RELATIONSHIP BETWEEN KNEE FLEXION MOMENT AND EARLY CARTILAGE CHANGES IN THE ACL RECONSTRUCTED KNEE

Sean Scanlan[1], Katerina Blazek[1], Joshua Schmidt[1], Seungbum Koo[1], Ajit Chaudhari[2], Jason Dragoo[1], and Tom Andriacchi [1,3]

[1] Stanford University, Stanford, CA, USA
[2] The Ohio State University, Columbus, OH, USA
[3] VA Palo Alto Health Care System, Palo Alto, CA, USA
E-mail: sscanlan@stanford.edu, Web: biomotion.stanford.edu

INTRODUCTION

Premature knee osteoarthritis (OA) is frequently reported in patients after anterior cruciate ligament (ACL) injury, even in patients who have had an ACL reconstruction [Gillquist, 1999]. While a mechanical etiology for the high prevalence of OA is commonly suggested, there are few studies linking altered ambulatory joint mechanics to morphological changes in the articular cartilage.

A reduction in the external peak knee flexion moment (balanced by net quadriceps moment) walking has been reported in ACL deficient knees and may be a necessary compensation to avoid excessive anterior translation of the tibia in the absence of the anterior-posterior (AP) restraint of the ACL [Andriacchi, 2005]. Following restoration of the AP restraint with ACL reconstruction, patients should presumably reestablish a more normal flexion moment during gait without experiencing AP instability. However, complete restoration of normal flexion moments in ACL reconstructed subjects is not observed during walking [Bulgheroni, 1997]. The impact of this alteration in joint mechanics on the health of the articular cartilage at the knee is unknown. This study tested the hypothesis that early post-operative changes in cartilage morphology are related to the peak knee flexion moment during walking in the ACL reconstructed knee.

METHODS

Nine subjects with unilateral ACL reconstructions and no other history of serious lower limb injury (avg 40 yrs, 1.7 m, 67 kg, 3 male, 3.4 mo injury to reconstruction, 8-48 mo past reconstruction) were recruited for the study after providing IRB-approved informed consent. Subjects underwent bilateral, non-weightbearing MR imaging and a gait test at self-selected walking speed. A force-plate and a previously-described link model were used to estimate the net external forces and moments acting at the joints [Andriacchi, 1997]. The patients were then partitioned into a low and high flexion moment group based on magnitude of the peak external knee flexion moment in the reconstructed limb, with a cutoff at 2.8 %bw*ht. Tibial cartilage in the bilateral knee MR images were segmented and reconstructed into 3D models with thickness maps [Koo, 2005](Fig 1).

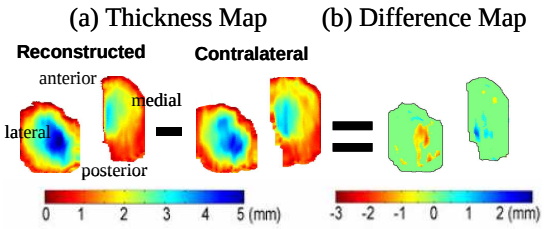

Figure 1. (a) Thickness maps for the ACL reconstructed and contralateral tibial cartilage (b) Difference maps created by subtracting the two thickness maps.

Tibial cartilage regions experiencing thinning or thickening (i.e. swelling) greater than 0.4mm relative to the contralateral, healthy tibia were classified as a region experiencing a measurable morphological change. These affected regions were then quantified as a percentage of the total medial and lateral cartilage area. A Student's t-test (α=0.05) was used to detect differences in the percentage of affected tibial cartilage area between the low and high peak knee flexion moment groups.

RESULTS

Significantly greater ($p<0.05$) early morphological changes in the medial tibial cartilage were observed in ACL reconstructed patients with a low peak external knee flexion moment (17.3±1.5%, n=5) when compared to those with a high peak flexion moment (8.3±2.3%, n=4) (Fig. 2) during walking. There was no relationship between the changes in lateral tibial cartilage and knee flexion moment.

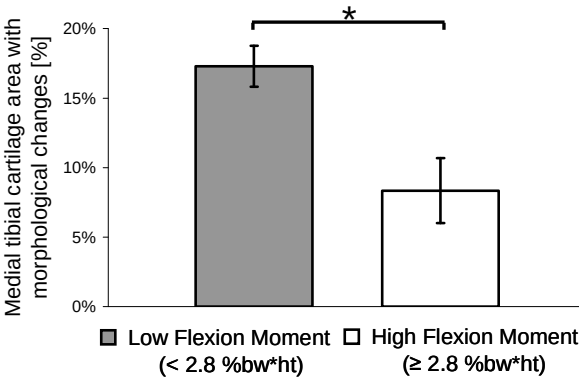

Figure 2. Comparison of percentage medial cartilage area with early morphological changes in the low and high flexion moment groups. * Significant difference ($p<0.05$).

DISCUSSION

The results support the theory that alterations in joint mechanics are associated with early morphological changes in the articular cartilage of the ACL reconstructed knee. While previous studies indicate that compensatory reduction in knee flexion moment may be critical in controlling tibiofemoeral stability in the ACL deficient knee [Andriacchi, 2005], the results of the current study suggest that a reduced flexion moment after ACL reconstruction may have a negative effect on the health of the cartilage. Combined with the altered tibiofemoral kinematics commonly observed in ACL reconstructed patients, a reduced flexion moment may significantly change the stress distribution within the cartilage and initiate a degenerative response. These patterns of early changes to the articular cartilage may be markers of events leading to the initiation of premature OA. Thus, these results support the importance of restoring normal knee mechanics in the ACL reconstructed knee.

CONCLUSIONS

These results suggest that restoration of the knee flexion moment after ACL reconstruction might be an important factor in maintaining the health of the articular cartilage at the knee.

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ACKNOWLEDGEMENTS

The authors acknowledge the aid of Chris Dyrby and NIH Grant #5R01-AR39421.