among systems) from the mixed logistic model.

It was determined that a sample size of 103 enrolled horses, using both Wilcoxon Signed Rank test and the mixed logistic model would have a greater than 95% statistical power (0.05) to reject the null hypothesis when the differences were equal to the sample standard deviation. Open-source public statistical software<sup>b</sup> was used for all data graphic presentations and statistical analysis.

## RESULTS

The study enrolled a total of 103 horses with 4 breeds predominating: 27 Warmbloods (26.2%), 22 Quarter Horses (21.4%), 21 Thoroughbreds (20.4%), 5 Morgan Horses (4.9%), and the remaining 28 other breeds (27.2%). Geldings made up two-thirds of the horses (69/103=67%); the other one-third consisted of 33 mares (32%), and 1 stallion (1%). There were 33 horses ranging from 1 to 10 years old (32.0%), 46 horses between 10 and 20 years old (44.7%), 23 were between 20 and 30 years old (22.3%), and 1 horse was over 30 years old (1%).

Under the null hypothesis, diagnosis accuracy is the same as chance level when assigning a diagnosis from the 8 diagnostic areas on the eye. Predicated on chance alone, the *Ba Kuo* and *Ba Gua* diagnostic systems would have a 36.33% chance of having a positive overall score, based on binomial distribution (at least 5 out of 8 diagnoses are correct). The *Wu Lun* system, which has 5 diagnostic areas, would have a 50% probability by chance (at least 3 out of 5 correct) to have a correct diagnosis. Based on a subject's “past medical history” data, it was observed that each of the three eye assessment systems had a distribution of diagnostic scores skewed to the right, which indicated positive diagnostic value (Figure 6). Using the Wilcoxon Signed Rank test, all three eye diagnostic systems had overall diagnostic scores significantly greater than 0 (i.e. score at the chance level), demonstrating better than chance diagnostic accuracy:  $p=5.8 \times 10^{-13}$ ,  $1.9 \times 10^{-13}$ ,  $9.4 \times 10^{-11}$  for *Ba Gua*, *Ba Kuo* and *Wu Lun* respectively. This is consistent with probability of a correct clinical diagnosis of 74.8%, 77.7%, and 79.6% for *Ba Gua*, *Ba Kuo* and *Wu Lun*,

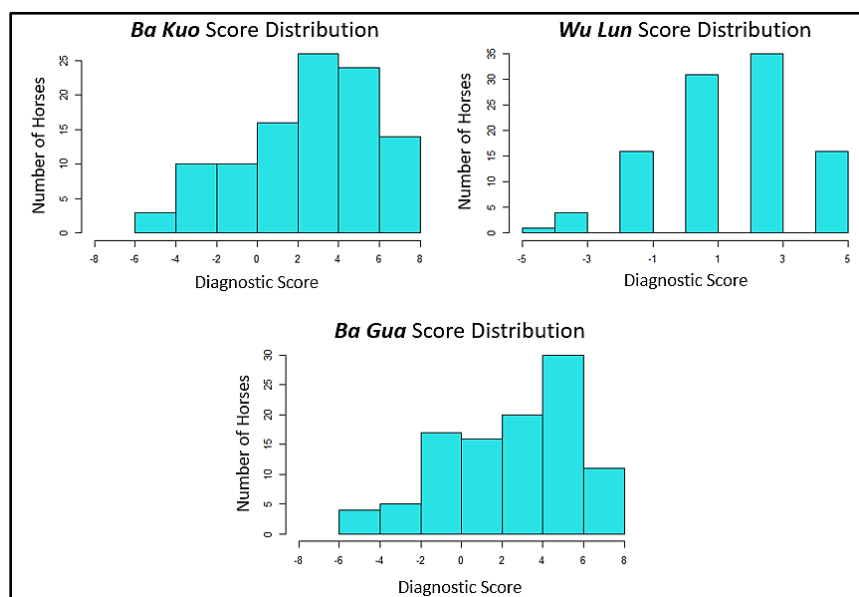
respectively, all significantly greater than the percentage at their respective chance level.

Since the *Wu Lun* system had a different number of diagnoses from the others (5 versus 8), the first group comparison was made only between the *Ba Kuo* and *Ba Gua* systems. The mixed logistic model for repeated measures data suggested that no significant difference existed between these two eye diagnostic systems ( $p=0.623$ ). When the comparison among the three systems (including the *Wu Lun*) was made only considering the five diagnoses (Heart, Spleen, Lung, Kidney, and Liver) in the *Ba Kuo* and *Ba Gua* systems, the analysis again found no significant difference among the three eye diagnostic systems ( $p=1.000$ ).

