The Effect of Medial Opening Wedge High Tibial Osteotomy on Medial Collateral Ligament Tension

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INTRODUCTION:

High tibial osteotomy as the treatment of varus gonarthrosis was first popularized in the United States by Coventry. The goal of valgus-producing high tibial osteotomy is to shift the weight-bearing axis of the lower extremity from the diseased medial compartment to healthy cartilage in the lateral tibiofemoral compartment. Originally, lateral closing wedge osteotomy was utilized to perform this shift of the weight-bearing axis. Lateral closing wedge osteotomy is technically demanding and may require a fibular osteotomy. Since the anterior muscular compartment is violated during this procedure, compartment syndrome and/or peroneal nerve issues are also a concern. Due to the multiple complications related to lateral closing wedge osteotomy, medial closing wedge osteotomy is preferred by some authors. This technique allows for multiplanar correction, is technically easier to perform, and avoids important lateral anatomic structures.

Multiple authors have demonstrated the clinical success of medial opening wedge high tibial osteotomy. Unfortunately, there are not many biomechanical studies evaluating this technique. Agneskirchner et al. recently demonstrated that medial compartment pressures actually increased following medial opening wedge HTO. They hypothesized that this was due to increased medial collateral ligament (MCL) tension. Medial collateral ligament tension was not actually measured during this study however. The findings of this study potentially have very important clinical implications. Multiple clinical studies have demonstrated that the subjective results of HTO gradually decrease with time. This step-wise deterioration may, in part, be the result of the increased medial compartment pressures. A technical modification to this procedure, such as partial MCL release, to decrease this phenomenon would be of clinical interest. Our first hypothesis is that MCL strain increases following HTO. Our second hypothesis is that MCL strain will decrease following partial MCL release. The objective of this study is to determine how medial opening wedge HTO effects MCL tension.

METHODS:

We utilized 5 fresh-frozen cadaveric knees. We removed the skin and muscle from each knee, leaving the capsuloligamentous structures intact. The articular surface and menisci were evaluated for degenerative changes. Each knee was transected through the femoral and tibial shafts and potted in aluminum cylinders using woods metal. The Differential variable reluctance transducer strain gauges were placed at the mid-substance of the superficial and posterior oblique (POL) portions of the MCL. Each transducer was secured to the medial collateral ligament utilizing simple suturing techniques. Each knee was tested using a 6-degree of freedom robotic simulator (RotoPod R2000). We tested 4 conditions: intact knee, opening wedge HTO, partial MCL release, and complete MCL release. Each of these conditions was also tested under clinical exam conditions and simulated gait conditions.

The opening wedge technique was performed utilizing the technique described by Fowler et al. The osteotomy began medially approximately 5 cm below the medial joint line. The osteotomy continued to a superolateral position, approximately 2 cm below the lateral joint line and 1 cm from the lateral metaphyseal cortex. Very special care was taken not to violate the medial collateral ligament. A small area of the MCL was lifted subperiosteally at the osteotomy site however. The osteotomy was secured utilizing the Arthrex osteotomy plating system (Arthrex Inc., Naples, FL). A 1 cm osteotomy was performed in all specimens. The osteotomy site was filled with polymethyl methacrylate cement for added stability.

The clinical exam variable consisted of a simulated Lachman’s exam and varus-valgus stress testing. The simulated Lachman’s exam consisted of a 134 N anteriorly-directed force as described by Kilger et al. Varus-valgus torque was applied at -10, -5, 0, 5, 10 Nm to simulate varus and valgus testing of the collateral ligaments during the physical exam as described by Kilger et al. A 1000 N compressive force was applied with variable varus torques to simulate gait. Cole et al demonstrated that the normally aligned limb only experienced varus torques during gait. These authors also found that maximum torque only reached 42 Nm. We utilized varus torques of 0, 10, 20, 30, and 40 Nm combined with a 1000 N compressive load to simulate gait. Superficial MCL and POL tensions were recorded. Each condition was performed at 0 and 30 degrees of flexion.

All statistical analysis was performed utilizing MiniTab (MiniTab Inc., State College, PA). ANOVA was utilized to determine differences between groups. Tukey’s test was utilized to determine the differences between means.

RESULTS:

The mean (± standard deviation) age of our cadaveric specimens was 58.8 (± 15.5) years. During simulated weight-bearing, the mean relative superficial MCL strain for the native, post-osteotomy, and partial release knee conditions was 11.05, 11.20, and 12.56 % and the relative mean POL strain was 0.61, 3.54, and 3.72 %, respectively (Figure 1). There were no significant differences between weight-bearing and clinical exam conditions. Although there was a trend towards increased strain following osteotomy and partial release, superficial MCL tension did not reach significance (p = 0.2). The relative POL strain demonstrated a significant increase from the native knee condition to the post-osteotomy knee condition (p < 0.001).

DISCUSSION:

The principal findings of our study demonstrate that superficial MCL tension does not change significantly but POL tension does change significantly following medial opening wedge HTO. We also found that partial release of the superficial MCL and POL did not significantly affect ligament tension. Our findings suggest that the increased medial compartment contact pressures seen following HTO may be the result of increased POL tension alone. Furthermore, based on the findings of the present study we cannot recommend partial release of the MCL during HTO as our model demonstrates that MCL tension is not significantly changed by partial MCL release. Multiple authors have demonstrated that good-excellent clinical results following medial wedge opening HTO is approximately 80 percent at 5 years. At 10 years following this procedure, good-excellent results are just 50 percent. Ultimately, the slow deterioration in subjective patient outcomes following opening wedge HTO may be the result of this increase in medial compartment pressures. Alternatively, this deterioration may be the result of the natural history of osteoarthritis. Further studies are needed to determine the true significance of this phenomenon.

REFERENCES:

References are optional.