Testing the Tekscan System as a Tool for Objectively Measuring Lameness in the Horse

Summary: This study evaluated the ability of the F-Mat (Tekscan) system to assess vertical ground reaction forces, contact area and pressure. The first test used horses with chondral defects to test the precision of the systems' measurements over time. The second test used an equine osteochondral fragment model to evaluate the ability of the F-Mat to precisely sense changes in pressure, contact area and force. The first test showed that potentially there were errors in measurements due to calibration of the system, wear on the sensors from multiple testing times and use of multiple horses.

The second test also emphasized that the use of the F-Mat system would require further testing.

Lameness is the most common performance-limiting problem in the horse. In a recent survey, one-half of U.S. horse operations reported at least one horse with lameness in the previous year. In addition, lameness was listed as the most important factor in wastage of young racehorses. The economic consequences of lameness justify further research of new techniques and improvement of current methods of gait evaluation.

Humans have been observing conformation and movement in horses for many years. The physical appearance of the horse dictated primarily by bone and muscle structures is an important part of identifying potential problem areas upon physical examination. Movement of the horse is assessed from the front or rear of the horse while action is assessed from a side view. Subjective evaluation from these views allows clinicians to monitor for abnormal gait patterns in the horse. However, the subjectivity of the evaluation, based on the ability of the human eye to detect changes and the different opinions among clinicians in what they have seen, leaves room for the use of a more accurate objective method for gait evaluation.

Quantitative assessment of lameness is well established in small and large animal research through the use of force plates. The force plate measures ground reaction forces in three orthogonal directions: mediolateral (Fx), craniocaudal (Fy), and vertical (Fz). However, lack of standardization of data evaluation has made it difficult to compare results of force plate tests. The expense of buying a force plate, training a technician and testing in a laboratory environment have pushed researchers towards finding a system that is cost effective, user-friendly and as accurate and precise as the force plate system.

Pressure measurement systems were designed for use in the human podiatric profession in order to provide a quick and easy method of determining plantar pressures, vertical ground reaction forces and contact areas. Using the F-Mat system (Tekscan, Boston, MA), tests were designed using equine orthopaedic cases to evaluate the ability of this user-friendly system to assess vertical ground reaction forces, contact area and pressure. The first test used horses with chondral defects to test the precision of the systems' measurements over time. The second test used an equine osteochondral fragment model to evaluate the ability of the F-Mat to precisely sense changes in pressure, contact area and force. This type of system is ideal for clinical use if the pressure and force measurements are accurate and precise enough to provide the information to assess lameness.

Testing of the F-Mat System Using Horses Treated with Subchondral Bone Plate Microfracture for Chondral Defects

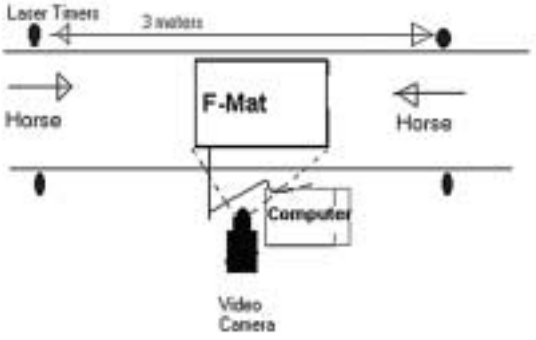
Twelve horses, two to five years of age, were studied by Valerie Perino as part of her MS work, under the supervision of Drs. David Frisbie and Chris Kawcak. The horses were determined to be in good health and free of joint effusion in the femorotibial joints. The horses were acclimated to a high-speed treadmill for a two-minute trot (3.2-m/s), two-minute gallop (7.6-9.0-m/s) and two-minute trot according to protocol to simulate athletic race training. Horses continued a similar exercise protocol 12 weeks after surgery and 4 weeks after hand walking had begun.

The horses all had 1-cm^2 defects created on the axial weigh-bearing portion of the medial femoral condyle of both hind limbs. In one limb, the defect was created to a depth leaving the calcified cartilage intact, while the other joint had a defect with the subchondral bone plate intact. All limbs underwent microfracture treatment after defect creation. Four months after initial surgery, the horses were re-anesthetized and arthroscopic examination of the defects was performed. A 2-mm biopsy was

harvested from the repair tissue filling in the defect in both hind limbs in six of the horses.

