Factors associated with racing performance of Thoroughbreds undergoing lag screw repair of condylar fractures of the third metacarpal or metatarsal bone

George S. Martin, DVM, MS, MBA, DACVS

Objective—To evaluate effects of sex, fracture configuration, affected limb, and screw placement on outcome of Thoroughbreds with condylar fractures involving the third metacarpal or metatarsal bone.

Design—Cohort study.

Animals—56 horses.

Procedure—Age, sex, affected limb, fracture configuration, fracture length, fracture fragment width, and distance of the most distal screw from the articular surface were analyzed in logistic regression models.

Results—Females were more likely to have displaced fractures and race in fewer races after surgery than males. Sex and fracture configuration were associated with number of postoperative races. Among horses that returned to racing, those with thicker fracture fragments were 11 times as likely as horses with thinner fracture fragments to win a race after surgery. Horses with longer fractures and older horses had fewer postoperative races. Horses in which the most distal screw had been placed further from the joint surface had more races.

Conclusions and Clinical Relevance—Results suggest that female horses with displaced condylar fractures and male horses with nondisplaced condylar fractures are more likely to be referred for treatment. The effect of sex on outcome for these horses cannot be clearly separated from the effect of fracture configuration. When adjusted for fracture configuration, males were 6 times as likely as females to race after surgery. When adjusted for sex, horses with nondisplaced fractures were 17 times as likely as horses with displaced fractures to race after surgery. Results suggest that the most distal screw should be placed above the epicondylar fossa. (J Am Vet Med Assoc 2000;217:1870–1877)

Condylar fractures are common among Thoroughbred racehorses and occur in the forelimb more frequently than in the hind limb and in the lateral condyle more frequently than in the medial. Medial condylar fractures more commonly affect the third metatarsal bone (MTIII) than the third metacarpal bone (MCIII) and are often long, incomplete, and spiraling in configuration; however, a recent study of Thoroughbred racehorses suggests that spiral fractures of the medial condyle may be more common in the forelimbs than previously thought. Lateral condylar fractures rarely spiral into the diaphysis.

The prognosis for Thoroughbreds with a condylar fracture depends on the fracture configuration. Horses with incomplete fractures or with complete but nondisplaced fractures are more likely to race after treatment and convalescence than horses with displaced condylar fractures. Horses with comminution of the fracture at the palmar or plantar surface of the condyle or with concurrent sagittal axial sesamoid bone fractures have a poorer prognosis for returning to racing. There is some indication that horses with a condylar fracture of the right MCIII have a better prognosis than those with a fracture of the left MCIII.

Sex of the horse will influence decisions regarding treatment of condylar fractures. For instance, female horses with incomplete condylar fractures can be treated conservatively if the owners only intend to use them for breeding in the future. Sex and age also influence the characteristics of horses in race training. Generally, females are retired earlier than colts and geldings because of their breeding potential. This stratification of the sex composition of horses in race training alters the characteristics of the group of horses likely to develop condylar fractures. In previous studies, however, sex was not examined as a cofactor along with fracture configuration for its effect on condylar fracture characteristics or on likelihood to return to racing.

Equine surgeons have conflicting opinions regarding the best surgical treatment for horses with condylar fractures. Some surgeons suggest that the best location for the most distal screw is at the epicondylar tubercle to avoid surgical injury to the collateral ligament. Other surgeons, however, stress the need for good compression across the fracture line at the level of the joint and, therefore, recommend placing the most distal screw through the collateral ligament in the epicondylar fossa as close to the joint surface as possible.

The purpose of the study reported here was to evaluate the effect of sex, fracture configuration, affected limb, and screw placement on outcome of Thoroughbred racehorses with condylar fractures involving MCIII and MTIII.

Materials and Methods

Horses—Thoroughbreds examined at the Louisiana State University Veterinary Teaching Hospital because of a fracture involving the condyles of MCIII or MTIII were included. Horses with fractures that spiraled up the diaphysis were excluded.

