COMPARATIVE GAIT ANALYSIS OF ANKLE ARTHRODESIS AND ARTHROPLASTY: INITIAL RESULTS OF A PROSPECTIVE STUDY

1,2 Michael Hahn, 1 Elise Wright, 1 Ava Segal, 4 Michael Orendurff, 1,3 William Ledoux and 1,3 Bruce Sangeorzan

1 RR&D Center of Excellence, Department of Veterans Affairs; Departments of 2 Mechanical Engineering, and 3 Orthopaedic and Sports Medicine, University of Washington, Seattle, WA, USA
4 Texas Scottish Rite Hospital for Children, Dallas, TX, USA
email: mehahn@u.washington.edu, web: http://www.amputation.research.va.gov/

INTRODUCTION

Ankle osteoarthritis (OA) has been reported to affect 6% of the general population [1]. The condition is characterized by pain, decreased range of motion (ROM), reduced quality of life, and general disability. Standard surgical treatment for end-stage ankle OA has been tibiotalar arthrodesis, however follow-up studies have reported the development of OA in surrounding joints due to altered motion and loading [2-3]. Tibiotalar endoprostheses have been shown as a functional alternative to arthrodesis [4]. A limited number of studies have reported biomechanical outcomes of ankle arthroplasty [5-7]. Only one study compared the post-surgery outcomes of ankle arthrodesis and arthroplasty, however their study design involved a mix of non-paired samples rather than a within-subject paired sample [8]. The purpose of this prospective study was to compare pre-/post-surgery gait between arthrodesis and arthroplasty patients. It was hypothesized that at 12 months post surgery, patients with arthroplasty would have improved temporal-distance parameters, and increased ankle ROM, peak internal plantar flexor moment, and power compared to their pre-surgery condition and compared to patients with arthrodesis.

METHODS

Sixteen patients (58.4 +/- 10.0 years, 1.7 +/- 0.1 m, 89.7 +/- 17.1 kg) scheduled for surgical treatment of end-stage ankle OA were recruited for a prospective pre-/post-surgery gait analysis protocol. The protocol was approved by the Institutional Review Board. Written informed consent was obtained prior to each subject’s participation. Patients were considered to have end-stage ankle OA based on their decision to undergo either arthrodesis or arthroplasty as a primary intervention to treat their OA condition. Potential participants were excluded if they had experienced a recent (<1 year) surgical, neurological, metabolic or lower limb musculoskeletal problem in the lower extremities, or had experienced multiple correction surgeries.

Eight patients received tibiotalar arthrodesis (FUSE), and eight received tibiotalar arthroplasty (TAR) (Salto® Talaris, Tornier, Edina, MN). All patients were evaluated prior to surgery and 12 months post surgery. Standard anthropometric measures were taken. Sixteen retro-reflective spherical surface markers were placed according to a standard bilateral lower extremity marker set. Patients were asked to walk across a 10m walkway at a self-selected walking speed, while barefoot. Three trials were analyzed for the affected limb in each condition. Ground reaction force data were recorded at 1200 Hz from embedded force platforms (AMTI BP400600, Watertown, MA; Bertec FP4060-NC, Columbus, OH). Marker trajectories were recorded at 120 Hz with a 12-camera Vicon MX system (Vicon, Lake Forest, CA) and filtered with the Woltring setting of MSE = 20. The Plug-In Gait model (Vicon) was used to calculate joint kinematics and net internal joint kinetics using standard inverse dynamics.

A mixed effects linear model was used to compare temporal-distance parameters, sagittal plane ankle ROM, peak ankle moments, and peak ankle powers between pre- and post-surgery conditions for both groups. Kinematic and kinetic comparisons included gait velocity as a covariate. Pre-/post-surgery changes were tested for group effects. Statistical tests were run using R (v.2.9.1).
RESULTS AND DISCUSSION

Temporal-distance measures of gait improved across both groups at 12 months post-surgery, with no significant group effect. Self-selected gait velocity increased from 0.97 to 1.17 m/s (p=0.002), stride length increased from 1.10 to 1.25 m (p=0.002), stride time decreased from 1.17 to 1.10 s (p=0.020), and cadence increased from 104.3 to 110.2 steps/min (p=0.021). Compared to pre-surgery conditions, TAR patients showed a trend of increased ankle ROM (3.4 deg; p=0.051), whereas FUSE patients showed no trend (Figure 1).

Figure 1: Group ensemble averages for ankle angle.

Pre-/post-surgery changes were different between groups for peak internal plantar flexor moment (p=0.032); increasing 0.18 Nm/kg for FUSE, and decreasing 0.14 Nm/kg for TAR (Figure 2).

Figure 2: Sample means (SD error bars) of internal ankle moments; pre- and post-surgery.

Considering gait velocity as a covariate, both groups increased ankle power absorption from -0.42 to -0.56 W/kg (p=0.039, see Figure 3), however there was not a significant group effect.

Figure 3: Sample means (SD error bars) of ankle power; pre- and post-surgery.

Though plantar flexor moment decreased in the TAR group, increased ROM and subsequently greater angular velocity during push-off resulted in large power generation. The combined effect allows sustained gait velocity and improved gait function overall. These findings are in agreement with those of Piriou et al. [8].

CONCLUSIONS

From the initial findings of this long-term study it appears that overall gait function is improved at 12 months post-surgery for both surgery types (as seen in improved temporal-distance measures). However, tibiotalar arthroplasty appears to retain more natural ankle joint function. Long term follow up should reveal more significant functional outcomes.

REFERENCES


ACKNOWLEDGEMENTS

This study was supported by Department of Veterans Affairs grant A4513R.