INTRODUCTION

Much clinical evidence exists that normal joint stability may not be fully restored after all anterior cruciate ligament (ACL) reconstructions which could explain some of the occurrence of premature osteoarthritis (OA) in these patients1. We have developed an ovine model of relatively ‘idealized’ reconstruction in which we core out the femoral insertion of the normal ACL on its bony insertion and immediately re-attach the bone core + ligament in its original anatomic location. The aims of the current study were to evaluate the stability of these joints up to 20 weeks following such simulated ACL reconstruction compared with sham surgery, and to perform detailed gross examination of these joints for evidence of OA. We hypothesized that following idealized ACL reconstruction, like sham surgery, joint kinematics would be unchanged and that there would be no evidence of increased OA change compared with age matched controls.

METHODS

Twenty nine skeletally mature (3-4 year old) female Suffolk-cross sheep were separated into a non-operated control group (n=17), used only for morphological analysis, and two surgical groups. Procedures were approved by the University of Calgary Animal Care Committee. Both surgical groups had baseline (joint intact) stifle joint kinematics recorded before either an idealized ACL reconstruction (n=5) or a sham arthroscopy procedure (n=7) using a re-implantable post and marker assembly and video-based motion analysis system2. Propagation of errors within this system lead to measurement changes of 0.3-0.4° (rotations) and 0.7-1.0 mm (translations)3. Idealized ACL reconstruction, the so-called ‘ACL-R’ group, was performed as previously described1. Shams had a similar arthroscopy but no bone coring was performed. Joint kinematics were recorded at 4 and 20 weeks after stifle surgery in shams and ACL-R animals. Six degree of freedom (DOF: flexion/extension (FE), abduction/adduction (AA), internal/external rotation (ROT), medial/lateral (ML), anterior/posterior (AP), inferior/superior (IS)) stifle kinematics were measured at mid-stance (MS) during walking and differences from the intact state for each animal quantified. Means of these differences were used to compare the groups (Mann Whitney U tests). Differences between the means were also expressed as a percentage of the mean intact range of motion (ROM) for all animals (n=12) in each DOF. All animals were sacrificed at 20 weeks following joint surgery. Stiff joints were graded for gross cartilage defects4 and osteophyte formation5 at 14 standardized locations. Comparison was made between left and right joint scores in all groups (Wilcoxon signed-rank test). To control for inter-animal variations and enable comparison between groups, these joint damage scores were adjusted by subtracting values recorded from the left (non-operated, contralateral) from the values recorded for the right (operated) joint for each animal (Kruskall-Wallis test followed by Wilcoxon signed rank tests with Bonferroni post hoc adjustments).

RESULTS

At 4 weeks, compared with the intact state, there was an increase in anterior tibial translation in the ACL-R group whereas animals in the sham surgery group showed a decrease (Figure A). This difference between groups was statistically significant (1.3 mm difference, 39% of intact ROM; P = 0.05). For comparison of the differences between the groups which were non-significant, statistical power calculated post hoc was low (6-51%). Expressed as a proportion of intact ROM, these non-significant differences were largest for the rotation (~1.1°) and abduction/adduction (~2.4 mm) DOFs, at both time points (approximately 19% and 27% respectively), and for the IS DOF at 20 weeks (~1.2 mm, 22%).

Cartilage scores for ACL-R animals were significantly higher (P< 0.05) in operated joints when compared with respective contralateral joints. There were no statistical differences detected within the non-operated and sham surgery groups. Osteophytes were observed only in the right (operated) joints of the ACL-R animals, and in none of the stifle joints of the sham operated or normal controls (P> 0.05).

DISCUSSION

The statistically significant difference in the AP DOF at 4 weeks was only slightly (0.3 mm) greater than the possible error of this measurement system and therefore may not have been biologically significant. However, differences for the ROT and AA DOFs, although not statistically significant were more than double the possible measurement error and statistical power was low. We are therefore unable accept or reject our first hypothesis. There was a significantly greater amount of early OA change in joints following idealized ACL reconstruction so we reject our second hypothesis. It remains possible that kinematic changes are responsible for the development of OA in the ACL-R group and remodeling of the graft may be the cause. An alternative hypothesis, however, is that the features of the surgical procedure itself, such as breach of the bone marrow cavity during bone tunneling, contribute to the development of OA. One limitation of the study is the short time course: differences between experimental groups are likely to have become more pronounced over a longer period. In conclusion, we have identified for the first time that even under relatively idealized conditions, early OA change and some kinematic disturbances develop following ACL reconstruction.

SIGNIFICANCE

Our data indicate that efforts to prevent premature OA following ACL reconstruction by improving graft design and fixation methods alone may not succeed. A more comprehensive understanding of the impact of the surgical insult is required.

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8. The McCaig Institute for Bone & Joint Health, University of Calgary and 9. Schulich School of Engineering, University of Calgary, Alberta, Canada
cfrank@ucalgary.ca

The mean adjusted cartilage, osteophyte, and combined cartilage + osteophyte scores were significantly higher in the ACL-R group compared with the non-operated group (Figure B). Mean adjusted osteophyte scores were also significantly higher in the ACL-R group compared with the sham surgery group. Sham operated and non-operated animals were statistically indistinguishable for all morphological measures.

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