From the Department of Veterinary Clinical Sciences, School of Veterinary Medicine, Louisiana State University, Baton Rouge, LA 70803.
Medical record review—Information concerning age, sex, limb involved, and any unusual events during hospitalization was obtained from the medical records. Race records were obtained from the Jockey Club. Radiographs were reviewed, and fractures were classified as incomplete, complete but nondisplaced, or displaced. In addition, radiographs were examined for evidence of comminution at the palmar or plantar surface of the condyle and for axial sesamoid bone fractures. Number of screws used for fracture fixation and location of the most distal screw (epicondylar fossa vs at or above the epicondylar tubercle) were also recorded.

On the dorsopalmar and dorsoplantar radiographic views, fracture length, distance of the fracture from the abaxial surface of the joint, and distance of the most distal screw from the condylar articular surface were measured. Measurements were adjusted for radiographic magnification by using the known diameter of the 4.5-mm screws used for fixation as follows:

$$\text{actual distance (mm)} = \frac{\text{measured distance (mm)}}{4.5 \text{ mm/screw diameter measured on the radiograph}}$$

The overall quality of repair was assessed on a scale from 1 to 5 on the basis of screw position and direction in the lateral and sagittal planes, use of a screw of appropriate length, decreased visibility of the fracture line on the postoperative dorsopalmar or dorsoplantar projection, and amount of irregularity, if any, at the articular surface. Fixation was considered good if the quality of repair score was ≥3.5 and poor otherwise.

Examination of race records—Race records of horses included in the study were purchased from the Jockey Club and organized as described. Indicator variables (0, 1) were used to denote whether horses raced prior to surgery, won prior to surgery, raced after surgery, and won after surgery and whether postoperative earnings exceeded twice the cost of treatment. Number of races, purse value, total earnings, earnings per race, earnings percentage (earnings/60% of purse value), and mean prediction error before and after surgery were also recorded. Prediction error is calculated as actual finish time minus predicted finish time and is a measure of average performance; therefore, horses with faster-than-average finish times have negative prediction errors.

Statistical analyses—Data were analyzed according to signalment and fracture characteristics, and distribution of limb involvement between sexes, distribution of limb involvement by age, distribution of fracture type by sex, and distribution of fracture type by age. The χ² test for independence was used to determine whether racing after surgery was associated with sex or fracture configuration. To compare postoperative performance of horses with displaced fractures with performance of horses with nondisplaced or incomplete fractures, numbers of postoperative races were examined by means of ANOVA, and numbers of horses earning twice the cost of treatment and earnings percentages were examined by means of the Kruskal-Wallis test. The influences of fracture configuration and sex on number of postoperative races were examined by means of 2-way ANOVA.

Logistic regression was used to assess the influence of various factors on the proportion of horses that raced after surgery, the proportion that won at least 1 race after surgery, and the proportion that earned at least twice the cost of treatment for all horses and for the subset of horses that raced after surgery. Univariate logistic regression was used to assess the effect of 17 independent variables on whether horses raced after surgery. These variables were age of the horse (years), fracture length (mm), fracture fragment width (mm), distance of the most distal screw from the articular surface (mm), location of the most distal screw (epicondylar fossa vs at or above the epicondylar tubercle), sex (male, female), comminution at the articular surface (yes vs no), fracture configuration (displaced vs complete but nondisplaced or incomplete), mean preoperative prediction error, affected limb (forelimb vs hind limb), affected side (left forelimb vs right forelimb), number of screws, presence of palmar fragmentation (yes vs no), number of preoperative races, presence of a sagittal sesamoid bone fracture (yes vs no), winning history, and quality of fixation score. Those variables that appeared promising were selected for inclusion in a multivariate logistic regression model. For horses that raced after surgery, the same variables were used in univariate and multivariate logistic regression modeling of whether a horse won after surgery and whether a horse earned twice the cost of treatment after surgery.

Poisson discrete regression was used to assess the potential influence of various factors on number of postoperative races among horses that raced after surgery. Factors used were the same as those used for logistic regression modeling. Among those horses that raced after surgery, number of races, purse value, earnings per race, earnings percentage, and prediction error before and after surgery were compared. The Shapiro-Wilks test was used to test for normal distribution of the data. The χ² test of independence was used to screen relationships among variables. Paired t-tests, ANOVA, and 2-way ANOVA tests were used to test for differences among normally distributed variables, and the Kruskal-Wallis test was used to test for differences among variables that were not normally distributed. For all analyses, a value of P < 0.05 was considered significant. Statistical software was used to perform the statistical tests.