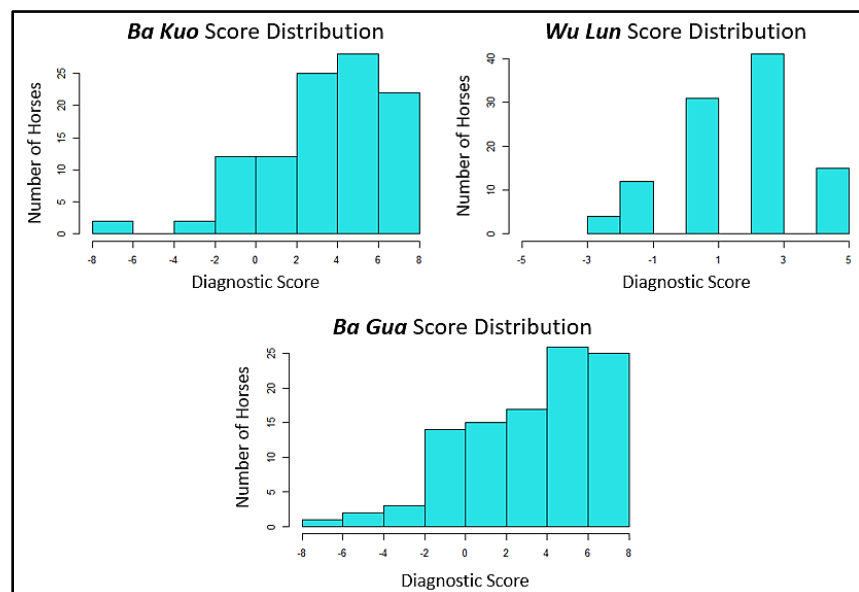
By employing the same diagnostic scoring system, based on a subject's "clinical exam findings" at enrollment, it was again observed that each of the three systems had a

distribution that was skewed to the right, which indicated a positive diagnostic value (Figure 7). Testing null hypothesis against the mean diagnostic score among the study subjects confirmed that all three eye-based diagnostic systems had overall diagnostic scores significantly greater than 0, demonstrating better than chance diagnostic accuracy:  $p=8.2\times10^{-15}$ ,  $3.0\times10^{-14}$ ,  $5.3\times10^{-13}$  for *Ba Kuo*, *Ba Gua* and *Wu Lun* respectively; all with smaller  $p$ -values (more significant) than the past medical history results. This was consistent with probability of a correct clinical diagnosis better than the chance level at 80.6%, 84.5%, and 84.5% for *Ba Gua*, *Ba Kuo* and *Wu Lun*, respectively.

The same system comparisons suggested no significant difference between *Ba Kuo* and *Ba Gua* systems ( $p=0.464$ ), nor among the three systems when considering only five diagnoses ( $p=0.243$ ).



**Figure 6:** Distribution of overall diagnostic score (against subject past medical history) for each eye diagnostic system. The higher the diagnostic score, the greater the correlation between the TCM eye assessment and conventional clinical diagnosis.



**Figure 7:** Distribution of overall diagnostic score (against subject clinical exam at study enrollment) for each TCM eye diagnostic system.

## DISCUSSION

The premise that eyes offer a window into systemic health is not new; both Western ophthalmology and ancient Chinese traditional medicine have long postulated that changes in ocular appearance can reflect internal disease or imbalances. This study investigated that premise by evaluating three ancient TCM ocular-based diagnostic systems (*Wu Lun*, *Ba Kuo*, *Ba Gua*) and their ability to accurately correlate with conventionally diagnosed equine clinical disease. An ocular examination was performed at the time of enrollment and findings from the exam, using each of the different TCM diagnostic systems, were compared to known past medical history of a horse and current disease present at the time of study enrollment. Study results demonstrated all three TCM eye-based diagnostic systems had statistically significant overall diagnostic scores correctly correlating with conventional disease diagnosis in subject horses. These findings satisfied the study hypothesis and suggest that the TCM eye-based diagnostic systems demonstrated significant correlation between *Zang-fu* organ imbalance expressed as observable external changes of the eye with conventionally diagnosed clinical disease patterns in study horses. Comparison of the TCM diagnostic systems to each other did not reveal statistically significant differences between the accuracy of *Wu Lun*, *Ba Kuo* and *Ba Gua* diagnostic assessments.

