ASSESSMENT OF MOTION OF LONG-STEMMED TIBIAL IMPLANT

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INTRODUCTION

Aseptic loosening is one of the most prevalent reasons for primary (Sharkey et al., 2002) and revision (Gofton et al., 2002) knee arthroplasty failures. Previous studies have shown correlations between aseptic loosening and initial implant motion (Freeman and Plante-Bordeneuve, 1994; Krismer et al, 1999). Therefore, several studies have used initial motion of an implant relative to the bone as a method to predict its clinical performance. In recent years, there has been a trend towards using three-dimensional (3D) optical marker systems to measure small motion in-vitro instead of the traditional means of one degree of freedom linear variable transducers. Previous studies using optical markers involving the tibial tray have investigated the effect of boney defects (Conditt et al., 2004) or the presence of a stem (Rawlinson et al., 2005), but none have explored the source of specimen-specific differences. The goal of this study was to perform an in-vitro study to investigate inter-specimen variability. Future work will be performed to develop specimen-specific finite element (FE) models to investigate possible sources of variability.

METHODS AND PROCEDURES

Six matched pair cadaveric tibias (n=12) were implanted with an appropriately sized Precoat A/P Wedge tibial tray with a 100 mm Offset Stem Extension (Nex Gen, Zimmer Inc., Warsaw, IN). The intramedullary canal was reamed until the reamer was felt to "chatter", and a stem with the same diameter as the final reamer was used. The implant had cement applied to the proximal cut surface and the underside of the tray, but not along the stem. Marker carriers with four optical markers were rigidly attached to the tibial tray, stem tip, and bone collar (Figure 1). A 60-to-40 medial-to-lateral sinusoidal load from 150 - 1500 N was applied at a frequency of 1 Hz for 5000 cycles. Displacements of the three bodies were measured with an optical marker system (Optotrak 3020, Northern Digital Inc., Ontario, Canada), which has a reported 3D resolution of 10 microns. Motion was captured during seven 30 second intervals and results are reported as a mean and standard deviation over all trials. The relative motion between the tray and the bone along the axis of the stem is reported.

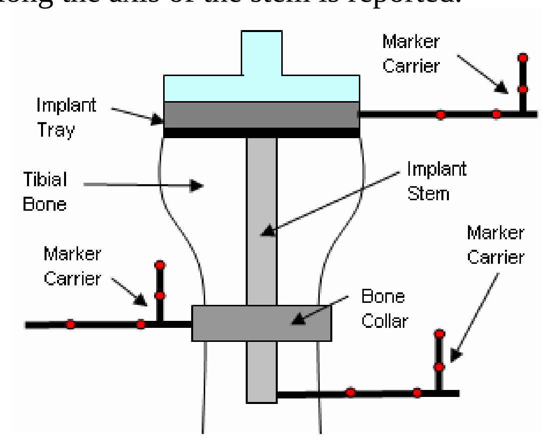

Figure 1. In-vitro test set-up of tibial bone with stemmed tibial tray and marker carriers.

RESULTS

The overall relative displacement for all bones was 51 ± 27 microns. The relative motion between the tray and the bone had high inter-specimen variability, but low intra-specimen variability (Figure 1). The intra-cadaver variability was large for most specimens.

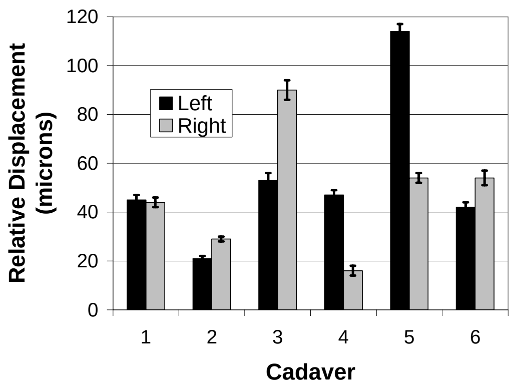

Figure 1. Relative displacement between the tray and bone along the axis of the stem.

DISCUSSION

The reported relative displacements between the bone and the implant were small (<120 microns). Similar magnitudes have previously been reported by Rawlinson et al., who performed a similar study measuring relative tray motion using an optical marker system (Proflex, Qualisys, Glastonbury, CT).

The relative displacement results between the tray and the bone for all specimens was highly variable (SD = 29 microns, coefficient of variation = 53%). Due to intra-cadaver variability it is predicted that variability is not only due to patient specific parameters (i.e. age, sex, etc.), but also implant specific parameters (i.e. tray size, stem diameter, etc.). This result is of particular interest since the implant specific parameters may be modified with implant design or surgical technique.

Finite element analysis (FEA) provides the opportunity for 3D analysis of implant motion, along with investigations of parameter effects. Therefore, future work is proposed using the bones of the current study to create specimen-specific FE models from computed tomography data. The relative displacement reported in the current study can provide validation for the FE models, which can be used to perform correlation studies on modifiable parameters.

SUMMARY

The relative motion between the tibial tray and bone of six matched-pairs of tibial bones demonstrated high inter-specimen and intra-cadaver variability. The results presented are a portion of a rich set of experimental data which will serve to validate subsequent numerical analyses. Future work will be performed to develop specimen-specific FE models to investigate the source of inter-specimen variability.

REFERENCES

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