Results
Fifty-six horses met the criteria for inclusion in the study. Race records were available for 53 of these 56, and radiographs were available for 44 of the 53 for which race records were available.

Associations among affected limb, sex, age, and fracture configuration—Sex of the horses was not significantly associated with the distribution of condylar fractures among limbs (χ² test; P = 0.93), but as expected, more horses had fractures involving the forelimbs (50) than hind limbs (6; Table 1). Similarly, age at the time of injury was not significantly associated with distribution of condylar fractures among limbs (χ² test; P = 0.96; Table 2). Sex was significantly associated with fracture configuration (χ² test; P = 0.003), with females more likely to have displaced fractures than males, but...
Table 2—Distribution of condylar fractures by affected limb and age for Thoroughbred racehorses

<table>
<thead>
<tr>
<th>Affected limb</th>
<th>2-year-old</th>
<th>3-year-old</th>
<th>4-year-old</th>
<th>5-year-old</th>
<th>6-year-old</th>
<th>7-year-old</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right forelimb</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Left forelimb</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Right hind limb</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Left hind limb</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>18</strong></td>
<td><strong>17</strong></td>
<td><strong>3</strong></td>
<td><strong>4</strong></td>
<td><strong>2</strong></td>
<td><strong>56</strong></td>
</tr>
</tbody>
</table>

*Includes nondisplaced complete fractures and incomplete fractures.

Table 3—Distribution of condylar fractures by fracture configuration and sex for Thoroughbred racehorses

<table>
<thead>
<tr>
<th>Fracture configuration</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displaced</td>
<td>5</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Nondisplaced*</td>
<td>23</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28</td>
<td>18</td>
<td>44</td>
</tr>
</tbody>
</table>

*Includes nondisplaced complete fractures and incomplete fractures.

Table 5—Outcome of Thoroughbred racehorses with condylar fractures as a function of fracture configuration

<table>
<thead>
<tr>
<th>Fracture configuration</th>
<th>Raced</th>
<th>Did not race</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displaced</td>
<td>3</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Nondisplaced</td>
<td>25</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28</td>
<td>16</td>
<td>44</td>
</tr>
</tbody>
</table>

Table 6—Mean ± SEM number of races after surgery for Thoroughbreds with condylar fractures classified on the basis of sex and fracture configuration

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-displaced fracture</td>
<td>23.4 ± 4.7a</td>
<td>5.5 ± 2.3b</td>
<td>8.6 ± 5.0b</td>
<td>0.8 ± 0.8b</td>
</tr>
<tr>
<td>Displaced fracture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values with different superscript letters are significantly ($P < 0.05$) different.

Influence of fracture configuration on return to racing, earnings, and earning percentage—Among the 53 horses for which race records were available, 50 had raced prior to surgery, and 34 of these had won at least 1 race. Thirty-two horses raced after surgery. None of the 3 horses that had not raced before surgery raced after surgery. Of the 44 horses for which race records were available, 15 had displaced fractures. For these horses, when outcome was considered independent of sex, those with nondisplaced fractures were 25 times (95% confidence interval, [CI], 4.82 to 129.75; $P < 0.001$) as likely to race after surgery as those with displaced fractures (Table 5). Horses with nondisplaced fractures were also 17.06 times (95% CI, 3.13 to 92.96) as likely to win after surgery as horses with displaced fractures and mean number of races after surgery for horses with nondisplaced fractures (mean ± SEM, 18.10 ± 3.8) was significantly (mean ± SEM, 18.10 ± 3.8) greater than mean number of races after surgery for horses with displaced fractures (3.4 ± 2.04). Horses with nondisplaced fractures did not have significantly (mean ± SEM, 18.10 ± 3.8) higher earnings per race after surgery, compared with horses with displaced fractures, but did have significantly (mean ± SEM, 18.10 ± 3.8) higher earning percentages. Only 2 of the 15 horses with displaced fractures earned twice the cost of treatment after surgery, whereas 22 of the 29 horses with nondisplaced fractures did.

