INTRODUCTION

When the meniscus is injured, its ability to distribute loads across the knee joint is compromised [1]. Surgical goals are to confer pain relief while restoring the load bearing capabilities of the injured tissue. However, the management of radial meniscal tears remains controversial. Partial meniscectomy may provide short-term pain relief but has been associated with an increased incidence of osteoarthritis. Reduction and repair has traditionally been restricted to peripheral and longitudinal tear patterns, but there is evidence that other tear configurations may heal, particularly with biological augmentation [2].

The purpose of this study was to characterize the contact mechanics of lateral and medial meniscus radial tears and subsequent treatment (repair via suturing and partial meniscectomy). Our hypothesis was that the dynamic contact mechanics of radial tears and the effect of repair will be significantly different between the medial and lateral compartments.

MATERIALS & METHODS

Fourteen human cadaveric knees were stripped of soft tissue sparing the capsule, collateral ligaments, cruciate ligaments, and the menisci. To facilitate reproducible alignment, all knees were pinned through the epicondylar axis under fluoroscopy and then aligned with the flexion-extension axis of a load-controlled Stanmore Knee Simulator. The simulator was pre-programmed with an axial force, rotational torque and flexion-extension dynamic profile that corresponds to human gait as per ISO standard #14243-1 (Figure 1) [3].

A pressure sensor (4010N, Tekscan Inc., MA) was conditioned, equilibrated, calibrated, and inserted below the medial (n=8) or lateral (n=6) meniscus, oriented to cover the entire plateau, and sutured to the base of the anterior cruciate ligament and posterior capsule using custom designed tabs. Data was recorded at 9.5Hz for 20 gait cycles for each of the following test conditions for each specimen: (i) intact meniscus, (ii) 30% meniscal width radial tear (RT) (iii) 60% RT, (iv) 90% RT, (v) inside-out repair with two horizontal mattress sutures, and (vi) partial meniscectomy. The radial tears were consistently created at the body-posterior horn junction on the medial side and at the level of the popliteus hiatus on the lateral side, and partial meniscectomy consisted of minimal resection to the width of the tear with smooth contouring of the adjacent edges.

The magnitude and location of peak contact pressure and the magnitude of contact area were computed for each condition at two points in the gait cycle - 14% and 45% gait (Figure 1) which corresponded to the two most pronounced peaks in axial force during gait. Data was statistically analyzed using a one way analysis of variance (ANOVA) followed by post-hoc Tukey test.

RESULTS

90% radial tears on the lateral side resulted in significantly increased peak contact pressure magnitude and reduced contact area when compared to the intact knee (p<0.05) (Figure 2). On the medial side, however, peak contact pressure and contact area were not significantly affected by up to 90% radial tears (p>0.09). On the medial side, the location of the peak pressure shifted posteriorly and centrally on the plateau with 90% tears. In contrast, no significant shift in the location of peak pressure was observed on the lateral side, with force transmission maintained at the central aspect of the plateau for all test conditions.

Horizontal mattress suture repair did not adversely affect the contact mechanics on the medial or lateral side, but was unable to restore the magnitude or location of peak contact pressure to that of the native knee. Partial medial meniscectomy was associated with significantly reduced contact area and significantly increased peak contact pressure relative to the repaired or torn medial meniscus (p<0.05). In contrast, partial lateral meniscectomy resulted in mean and peak contact pressures that were not significantly different from 90% radial tears (Figure 2&3).

DISCUSSION

By way of a dynamic in-vitro cadaveric test, we have demonstrated significant differences between the dynamic contact mechanics on medial and lateral compartment as a function of meniscal status. While attempts at repair should be made whenever possible in both compartments, large radial tears of the lateral meniscus are more detrimental to contact mechanics than those which occur on the medial side and are functionally equivalent to partial meniscectomy. In contrast, large radial tears of the medial meniscus demonstrate considerably favorable contact mechanics compared to partial meniscectomy, emphasizing the importance of minimal tissue resection in this setting.