Based on a horse's clinical history, the *Wu Lun* system was the most general, but limited by diagnosis capability to five diagnoses associated with 5 eye structures. This system, however, appeared to have significant correlations for *Zang-fu* organs Spleen, Lung, Kidney, and Liver; everything but Heart. The *Ba Gua* had strongest correlations in the areas of Heart, Intestines, Kidney, Stomach, and Liver. The *Ba Kuo* had strongest correlations with the *Zang-fu* organ areas of Heart, Intestines, Lung, Stomach, Liver, and Gall Bladder.

The results of this study also showed greater positive correlation of the eye systems with current clinical presentation than it did with past medical history. Correlation with past medical history was 79.6%, 77.7%, 74.8% for *Wu Lun*, *Ba Kuo*, *Ba Gua* respectively. This exceeded diagnostic accuracy due to chance for *Ba Kuo*/*Ba Gua* (36.33%) and for *Wu Lun* (50%). Positive correlation was even greater when comparing TCM diagnosis with current clinical findings which resulted in 84.5%, 84.5%, 80.6% for *Ba Kuo*, *Wu Lun* and *Ba Gua*, respectively.

In human ocular exams, TCM inspection of the eye can play an important part as an adjunct method of diagnosing diseases.<sup>1</sup> For example, Lu et al. observing changes in eye color and using *Wu Lun* (5 Spheres), described the ability to diagnose a Deficiency of Cold or Heat in patients. They describe 66.5% of patients with primary nephrotic syndrome as having changes in color and shape of white-eye collaterals (i.e. sclera). Additionally, Liver-Kidney *Yin* Deficiency will present a pattern of white-eye collaterals that are mostly dark red. Eye shape changes based on inspecting the orbits, eyelids, pupils and blood collaterals provide information on location and

characteristics of disease; such as eyelid edema can be attributable to dysfunctions of the Lung, Spleen or Kidney.<sup>1</sup> Lai et al. goes further and relates *Wu Lun* (Five Spheres) theory in human patients to ophthalmic instrument exams of the eye with an "Inner Five Wheels/Spheres" theory.<sup>7</sup> Changes to the inner structures of the eye can be associated with *Zang-fu* organ imbalance. Rich vascular structures such as the choroid and retinal vessels are related to the Heart. All muscle fibers inside and outside the eye are dominated by Spleen, and the vitreous which is transparent, is related to the Lung. Retinal nerves and retinal pigment epithelium belong to Kidney and fascia/ligaments in the eye (i.e. lens suspensory ligament) belong to Liver. An example, such as benign primary blepharospasm, demonstrated statistical significance when treated by softening the Liver and invigorating the Spleen.<sup>7</sup> Finally, Chi et al. reviewed 81 studies (7113 human patients) using *Ba Gua* organization of the eye for selection of areas of the eye (rather than as a diagnostic system) to treat 44 different pain-related diseases.<sup>6</sup> The conclusion of this scoping review of clinical studies was that selection of acupoints by this ocular system was a promising intervention for managing diverse pain conditions.

The biggest limitation of this study was the lack of a study population with significant current health problems. Very few horses presented with acute, sub-acute, or chronic unmanaged health conditions. Many horses utilized in the study had performance concerns rather than significant internal medicine issues at the time of exam. This limitation hindered the study's capability for assessment of correlations between the tested eye systems and a wide sampling of clinical diseases. Furthermore, a good number of subjects in this study (estimated at 25%) were older and retired. Many of these horses had multiple concurrent clinical issues, which may have provided less distinct clinical pictures to correlate to eye areas.

