INTRODUCTION

High tibial osteotomy (HTO) is a corrective surgical procedure used to treat osteoarthritis of the tibiofemoral joint. This operation redistributes the load across the medial and lateral aspects of the tibiofemoral joint in order to relieve joint pain and delay further degeneration of the articular cartilage. Although this procedure directly affects the tibiofemoral joint, it may also indirectly affect the patellofemoral joint.

The mechanical change produced by HTO is assessed using the femorotibial angle. However, this measurement does not describe the three-dimensional changes to joint alignment well and its association with the amount of cartilage degeneration is poor. A number of studies have reported alterations in patellar height after HTO and found that the change in patellar height is dependent upon surgical technique. However, the effect of HTO on patellar motion has not been assessed because no suitable method has been available to measure these quantities accurately and non-invasively in symptomatic patients.

Our research question was: How does HTO affect tibiofemoral and patellofemoral joint kinematics?

METHODS

We assessed three-dimensional tibiofemoral and patellofemoral kinematics in four subjects before and after closing wedge HTO using a new, validated MRI-based technique [3]. Insall-Salvati and Blackburne-Peel ratios were also measured pre- and post-operatively. Titanium plates (Nextgen, Smith & Nephew) were used to fix the tibial fragments to minimize the effect of hardware on the MR signal after surgery. All subjects followed the same post-operative remobilization program. Subjects wore a protective knee brace, initiated range of motion (0–90 degrees) exercises, and performed feather weightbearing during the first four weeks, progressing to partial weightbearing for the next four weeks.

To assess kinematics the subjects were positioned supine in a GE Signa 1.5T MRI unit on a specially made MRI compatible rig. High-resolution MR images of the subjects’ knees in relaxed, full extension were obtained and segmented to create three-dimensional geometric models of the proximal tibia, distal femur and patella. Fast, (38 sec), low-resolution images were taken of the subjects’ knees in five positions of loaded flexion between full extension and roughly 40° of flexion. These low-resolution images were then segmented to create bone outlines. The relative positions of the geometric bone models at each loaded flexion position were determined by shape-matching the bone models to the segmented bone outlines using the iterative closest points (ICP) algorithm [4]. Anatomical coordinate systems were assigned to each bone model and the kinematic parameters describing the position and orientation of the patella relative to the femur were represented using a joint coordinate system [5].

The null hypotheses that each component of tibiofemoral and patellofemoral kinematics was not altered by HTO was assessed using a 2 way repeated measures ANOVA.

ESSENTIAL RESULTS

CWO decreased tibial adduction by a mean of 6.5° (p < 0.001) and decreased lateral tibial translation by a mean of 0.8 mm (p < 0.001) (Figure 1). CWO decreased patellar flexion by a mean of 5.1° (p < 0.003), decreased internal patellar spin by a mean of 1.2° (p < 0.001), increased medial patellar tilt by a mean of 1.6° (p < 0.001) and increased proximal patellar translation by a mean of 4.2 mm (p < 0.008) (Figure 1).

As a result of the closing wedge osteotomy only two subjects displayed a condition of patella alta as assessed by the Blackburne-Peel ratio. Although CWO significantly decreased the Insall-Salvati ratio (p < 0.007), for the number of specimens tested, we did not observe a difference in the Blackburne-Peel ratio after surgery.

DISCUSSION

We used a validated, non-invasive method to measure 3D tibiofemoral and patellofemoral kinematics through a range of loaded flexion before and after CWO in four patients. These results clearly show that HTO produces a medial translation of the tibia as well as abduction. The patellofemoral results support the hypothesis that some complications of closing wedge osteotomy are caused by altered mechanics at the patellofemoral joint. Changes in patellar tilt and spin are associated with changes in load on the lateral patellar facet [6], which may lead to pain and premature cartilage degeneration.

The inconsistency between our MRI-based measurements and radiographic indices highlight some of the limitations of measurements made from plain film radiographs. A key advantage of this study is that, by using a new method, we were able to measure all components of patellar movement through a range of loaded knee flexion. Most studies of high tibial osteotomy have focused on clinical radiographic indices that describe only some of the components of patellar alignment and describe it only at one position of knee flexion.

REFERENCES


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