INTRODUCTION: The role of the menisci on load transmission and tibial stress distribution has been extensively studied, but few studies focused on the menisco-femoral interface during physiologic weightbearing. The purpose of this study was to determine the contact areas and local contact stresses at the menisco-femoral joint during physiologic range of motion (R.O.M.) and axial-loading in the canine knee model, and to determine the influence of a partial or total meniscectomy. The long term purpose of this study was to investigate the applicability of a biologic scaffold to treat femoral osteochondral defects.

MATERIAL and METHODS: Both fresh-frozen knees of 3 mature, randomly selected hound type canines (16-24 kg body weight) underwent biomechanical evaluation. All of the soft tissues were dissected from the femur and tibia, leaving the extensor mechanism, anterior and posterior cruciate ligaments intact. A 3 N tension was applied to the quadriceps tendon to simulate the function of the extensor mechanism. Femur, tibia, and fibula were transected 10 cm from the joint line and mounted in blocks of epoxy resin. Each specimen was secured to a universal testing machine. The test machine was configured for an axial-load of 90-120 N (9-12 kg), applied over 6 seconds. Each specimen was tested in standing position (50°), hyperextension (30°), and flexion (70°). Load-deflection patterns were monitored to assure uniform loading. Measurement of the contact area (CA) and local contact stresses (LCS) in the joint were performed in three different situations: with both menisci intact, after bilateral partial meniscectomies with removal of half of the posterior horn, and after bilateral total meniscectomies. Following the axial-loading test, the pressure distribution was estimated using pressure sensitive film (Pressureex SuperLow, Sensor Products Inc., NJ) with a sensitivity of 5-25 kgf/cm² inserted above the menisci. Densitometry was used to read the resultant pressure patterns. Statistical analysis was done using the ANOVA test (p< 0.05).

RESULTS: Medial meniscus at 50°: the average CA decreased from 2.1 cm² in the intact knee, to 1.6 cm² in the partial meniscectomy knee, to 0.5 cm² in total meniscectomy knee; the average LCS increased from 1.3 MPa in the intact knee, to 1.7 MPa in the partial meniscectomy knee, to 2.1 MPa in the total meniscectomy knee. Medial meniscus at 30°: the average CA decreased from 1.7 cm² in the intact knee, to 1.3 cm² in the partial meniscectomy knee, to 0.4 cm² in total meniscectomy knee; the average LCS increased from 1.2 MPa in the intact knee, to 1.5 MPa in the partial meniscectomy knee, to 2.5 MPa in the total meniscectomy knee. Medial meniscus at 70°: the average CA decreased from 2.4 cm² in the intact knee, to 1.7 cm² after partial meniscectomy, to 0.5 cm² after total meniscectomy; the average LCS remained at 1.5 MPa in the intact knee and after partial meniscectomy, but increased to 2.3 Mpa after total meniscectomy. Lateral meniscus at 50°: the average CA decreased from 3.3 cm² in the intact knee, to 2.4 cm² in the partial meniscectomy knee, to 0.7 cm² in total meniscectomy knee; the average LCS remained at 1.5 MPa in the intact knee and in the partial meniscectomy knee, but increased to 2.9 MPa in the total meniscectomy knee. Lateral meniscus at 30°: the average CA decreased from 3.0 cm² in the intact knee, to 2.3 cm² in the partial meniscectomy knee, to 0.5 cm² in total meniscectomy knee; the average LCS remained at 1.3 MPa in the intact knee and in the partial meniscectomy knee, but increased to 2.4 MPa in the total meniscectomy knee. Lateral meniscus at 70°: the average CA decreased from 3.2 cm² in the intact knee, to 2.4 cm² in the partial meniscectomy knee, to 0.8 cm² in total meniscectomy knee; the average LCS increased from 1.4 MPa in the intact knee, to 1.6 MPa in the partial meniscectomy knee, to 2.9 MPa in the total meniscectomy knee. These differences were statistically significant (p< 0.05).

DISCUSSION: Our data indicate that the average CA and LCS can be consistently measured at the femoro-meniscal interface in the canine knee using pressure sensitive films, at least at low loads. In the intact knee, at little contact occurs on the exposed femoral cartilage, the vast majority occurs at the meniscus. The lateral meniscus carries a significant fraction of the load and no significant contact was found until a total meniscectomy was performed. Increasing the knee flexion from 30° to 70° showed progressive posterior shift of the CA with a corresponding retrograde shift of the location of the LCS. The proportion of load borne by the menisci remains unchanged during R.O.M., with the exception of an increase of 40% in the medial meniscus at 70°. Conservative partial meniscectomy leaves the meniscus with a considerable weight redistribution capability, protecting the cartilage covering the femoral condyles. After total meniscectomy, the average LCS on the femoral condyles is markedly increased (60% in the medial compartment; 100% in the lateral compartment), varying its location during R.O.M. The limitations of our study include lower axial loads compared to previous studies in the animal and human model and the possibility of film artifact, due to the small radius of frontal curvature of the femoral condyles.