Objective evaluations were done using the F-Mat system to measure in vivo vertical ground reaction forces. The horses were tested preoperatively, four months post-surgery and every two months thereafter until the conclusion of the project at 12 months after initial surgery.

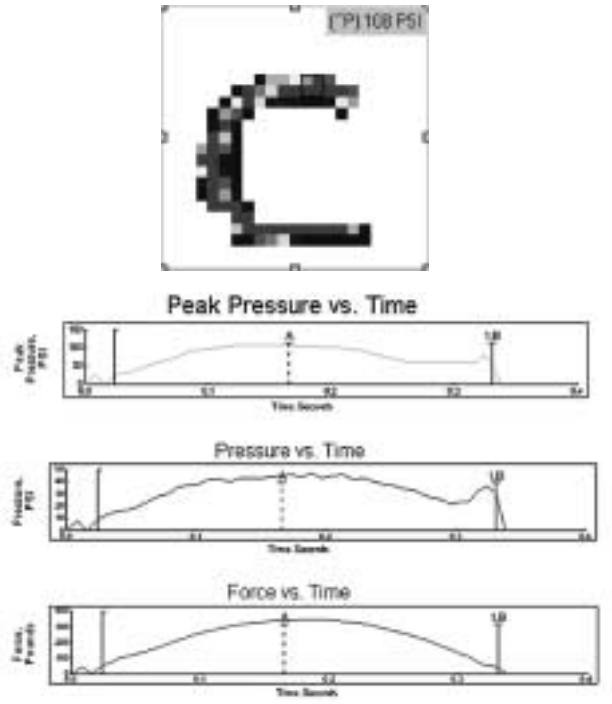
In vivo ground reaction forces were set up to be measured using the F-Mat system. A chute constructed of pipe was used to assure the horses traveled in a straight line across the F-Mat. The chute was 15.2 meters in length and 0.8 meters wide. The F-Mat used was 0.9 meters by 0.4 meters and placed at the center of the chute. A computer was connected to the F-Mat in order to record and collect data for future analysis. Infrared laser timers were placed 3.2 meters apart with the F-Mat center between the two devices. The timers were adjusted in height so the ears of the horse under study would break the sensor line. A 60 Hz video camera was used to record which hoof struck the mat as the horse passed through the chute.



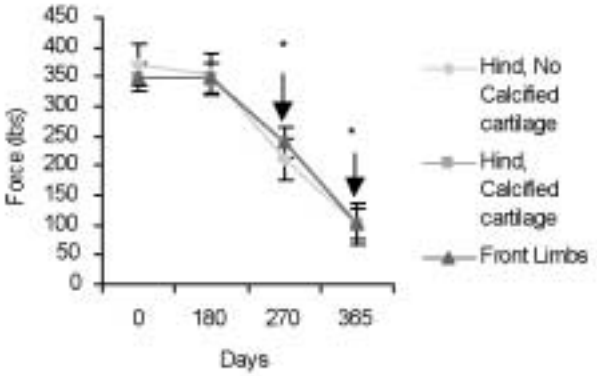
During testing, the horses were trotted through the chute at a target rate of 2.6- to 3.3-m/s. The speed of travel was monitored by laser timers, and reflected by times between 0.95- and 1.15 seconds. Data was used for analysis when hoof strikes on the F-Mat were considered whole prints collected, and the horses were traveling at the appropriate velocity. From those hoof strikes, measurements of pressure, contact area and force were collected.

From this data, a four-fold decrease in measured values was seen over a 12-month testing period in vertical force measurements.

Further analysis on the data showed that after normalization of the vertical force measurements to a front, left limb for each horse, there no longer were any significant differences in measurements when



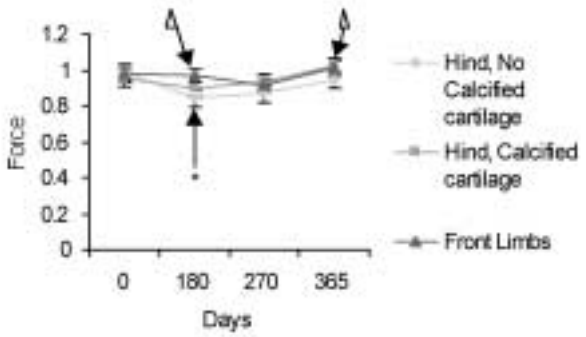
comparing limbs. This showed that potentially there were errors in measurements due to calibration of the system, wear on the sensors from multiple testing times and use of multiple horses.



