ANKLE ARTHROPLASTY INCREASES JOINT RANGE OF MOTION IN END-STAGE ARTHRITIC PATIENTS

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INTRODUCTION

Osteoarthritis is a disease that affects 27 million Americans each year [1]. Until recently, the standard treatment for end-stage ankle arthritis (ESAA) was arthrodesis or fusion. However, advancements in arthroplasties, or total ankle replacements (TAR), have made this an increasingly popular option, becoming the procedure of choice for many end-stage arthritic patients [2]. No TAR longitudinal studies thus far have used a multi-segment foot model, thus no data exists looking at how distal foot kinematics are affected due to the device.

The purpose of this study was to analyze kinematic differences in foot joint angles for end-stage ankle arthritic patients before and 1 and 2 years after receiving a total ankle replacement. This analysis will help quantify the recovery pattern from ankle arthroplasty in restoring movement and improving gait.

METHODS

Twenty-one adults (10 F/11 M, aged 60.4 ± 6.7 years, height 1.71 ± 0.08 m, mass 85.0 ± 15.8 kg, BMI 29.2 ± 4.9) with ESAA scheduled for ankle arthroplasty surgery were enrolled in the study. Subjects were evaluated pre-surgery (P0, n=21), and at 12 (P1, n=14) and 24 months (P2, n=9) after surgery. Data collection for P1 and P2 is still in progress.

To allow for averaging across subjects, these mean reaction force was used to determine stance phase. Three joint markers were placed on anatomical landmarks of the affected limb in accordance with the multi-segment foot model previously described by Leardini et al. [3] Three-dimensional marker trajectory data were collected at 120 Hz using a 12-camera motion analysis system (Vicon MX; Vicon Motion Systems, Oxford, UK). Five embedded force plates collected ground reaction force data (AMTI, Watertown, MA) at 1200 Hz. A static registration trial was collected first with the subject standing on a single force plate. Participants then performed five trials of barefoot walking at a self-selected walking speed along a 10 m walkway.

Trials were exported to Visual 3D (v5.0, C-motion Inc., Germantown, MD), where the four-segment foot model was created from the static trial markers: the shank, hind-foot (calcaneus), midfoot, and forefoot (metatarsals) [3]. This model was applied to the associated dynamic trials. Vertical ground reaction force was used to determine stance phase. Three joint angles were calculated: calcaneus with respect to (wrt) shank, midfoot wrt calcaneus, and metatarsus wrt midfoot. To allow for averaging across subjects, these angles were resampled to every 1% stance phase, and the mean angle from the associated static trial was subtracted from each dynamic trial. Only P0 and P1 data is presented here.

RESULTS AND DISCUSSION

Mean kinematic curves (Figure 1) as well as functional range of motion (Table 1) show improved range of motion in the sagittal plane between the calcaneus and shank between P0 and P1 sessions. In the coronal plane, this angle also displays an overall shift in the position of the ankle. Prior to surgery, this joint remains everted throughout the entirety of stance phase. After surgery, it becomes inverted at both heel strike and toe off.

Table 1: Average ± SD Functional Range of Motion

<table>
<thead>
<tr>
<th>Session</th>
<th>Sagittal</th>
<th>Coronal</th>
<th>Transverse</th>
<th>Sagittal</th>
<th>Coronal</th>
<th>Transverse</th>
<th>Sagittal</th>
<th>Coronal</th>
<th>Transverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>10.8 ± 3.8</td>
<td>3.9 ± 2.3</td>
<td>3.8 ± 1.5</td>
<td>10.3 ± 4.2</td>
<td>5.0 ± 2.2</td>
<td>3.5 ± 1.6</td>
<td>4.8 ± 2.6</td>
<td>4.0 ± 1.4</td>
<td>3.7 ± 1.9</td>
</tr>
<tr>
<td>P1</td>
<td>12.5 ± 2.9</td>
<td>4.0 ± 1.4</td>
<td>3.6 ± 1.5</td>
<td>10.3 ± 2.9</td>
<td>5.3 ± 1.7</td>
<td>2.6 ± 1.4</td>
<td>4.7 ± 2.3</td>
<td>3.0 ± 1.0</td>
<td>4.0 ± 1.7</td>
</tr>
</tbody>
</table>

Figure 1: Average kinematic curves throughout stance phase at P0 and P1 for three joints, compared to those of healthy patients found by Leardini [3].

Mean kinematic curves (Figure 1) also show that the calcaneus wrt midfoot angle in the sagittal plane has a noticeable increase in plantar flexion at P0 and P1 occurring around 80% stance phase. This is different than the monotonic behavior found by Leardini et al. [3]. In comparison, the peak plantar flexion angle occurring at 80% stance phase for the calcaneus wrt shank is less than the 9 degrees reported by Leardini. [3] One explanation of the increased midfoot motion is that it could be compensating for the lack of function in the talocrural joint caused by osteoarthritis and the device.

These results are limited in that the study is ongoing, of small sample size, and has a large degree of variability. The end goal is for physicians and physical therapists to use these results to inform rehabilitation protocols for patients recovering from arthroplasty surgery.

REFERENCES


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