Influence of sex and fracture configuration on number of postoperative races—Mean number of races after surgery for females (mean ± SEM, 2.4 ± 1.1) was significantly ($P = 0.001$) less than mean number of races after surgery for males (19.8 ± 4.0). Two-way ANOVA adjusted for nonorthogonal data revealed significant effects of sex ($P = 0.016$) and fracture configuration ($P = 0.01$) on number of postoperative races, but the interaction between sex and fracture configuration did not have a significant ($P = 0.16$) effect on number of postoperative races (Table 6).

Influence of left versus right forelimb—Twenty-one horses had fractures of the left MCIII, and 19 had fractures of the right MCIII. For horses with forelimb fractures, affected side (left vs right) was not significantly associated with fracture configuration ($P = 0.92$) or with whether horses did or did not race after surgery ($P = 0.69$). When postoperative prediction error was used as a measure of racing speed, there was no significant difference in prediction error ($P = 0.82$), postoperative earnings per race ($P = 0.36$), or earnings percentage ($P = 0.10$) between horses with...
fractures of the left forelimb versus horses with fractures of the right forelimb. For horses that raced after surgery, mean prediction error before surgery (mean ± SEM, −1.71 ± 0.26) was not significantly different from mean prediction error after surgery (−1.61 ± 0.32).

Factors associated with a return to racing—When results for the 44 horses for which complete records were available were analyzed, females were found to be a tenth as likely to return to racing after surgery as males (95% CI, 0.02 to 0.41; P = 0.004) and had 0.13 times the likelihood of earning twice the cost of treatment after surgery (95% CI, 0.03 to 0.54; P = 0.005), but females were 7.67 times as likely as males to have displaced fractures (95% CI, 1.89 to 31.08; P = 0.003), and 10 of the 15 horses with displaced fractures were female. Males were 10.12 times as likely as females to return to racing after surgery (95% CI, 2.42 to 42.38; P = 0.002), but males were also significantly more likely to have nondisplaced fractures than females.

Factors found, by means of univariate logistic regression, to be associated with racing after surgery were fracture length (P = 0.0241), sex (P < 0.001), fracture comminution (P = 0.04), fracture configuration (P < 0.001), mean preoperative prediction error (P = 0.005), number of screws (P = 0.009), and a concomitant sagittal sesamoid bone fracture (P = 0.003). In multivariate logistic regression, however, sex and fracture configuration were the only factors that could be combined to result in significant effects and meaningful odds ratios. When adjusted for fracture configuration, male horses were 5.54 times (95% CI, 1.00 to 30.68) as likely as females to race after surgery. When adjusted for sex, horses with nondisplaced fractures were 16.67 times (95% CI, 2.96 to 94.03) as likely as horses with displaced fractures to race after surgery.

The interaction of sex and fracture configuration was not significant.

Factors associated with winning after surgery—For the 44 horses for which records were complete, factors found, by means of univariate logistic regression, to be associated with winning a race after surgery were similar to factors found to be associated with a return to racing, but none could be combined in a multivariate model in a useful fashion. The 2 most important variables again were sex and fracture configuration. In univariate analyses, males were 7.5 times as likely to earn twice the cost of treatment after surgery as females (95% CI, 1.86 to 30.3; P = 0.003), and horses with nondisplaced fractures were 20.43 times as likely as horses with displaced fractures to earn twice the cost of treatment after surgery (P < 0.001). When these 2 variables were combined in a multivariate model, horses with nondisplaced fractures were 13.75 times as likely as horses with displaced fractures to earn twice the cost of treatment after surgery (95% CI, 2.34 to 80.85; P = 0.001). Fracture configuration remained significant in the multivariate model, whereas sex was not significantly associated with whether a horse earned twice the cost of treatment after surgery (P = 0.11). When only the 28 horses that returned to racing were considered, none of the factors examined were significantly associated with earning twice the cost of treatment after surgery.

