INFLUENCE OF JOINT CAPSULE INTEGRITY ON LIGAMENT STRAIN: VALIDATION OF A FINITE ELEMENT MODEL OF THE EQUINE METACARPOPHALANGEAL JOINT

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INTRODUCTION

Fracture is a major problem for clinicians in both the human and the equine medical fields and improvement in fracture risk detection is needed. Racehorses in particular represent an excellent model for study of fracture risk since they suffer fractures at consistent sites. The metacarpophalangeal joint (MCP) is the most commonly injured joint in the Thoroughbred racehorse [1]. Work in the investigators' laboratory has shown that certain geometrical paramters may predispose some horses to fracture in the MCP. A finite element (FE) model of the MCP is currently being developed in order to elucidate how stress distribution patterns change due to variations in bone geometry and the objective of this study was to provide data for the validation of such a model.

METHODS

Four equine forelimbs from horses presented to the necropsy service at the Colorado State University Veterinary Medical Center were harvested. The forelimb was loaded on a materials testing system to displacements equivalent to those found at the walk, trot, and gallop at a rate of 85mm/s. Strain was recorded in 16 ligaments and tendons surrounding the MCP using linear variable differential transducers (LVDTs) both before and after opening the joint capsule for insertion of the Tekscan sensor. Bone strain was recorded in 6 locations: 2 on the dorsal aspect of MC III just proximal to the joint capsule insertion, 2 on the abaxial edges of MC III, and 2 on the dorsal aspect of the proximal phalanx using rectangular rosettes. Data was analyzed using a multifactorial ANOVA with a p-value < 0.05 indicating significant differences.

RESULTS AND DISCUSSION

Ligament and bone strains increased with increasing load. There was a significant condition (intact vs. open joint capsule) by displacement (walk, trot, gallop) interaction for the main (SL), lateral (LBSL), and lateral extensor (LESL) branches of the suspensory ligament. There was a trend for the strain to increase at the gallop with the open joint capsule in comparison to the intact capsule for the SL and LBSL (p=0.0581 and 0.0802 respectively). Strain in the LESL and the medial branch of the suspensory ligament (MBSL) significantly decreased at all 3 displacements when the joint capsule was opened (Figure 1). These results suggest the importance of maintaining the joint and supporting structures as close to the in-vivo condition as possible. Limiting the structures that are disrupted and minimizing the potential effects of disruption by longitudinally incising ligaments as opposed to completely transecting them may help in obtaining more accurate values.

The largest magnitude principal strains calculated were compressive for all locations except for dorsal lateral MC III. Le Jeune et al. [2] found that the largest magnitude principal strains were compressive for all locations. The principal strains in the current study tended to be of a greater magnitude than those found in the study by Le Jeune et al., who reported their strain values as a change from that found at an 890 N load and transected the long fibers of the collateral ligaments.

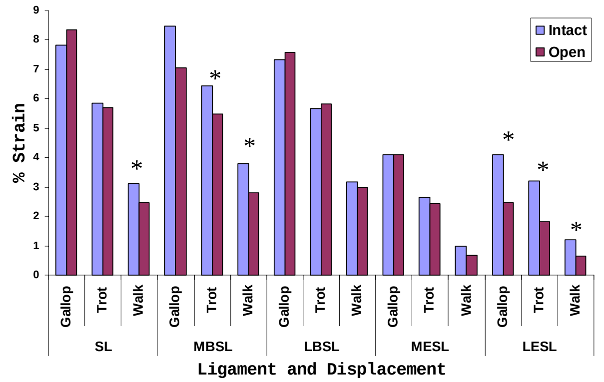

Figure 1: Percent strain between the intact and open joint conditions. * indicates significant differences between the joint conditions.

The lateral and medial proximal sesamoid bones (PSBs) and proximal phalanx moved dorsally and contact area and pressure increased with increasing load. There were problems with pinching of the Tekscan sensors, however, one limb had stable recordings and showed the pressure to be uniform in areas of contact at the walk displacement. At trot and gallop displacements, the pressure from the PSBs was increased on the axial, abaxial, and palmar regions in comparison to the mid-condylar and transverse ridge regions (Figure 2). The pressure distribution pattern may suggest possible reasons for the high incidence of PSB fracture.

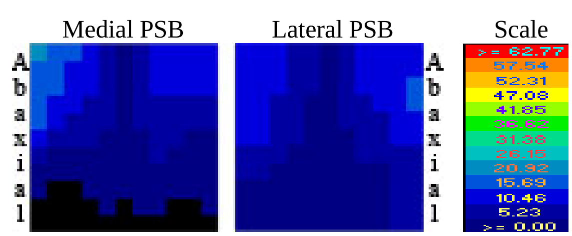

Figure 2: Tekscan images of contact pressure of the PSBs on the MC III condyle at gallop displacement. Top of image is palmar; bottom is at the level of the transverse ridge. Scale is in MPa.

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2. Le Jeune SS, et al., *Vet Surg*. **32**:585-597, 2003.