Pastern Joint Motion in Trotting Horses

Hilary M. Clayton, BVMS, PhD; Wesley Singleton, BS; Joel L. Lanovaz, MS; Marta Prades, DVM

The forelimb pastern joint flexes and extends through 35° during the stance phase at the trot. Much of the rotation in the distal limb that has previously been ascribed to the coffin joint is actually occurring at the pastern joint. Authors’ address: Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, MI 48824-1314. © 2000 AAEP.

Introduction
The pastern joint is important clinically as a site of degenerative joint disease (high ringbone). This problem occurs most frequently in horses that compete in sports involving quick stops, turns, and twisting movements, such as Western performance, polo, and jumping. Luxations or subluxations of the pastern joint sometimes occur as a result of traumatic disruption of the supporting soft tissues, with or without phalangeal fracture. Treatment sometimes involves surgical arthrodesis. Knowledge of pastern joint mechanics is a step toward a better understanding of the development and treatment of pastern joint diseases.

The pastern joint is traditionally regarded as a low motion joint that has a limited amount of flexion and extension. In vitro studies indicated that pastern joint motion is minimal except under very high loading conditions. As a result, biomechanical analyses usually model the proximal and middle phalanges as a single segment, which ignores motion occurring at the pastern joint.

Our observations of slow motion video recordings of the distal limb suggest that the pastern joint undergoes more motion than is normally ascribed to it. Visually, it is possible to see pastern joint motion both in Thoroughbreds galloping at racing speed and in sport horses performing a collected trot. Accurate measurement of pastern joint motion requires the use of skin markers during the video recording to define the relative motions of the proximal and middle phalanges.

The objective of this study was to measure pastern joint motion during the stance phase for horses trotting in hand.

Methods
Six sound horses (mean weight 543 ± 60 kg) were recorded at the trot using a high speed video camera (200 frames/s) oriented perpendicular to the horses’ plane of motion. Circular (2 cm diameter) reflective markers were attached to the skin of the right forelimb overlying the centers of rotation of the carpal, fetlock, pastern, and coffin joints and to the mid-distal hoof wall. Since the center of the coffin joint cannot be located accurately by palpation, this marker was placed under fluoroscopic guidance. The markers defined the limb segments (cannon, proximal phalanx, middle phalanx, hoof) and the joints between them (fetlock, pastern, coffin).
The recording space was calibrated using a rectangular calibration frame with 18 non-collinear points. Four trials per horse were recorded from the right side as the horses trotted along a firm-surfaced runway. Sagittal plane motion was analyzed using custom software. The raw data were smoothed using a 6-Hz Butterworth digital filter. In the distal limbs, skin motion relative to the underlying bones is minimal, so correction for skin displacement was not necessary. The angles of the fetlock, pastern, and coffin joints were calculated and plotted.

**Results**

All horses showed the same pattern of pastern joint kinematics during the stance phase (Fig. 1). In early stance, the pastern joint flexed, reaching a minimal angle of $155 \pm 11^\circ$ at 34% of stance. The joint then extended to a maximal angle of $190 \pm 3^\circ$ at 92% of stance followed by a slight flexion during breakover (Fig. 1, Table 1). The range of motion for the pastern joint during the stance phase of the trot was $35 \pm 8^\circ$. Timing of the flexion and extension peaks at the pastern joint coincided quite closely with the flexion and extension peaks at the coffin joint (Fig. 1). The fetlock joint showed a single cycle of extension during stance that peaked in the middle of the stance phase (Fig. 1).

**Discussion**

The proximal and middle phalanges articulate at the pastern joint. Since these bones are short, relative motion between them is difficult to appreciate unless skin markers are used to define their movements. The use of such markers in this study indicated that the pastern joint undergoes a larger range of motion than was previously realized, and some of the motion that has been ascribed to the coffin joint actually occurs at the pastern joint.

The pastern joint moves around the angle of alignment of the proximal and middle phalanges. For the stance phase of the trot, the joint shows $25^\circ$ of flexion on the palmar aspect and $10^\circ$ of extension on the dorsal aspect. The fact that the joint moves around the position of alignment is, perhaps, a factor contributing to the success of pastern joint arthrodesis. When the horse is in a standing position, it has been shown radiographically that the proximal phalanx is slightly more vertical than the middle and distal phalanges by about $10^\circ$.6 This is the

![Fig. 1. Angles of the coffin joint (dark, solid line), pastern joint (dashed line), and fetlock joint (light, solid line) during the stance phase of the trot.](image-url)

**Table 1. Peak Angles and their Times of Occurrence at the Coffin, Pastern, and Fetlock Joints of the Forelimb During the Stance Phase of the Trot.**

<table>
<thead>
<tr>
<th>Joint</th>
<th>Coffin Joint (deg)</th>
<th>Pastern Joint (deg)</th>
<th>Fetlock Joint (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal Angle</td>
<td>169.4 (4.6)</td>
<td>155.3 (11.0)</td>
<td>—</td>
</tr>
<tr>
<td>Time of Minimal Angle (% stance)</td>
<td>36.7 (5.0)</td>
<td>34.2 (3.4)</td>
<td>—</td>
</tr>
<tr>
<td>Maximal Angle (deg)</td>
<td>193.0 (4.3)</td>
<td>190.2 (3.8)</td>
<td>250.1 (6.7)</td>
</tr>
<tr>
<td>Time of Maximal Angle (% stance)</td>
<td>94.3 (1.7)</td>
<td>92.7 (5.9)</td>
<td>46.4 (3.4)</td>
</tr>
<tr>
<td>Range of Motion (deg)</td>
<td>23.6 (4.3)</td>
<td>34.9 (8.0)</td>
<td>60.6 (7.1)</td>
</tr>
</tbody>
</table>

Values are mean and (SD).
same as the maximal angle recorded in this study during the stance phase at the trot, which suggests that extension is limited mechanically during locomotion by the same soft tissues that support the joint in the standing position.

The segmental motions that produce the coordinated flexions and extensions of the distal joints in early stance are complex and finely coordinated. In early stance the coffin and pastern joints flex simultaneously while the fetlock is extending. Peak flexions of the coffin and pastern joints occur almost simultaneously. The extensor branches of the suspensory ligament play an important role in limiting flexion of the distal joints, and in preventing these joints from buckling forward in early stance. Later in the stance phase the pastern joint extends, probably in response to tension in the superficial digital flexor tendon and the distal sesamoidean ligaments, which pull their phalangeal attachments in a palmar direction.

In conclusion, the pastern joint showed 35° of flexion and extension during the stance phase of the trot, with maximal flexion (155°) occurring at 34% stance and maximal extension (190°) at 92% stance. The effects of pastern joint motion should be taken into account in future studies of the distal joints of the equine limbs. The fact that the pastern joint undergoes a significant amount of flexion during the braking phase may offer an explanation for the rather high incidence of pastern joint arthritis in sports that involve rapid deceleration.

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References