Factors associated with number of postoperative races—For the 28 horses that returned to racing, univariate Poisson regression analysis indicated that fracture configuration width (P = 0.002), age at the time of surgery (P = 0.001), fracture length (P < 0.001), sex (P < 0.001), fixation quality score (P < 0.001), and distance of the most distal screw from the condylar articular surface (P < 0.001) were significantly associated with number of postoperative races. Multivariate Poisson regression analysis indicated that fracture configuration width (P = 0.001), age at the time of surgery (P = 0.001), distance of the most distal screw from the condylar articular surface (P < 0.001), and fixation quality score (P < 0.001) were significantly associated with number of postoperative races. The signs of the coefficients indicated that horses with longer fractures and older horses had fewer postopera-
tive races. Fracture length was not associated with age at the time of surgery ($\chi^2$ test; $P = 0.83$) or with fracture configuration ($P = 0.12$). Horses with nondisplaced fractures raced a total of 525 times after surgery, but horses with displaced fractures raced a total of only 51 times. Males had more postoperative races than females. Horses in which the most distal screw had been placed further from the joint surface had more races. The most distal screw was placed significantly ($P < 0.001$) farther from the joint surface in horses with thicker fracture fragments (> 13.5 mm) than in horses with thinner fracture fragments. Distance of the most distal screw from the condylar articular surface was not associated with sex ($P = 0.42$). Finally, horses with higher quality of fixation scores had more races than those with lower scores. When quality of fixation was divided into poor versus good, neither postoperative earnings per race ($P = 0.07$) nor earnings percentage ($P = 0.08$) was significantly associated with fixation quality; however, lower quality of fixation scores were significantly ($P = 0.008$) associated with displaced fractures.

Earnings among horses that raced after surgery—Horses that raced after surgery had significantly ($P = 0.017$) higher earnings per race prior to surgery (median, $1,174$) than they did after surgery (median, $580$); however, total earnings ($P = 0.62$) and earnings percentage ($P = 0.80$) before surgery were not significantly different from values after surgery. Median total earnings per horse were $11,145$ after surgery and $11,145$ after surgery. Median earning percentage per race was $13.5\%$ prior to surgery and $11.7\%$ after surgery. Purse value per race was significantly ($P < 0.001$) higher prior to surgery (median, $12,067$) than after surgery (median, $5,528$).

Discussion

The percentage of horses with condylar fractures in the present study that had a forelimb involved (50/56; 89%) was higher than the percentages in previous reports, however, the preponderence of forelimb involvement was consistent in all reports. Forelimb injury is probably more common because of the additional weight carried by the forelimbs, and because of the additional stresses encountered by the lead forelimb at a gallop. The percentage of horses with forelimb involvement may have been high in the present study, because horses with fractures that spiraled up the bone were excluded. Spiral fractures are more common in the hind limb than in the forelimb in most reports; however, a recent study suggests that in some groups of horses, spiral fractures are more common in the forelimb.

Sex and age were not associated with which limb was affected in the present study. Interestingly, previous retrospective studies have not specifically ruled out the possibility that sex and age may have an effect on which limb is injured. In the present study, age was not significantly associated with fracture configuration (displaced versus complete but nondisplaced or incomplete). Ellis reported that medial condylar fractures were more common among 2-year-old horses but did not mention any effect of age on fracture configuration. The effect of age was investigated in the present study, because bone elasticity is likely to change as young Thoroughbreds mature, making it seem likely that older horses would be predisposed to develop displaced fractures. However, this supposition was not found to be true. Recent scanning electron microscopic examination of the subchondral bone of the distal aspects of MCIII and MTIII indicates that these bones have a high degree of anisotropy. The trabeculae are in the form of parallel plates in the sagittal plane and joined by smaller, and perhaps weaker, side-struts. Using computed tomography and microradiographic stereolgy, Riggs et al demonstrated sclerosis of the palmar and plantar medial and lateral condyles of MCIII and MTIII and a substantial density gradient between the condyles and the less-dense subchondral bone of the sagittal ridge. This gradient may lead to stress concentration and predispose horses to condylar fractures between the parallel plates of subchondral bone. Stover et al demonstrated areas of osteoporosis in this same area in horses necropsied after lateral condylar fracture. These factors are likely to predominate in the etiology of condylar fractures and overwhelm any influence of age-related bone characteristics.

Sex was strongly associated with fracture configuration in the present study; 10 of 16 females (69%) had displaced fractures, whereas only 5 of 23 males (18%) did. Referential bias is the most likely explanation for these differences. Most females with nondisplaced fractures would be treated conservatively, with the expectation that they would retire to breeding and would not be referred to a veterinary teaching hospital for treatment. On the other hand, females with displaced fractures would be expected to have a poor prognosis even for breeding without surgery and would be more likely to be referred. The situation for males would be the opposite. Males with displaced fractures would be less likely to be referred because of the poor prognosis for a return to racing, and males with nondisplaced fractures would be referred more frequently because of the better prognosis associated with nondisplaced fractures.