Additionally, although these systems have potentially significant predictive value, there were unexpected inconsistencies. Most notably, the same organ may be linked to different anatomical regions within ocular topography, despite both systems reporting statistically significant findings for that organ. For instance, Heart, which was a significant correlate in both *Ba Kuo* and *Ba Gua*, was assigned to very different anatomic areas. In the *Ba Kuo* system, Heart is mapped to the peripheral area dorsal to the pupil, whereas the *Ba Gua* system assigns it to the lower mediolateral quadrant of the eye. To reconcile the contradictions, it would seem useful to further explore the historical and theoretical foundations of these diagnostic systems. The *Ba Kuo* system appears to be most concerned with the surface structures of the eye with anatomical divisions and boundaries.<sup>5</sup> The dorsal periphery, situated above the pupil would be related to upper organs of *Yang* nature with the Heart occupying a critical central position to maintain vitality. The *Ba Gua*, in contrast, is based on symbolic arrangement of the 8 trigrams, and its mappings are shaped by both philosophical principles as well as clinical experience. The lower mediolateral quadrant corresponds to specific trigrams and

may be selected for its underlying energy flows that were believed by practitioners to mirror the Heart's interaction with other systems. Notably, the *Ba Gua* features an Upper Burner quadrant (Heart, Lung, Pericardium) positioned similarly to the Heart area in *Ba Kuo*. These confounding factors highlight that there are differences in the TCM eye assessment systems and that the selection criteria for each of these systems offer alternate perspectives on how *Zang-fu* organ health manifests in the eye.

Although there have been no studies in veterinary medicine looking at the advantages of blending TCM eye exam into general TCVM clinical examination, future veterinary studies could further evaluate TCM eye exam usefulness. Weaknesses inherent in this study could be strengthened by including horses with more acute illnesses, such as those presenting to a referral hospital. By using subjects with more severe clinical signs, such as seen in the human studies, researchers would have a broader set of changes with greater severity in the outer eye structures, and therefore have more information to use for assessment of the usefulness of the TCM ocular-based diagnostic systems.

In conclusion, all three eye-based diagnostic systems had an overall diagnostic score significantly greater than the chance level score. Group comparisons on overall diagnostic results did not suggest a significant difference among eye assessment systems. Furthermore, this study found that using any of the ancient eye systems to assess TCVM pattern and clinical diseases could be helpful in diagnosing medical problems and body imbalance in the horse. Based on the results of this study, the use of TCM ocular based diagnostics in the horse during TCVM clinical examination is recommended. Future research in this area is needed to both verify the results of this study and possibly identify a more specific TCVM eye-based diagnostic system combining the 3 ancient TCM ocular assessments to produce a robust accurate veterinary TCVM ocular exam.

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## Declaration of Interest and Funding

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## FOOTNOTES

<sup>a</sup> iPhone 12, Apple Technology Co, Apple Park, Cupertino, California, USA

<sup>b</sup> R version 3.5.2; 2018-12-20. The R Foundation for Statistical Computing, Vienna, Austria; <http://www.R-project.org>

## REFERENCES

1. Lu Q, Wei K, Yan C. Review of eye diagnosis in traditional Chinese medicine: Modernization and future prospects. *J Trad Chin Med Sci* 2022; 9(3):217-221. <https://doi.org/10.1016/j.jtcms.2022.06.001>
2. Xie H, Preast V. *Traditional Chinese Veterinary Medicine, Fundamental Principles* 2<sup>nd</sup> Ed. Reddick, FL: Chi Institute Press 2013:110-151, 157-159.
3. Cheng H, Marshall A. Traditional Chinese veterinary medical ophthalmology. *Am J Trad Chin Vet Med* 2016; 11(2): 53-62. <https://doi.org/10.59565/001c.144391>
4. Cheng H, Marshall A. TCVM for the treatment of eye diseases. *Am J Trad Chin Vet Med* 2016; 11(2):79-87. <https://doi.org/10.59565/TYX14292>
5. Sun Si Miao. *Comparative Studies of Health Systems and Medical Care, Vol 38: Essential Subtleties on the Silver Sea* (682 BC), Yin-Hai Jing-Wei: A Chinese Classic on Ophthalmology. Berkley & Los Angeles, CA: Un of California Press 1998:47-58, 499.
6. Chi Y, Barth J, Wang M et al. Eye acupuncture for pain conditions: A scoping review of clinical studies. *BMC Complement Med Ther* 2021; 21(1):101. <https://doi.org/10.1186/s12906-021-03272-8>
7. Lai W, Cai H, Liu X. Broad extension of the five-wheel theory. *Trad Med Res* 2020; 3(2):331-336. <https://doi.org/10.53388/TMRT H202002004>
8. Zhang W, Hai Y, Huang C et al. Tian Weizhu's Experience on eye needling acupoints location. *Chinese Archives of Traditional Chinese Medicine* 2015; 33(1): 57-60, VI. (in Chinese). <https://doi.org/10.13193/j.issn.1673-7717.2015.01.018>