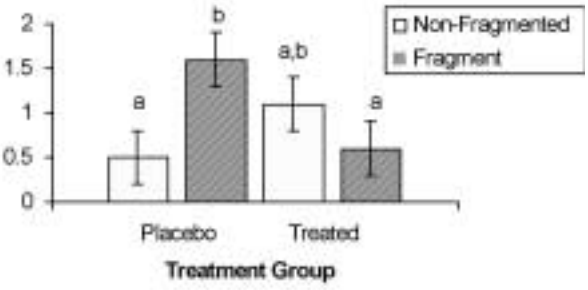
Testing the F-Mat System Using Horses Treated with Gene Therapy of IL-1RA in an Osteochondral Fragment Model of Joint Disease

Sixteen horses, two to five years of age were studied. Horses were in good health without significant musculoskeletal lesions. Each horse was acclimatized to a high-speed treadmill for a two-minute trot (13-19-km/hr), two-minute gallop (40-53-km/hr), and two-minute trot protocol to simulate athletic race training. Horses continued a similar protocol five days a week, starting 14 days after surgery.

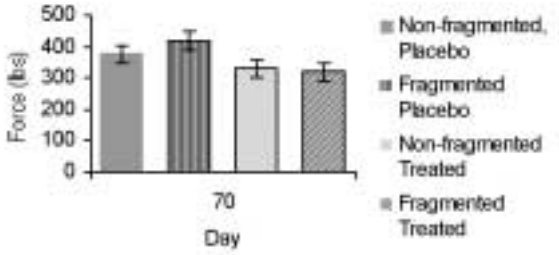
The horses were divided into two groups (treated and placebo). All horses had an osteochondral fragment created arthroscopically in one randomly selected intercarpal joint. Horses in the treated group were injected with a balanced salt solution diluting an equine adenovirus carrying the interleukin-1 receptor antagonist in the joint while placebo horses received the same dose of an injection of a balanced salt solution.



The horses underwent subjective and objective lameness examinations prior to surgery, as well as 14 and 70 days after surgery. Results from the subjective lameness exams at day 70 demonstrated that limbs with a fragment receiving placebo treatment had higher lameness scores compared to limbs with a non-fragment joint. The limbs with a fragment receiving treatment were less lame when compared to the placebo treated horses.



Results from the objective evaluations showed slight differences between the treatment groups at baseline testing. This indicated that there were small differences between the groups in vertical force measurements prior to surgery and treatment. At day 14, there was a decrease in vertical force measurements in all groups. Then, at day 70, the maximum force measurements showed that the limbs with fragments and placebo treatment had higher vertical force measurements than the limbs with fragments and treatment. This indicated that the limb observed as showing the most lameness had the highest vertical force measurements when comparing subjective to objective lameness evaluations at day 70. From these comparisons, it seems that vertical force measurements on the F-Mat inversely correlate to subjective evaluations.



These results indicated that use of the F-Mat system would require further testing. This would allow for closer monitoring of calibration of the system making sure that enough weight was placed statically on the system to compare to a horse landing on the mat. In addition, the system needs to be closely monitored for wear in the sensors that could lead to false measurements. The sensors may stay on and give force measurements that are too high, or the sensors may not turn on at all, giving low measurements. Testing temperature is also a parameter that needs close monitoring. In cold temperatures, the sensors are slow to engage, and this could affect overall force measurements. The speed the horse is traveling at and how the handler controls the animal may also affect measurements. Finally, the size of the horse's hooves may make comparisons from one animal to another difficult and the ability of the horses to adjust to the testing environment as well as to exercise may also have an effect on the overall vertical force measurements. All of these factors, in addition to the comparison of this system to a force plate, need to be looked at before investigators will be confident that the F-Mat can be used to objectively assess lameness in the horse. Comparison to a force plate will show what effect shear forces have on measurements, as well as testing the accuracy of the F-Mat by comparing it to the gold standard for objective assessments—the force plate.

Publications:

Perino, Valerie. MS Thesis.
Colorado State University. 2002.

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