Meagher introduced the complete, complete but nondisplaced, and incomplete classification system for condylar fractures in 1972, and Rick et al demonstrated in 1983 that horses with displaced fractures had a poor prognosis. Unfortunately, neither study reported the distribution of fracture configuration by sex. Therefore, we do not know if a referral bias existed prior to these reports. Conceivably, the referral bias developed because of these reports of the poor prognosis for racing for horses with displaced condylar fractures. Since then, a more recent retrospective report found that the prognosis for a return to racing for horses with displaced condylar fractures was better than expected. Fifty-eight percent of horses with displaced fractures raced after surgery, whereas in the study by Rick et al, only 32% did. Unfortunately, neither study evaluated whether sex was associated with outcome.
Additionally, many factors not measured in the present or previous studies may be associated with the likelihood that horses with condylar fractures will race after surgery. For example, surgical and anesthesia methods have improved, improving our ability to treat equine patients. We have a better understanding of the injury process, a better ability to recognize prodromal signs, and better diagnostic capabilities through improved radiographic and scintigraphic imaging. Further, a greater number of medications are available for treatment of musculoskeletal disorders in horses. In the present study, however, only 3 of 12 (25%) horses with displaced condylar fractures returned to racing.

The higher prevalence of displaced fractures among females may also be attributable to a true biological sex effect. Sex is a profound biologic factor, and perhaps the MCIII and MTIII in females are mechanically predisposed to develop more severe fractures. Data from the present study neither support nor refute this possibility.

Unlike previous reports, only a few horses in the present study had not raced prior to injury, but none of these horses raced after surgery. In a report from England,2 most Thoroughbreds with condylar fractures had not raced prior to injury, and 61% did race after treatment. In a recent report from Kentucky,17 25% of horses with condylar fractures had not raced prior to injury, but 65% did race after treatment. Differences between results of the present study, which involved horses predominantly from Louisiana, and results of these previous studies may be a reflection of differences in horse quality. In a retrospective study of horses from Kentucky that underwent periosteal transection because of angular limb deformities,21 treated horses had higher 2-year-old starting status (39%) than the breed mean (16%), and comparisons between treated horses and their half-siblings were used to control for the superior quality of treated horses. In addition, mean market price for yearlings sold in Kentucky ($97,749) is much greater than mean market price for yearlings sold in Louisiana ($6,157).2 Basic theories of market efficiency suggest that horses from Kentucky are of better breeding, and this better breeding of horses in previous studies may have led to higher expectations among the owners, which may have motivated them to seek surgical treatment even for horses that had not raced previously. Owners of horses of lower quality breeding may have been less likely to seek surgical treatment for horses that had not raced previously.

In the present study, horses with nondisplaced fractures were more likely to race and raced more often after surgery. Because they were able to race more often, they were also more likely to win. This is in agreement with results of previous studies.237 Females raced in significantly fewer races after surgery than males in the present study. Two-way ANOVA revealed that sex and fracture configuration were significantly associated with number of postoperative races. Fracture configuration was probably important because it is a measure of the degree of permanent damage to the articular cartilage and the severity of secondary osteoarthritis likely to develop. Sex probably was important because of its effects on decision-making by owners. Because of a female's potential breeding productivity, many owners will not pursue further racing even though the horse may be physically capable. A selection bias associated with sex has been recognized in racing Quarter Horses11 and has been speculated to have an influence on outcome of horses with condylar fracture.3,37 Results of the present study indicate that sex has a substantial influence on outcome, which limits our ability to understand postinjury performance clearly.

In horses involved in the present study, the injury occurred about equally in the right and left forelimbs. Rick et al2 and Ellis3 reported a higher prevalence in the left forelimb, but Zekas et al17 reported a higher prevalence in the right forelimb. Differences among these reports are likely attributable to the variety of track surfaces, size, shape, banking, and direction through turns (clockwise vs counterclockwise).

