The periarticular loss of bone mineral density (BMD), early after anterior cruciate ligament (ACL) rupture in the knee, has been well documented (1,2). Much focus has involved bone mineral changes in the subchondral bone plate and underlying trabecular bone (3,4). However, because the hallmark of cruciate insufficiency is chronic joint instability (laxity), potentially influenced by increasing laxity of the remaining ligamentous restraints (5), we examined the changes in bone mineral surrounding the femoral insertion of the medial collateral ligament (MCL). We also investigated whether short-term antiresorptive therapy altered bone changes at the MCL insert and ligament-complex biomechanics. Thus, the objective of this study was to assess in an osteoarthritis (OA) model whether antiresorptive therapy altered periarticular bone and collateral ligament biomechanics and OA progression.

The ACL was surgically transected in three groups of 7 skeletally mature New Zealand White rabbits. The first and second groups remained untreated for 6 wk and 14 wk respectively, and served as age-matched ACL-transected (ACLX) controls. The third group was dosed (0.01 mg/kg s.c) daily with Risedronate bisphosphonate (BP) for 6 wk. A final group of 10 age-matched, unoperated normal controls were also evaluated. The bone-MCL-bone complexes were removed and tested on a servomechanical testing system (1122 Instron, Canton, MA, USA). We measured medial collateral ligament (MCL)-complex laxity, and related it to changes in MCL insertional bone geometry (using micro computed tomography (micro-CT, Skyscan 1073, Aartselaar, Belgium). The two-dimensional scanned images generated were quantified to extract MCL insertional bone measurements (Scion image, Frederick, Maryland, USA). Functional measures were related to assessments of cartilage-membranous gross morphology and histology for evidence of early OA. The University of Calgary Animal Care Committee approved all procedures. Analysis of variance (ANOVA) was used to detect significant differences between experimental and control groups. A post hoc multiple comparisons test (Tukey’s test) localised significant differences. A significance level of P<0.05 was used for all statistical tests.

Early alterations of periarticular bone mineral after ACLX included loss at the MCL insertion. Compared to normal unoperated controls, MCL insertional volume was significantly greater in the ACLX cohort at 6 wk (p<0.04)(Figure 1) and increased further at 14 wk after ACLX (p<0.01). When we dosed ACLX animals daily with Risedronate for 6 wk, however, the loss of MCL insertional bone was less and not significantly different from normal control animals. Similarly, MCL-complex laxity was significantly less in 6 wk Risedronate-dosed animals (1.2 times that of normal controls) compared to untreated 6 wk ACLX animals (1.7 times that of normal controls; p<0.05)(Figure 2). Blocking bone resorption with Risedronate BP (at the dose indicated) did not reduce capsular thickening or inflammatory angiogenesis in unrestrained ACLX joints, and these measures were elevated in both untreated and BP-treated ACLX joints compared with normal controls.

Figure 1. Transverse sections (micro-CT) of exemplar femoral medial condyles illustrating the MCL insert at its deepest point (arrow) in a normal age-matched control (a) and 6-wk ACLX (b) animal. Dashed lines denote a sagittal cut dividing distal medial and lateral condyles (lateral condyle is not shown for each sample).

Figure 2. Medial collateral ligament (MCL)-complex biomechanics in normal control, 6 wk anterior cruciate ligament transected (ACLX), and 6 wk ACLX-bisphosphonate dosed animals (ACLX-BP).

Our results showed that the early loss of periarticular bone mineral after ACL insufficiency included loss at the MCL insertion. Such alterations in ligament-bone mineral interface could influence MCL mechanical functioning, including bone-ligament-bone complex laxity. Loss of insert bone mineral could also compromise the mechanical strength of the underlying bone during MCL tensile loading, which may lead to microdamage and microfracture of trabecular bone beneath the insert cortical rim. We also showed that blocking resorptive activity with a BP immediately after loss of the ACL resulted in a significant improvement in MCL-complex laxity, implying some conservation of MCL-bone complex structural properties. Compared to the untreated ACLX condition, administering BP immediately after ACLX damage conserved periarticular bone and medial collateral ligament-complex properties in an early OA model.