ABSTRACT

As the baby boomer generation ages, the incidence of knee joint osteoarthritis (OA, a degenerative joint disease) will continue to increase. Knee OA involves the erosion of articular cartilage (i.e., the cartilage covering the ends of the bones), most frequently in the medial compartment of "bow-legged" individuals. Progression of the disease results in increased pain and loss of function and often leads to total knee replacement (TKR).

High tibial osteotomy (HTO) is a more conservative surgical treatment than TKR for knee OA, especially in younger or active patients for whom TKR is not advised. This procedure usually involves adding/removing a wedge of bone to/from the tibia, thereby changing the frontal plane limb alignment from "bow-legged" to slightly "knock-kneed." This shifts the weight-bearing axis from the diseased medial to the healthy lateral compartment of the knee, resulting in decreased pain and possibly limited cartilage healing.

Dynamic gait measurements rather than static limb alignment have been shown to be the best predictor of long term clinical outcome following HTO. Specifically, patients with a peak post-operative knee adduction moment (i.e., moment tending to compress the medial compartment) of less than 2.5 times body weight times height tend to do the best. However, there is currently no reliable way to predict how a given choice of surgical parameters will affect the post-surgery adduction moment in a specific patient. Consequently, clinical outcome tends to be highly variable, prompting many orthopedic surgeons to discontinue the use of this valuable procedure.

The hypothesis of this study is that a patient-specific computer model can be used to predict the knee adduction moment following HTO given pre-surgery gait data and the surgical parameters. To test this hypothesis, the PI proposes the following specific aims:

(1) *Create a dynamic musculoskeletal model of gait*. A three dimensional dynamic model will be created that can be tailored to each patient using anthropometric measurements to estimate limb segment parameters and kinematic measurements to locate joint functional axes.

(2) *Develop a predictive optimization based on pre-surgery gait data*. Patients will perform pre-surgery gait trails using heel wedges to approximate the effects of HTO and to increase the amount of data per patient. These data will be used develop an optimization procedure that can predict adduction moment changes observed pre-surgery.

(3) *Predict the post-surgery knee adduction moment*. The optimization model will be used to predict how combinations of HTO surgical parameters would affect the post-surgery knee adduction moment in each patient.

(4) *Compare the optimization predictions with post-surgery gait data*. Patients will repeat the same gait trials post-surgery to evaluate the model's ability to predict the resulting knee adduction moment and to investigate possible synergistic effects with heel wedges.

The immediate benefit of this project will be improved surgical planning and patient selection resulting in improved reliability and clinical outcome. The long-term benefit will be the development of a computational framework that can be extended to study cartilage loading during gait. Since HTO procedures are often performed as part of cartilage repair or replacement surgeries, prediction of how HTO alters *in vivo* cartilage loading will be a valuable adjunct to tissue engineering advances for articular cartilage.

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