In the present study, involvement of the right versus the left forelimb did not influence whether a horse raced after surgery or, as assessed by evaluating prediction errors, postoperative race speeds. Accordingly, there was no difference in the postoperative earnings between horses with left and right forelimb injuries. Analysis of prediction errors also indicated that regardless of limb involved, horses could race as fast after surgery as they had before surgery. This contradicts the suggestion that horses with a right forelimb injury have a better prognosis.60 Females were less likely than males to race after surgery in the present study; however, the sex effects cannot be clearly separated from the effects of fracture configuration because of the asymmetric distribution of fracture configuration between sexes. Although several factors appeared potentially useful in univariate logistic regression analysis for predicting which horses would race after surgery, only sex and fracture configuration could be combined in a meaningful multivariate logistic regression model. This information may be useful for clinicians when speaking with owners and trainers. For example, when adjusted for fracture configuration, male horses with condylar fractures are about 6 times as likely as female horses to return to racing. Similarly, when adjusted for sex, horses with nondisplaced fractures are about 17 times as likely as horses with a displaced fracture to race again.

Attempts to create a multivariate logistic regression model of winning a race after surgery and of earning twice the cost of treatment after surgery were not thoroughly successful. The effort, however, confirmed the importance of fracture configuration and suggested that fracture configuration was more important than sex. Thus, when adjusted for sex, horses with nondisplaced condylar fractures were about 12 times as likely to win a race and about 14 times as likely to earn twice the cost of treatment after surgery, compared with horses with displaced fractures.

In a previous study, fracture fragment width could not be related to success of postoperative racing. In the present study, for horses that returned to racing after surgery, univariate logistic regression indicated that horses with thicker fracture fragments were more likely to win a race than horses with thinner fracture frag-
ments. This may have been attributable to the association between fracture fragment width and inherent stability of the fracture fixation. Thicker fracture fragments were commonly associated with longer fractures, and it is possible to place more screws across longer fractures, resulting in better stability. The issue is confused, however, by the association of thicker fracture fragments with males, and the association between fracture fragment width and success of postoperative racing may have been attributable to the fact that males raced more often and, thus, had greater opportunities to win after surgery. Sex, however, was not a significant factor in the model for winning after surgery.

The argument that owners would not continue racing a horse that failed to show adequate recovery from an injury and adequate promise of a reasonable return on their investment in training suggests that number of postoperative races is a meaningful measure of postoperative performance. In the present study, older horses had fewer postoperative races, which is consistent with the lower number of racing opportunities for older horses and the incremental accrual of lesser musculoskeletal injuries as competitive Thoroughbreds age. It is unclear why horses with longer fractures had fewer starts; however, it may be because the longest fractures (> 75 mm) were most often displaced. Colts and geldings raced more often after surgery, which is likely attributable to the lower opportunity for retirement to breeding for colts and the lack of such opportunity for geldings.

As mentioned earlier, some surgeons recommend placing the most distal screw as close to the joint surface as possible to improve compression across the fracture, but others recommend placing the most distal screw at the epicondylar tubercle to avoid damage to the collateral ligament. In the present study, inclusion of the distance of the most distal screw from the articular surface in the Poisson regression model suggests that it is better not to place a screw in the epicondylar fossa. However, fracture fragment width was associated with winning after surgery and with fracture length. With longer fractures, there is additional space to place the most distal screw further from the articular surface, but with shorter fractures, surgeons must place the most distal screw closer to the joint surface. Thus, it is unclear whether the association between number of starts and screw placement was a result of screw placement itself or attributable to the better prognosis for horses with thicker longer nondisplaced fractures, perhaps because of the better stability that can be achieved with fixation of these fractures.

A previous study reported an association between poorer quality healing on follow-up radiographs and lower mean earnings per start after surgery. In the present study, better fixation quality, as judged by examining radiographs obtained immediately after surgery, was associated with a higher number of races after surgery. However, neither earnings per start nor earnings percentage per start was associated with fixation quality score. The effect of fixation quality was difficult to assess, because displaced fractures were more often judged as having poorer quality fixation. Within the constraints imposed by severity of fracture configur-a

References

18. Boyd A, Haroun Y, Jones S, et al. Three dimensional struc-

Unauthenticated | Downloaded 10/07/23 04:50 PM UTC

