THE EFFECTS OF TOTAL ANKLE REPLACEMENT ON ANKLE JOINT MECHANICS DURING WALKING

Scott Brown, Henry Wang, Jeffery Frame and Steven Herbst

1. Ball State University, Muncie, IN, USA
2. Central Indiana Orthopedics Center, Muncie, IN, USA

email: srbrown@bsu.edu web: http://bsu.edu/biomechanics

ABSTRACT

PURPOSE: The purpose of this study was to examine the ankle joint function and mechanics during level walking in patients diagnosed with severe end-stage ankle Osteoarthritis (OA) on the following two occasions: pre and three months post Total Ankle Replacement (TAR) surgery. METHODS: Five subjects ranging from 61–73 years, participated in level walking trails. Testing sessions were performed pre and three months post TAR surgery. RESULTS: Variables such as walking speed, stride length, double support, ankle ROM and ankle power showed significant increases in all subjects following the TAR surgery. CONCLUSION: It was found that the TAR joint exhibited improved gait parameters and ankle joint mechanics during level walking when compared to the pre surgery condition.

INTRODUCTION

• In the past, ankle arthrodesis (ankle fusion) procedure was considered as the “gold standard” for the surgical treatment of end-stage ankle OA [1].
• In recent years, TAR has become an alternative of arthrodesis for the treatment of severe ankle OA.
• TAR can alleviate ankle pain due to OA and restore normal ankle joint function [2,3].
• The SALTO® Talar Anatomic Ankle (STAAA) (Torrier Inc., France) is a fixed bearing TAR that can mimic the anatomy and flexion/extension movement of the natural ankle joint [3] (Figure 1).

Figure 1: SALTO® Talar Anatomical Ankle

The purpose of this study was to examine the ankle joint function and mechanics during level walking in patients with unilateral ankle OA on the following two occasions: pre and three months post surgery with the STAA TAR. It was hypothesized that the TAR joint would demonstrate improved gait parameters and ankle joint mechanics when compared to the same limb before surgery during level walking.

METHODOLOGY

Subjects
The study included five subjects (3 males and 2 females; mean age of: 67 ± 6 yrs; body height: 173 ± 7 cm; body mass: 91 ± 17 kg) all previously diagnosed with unilateral advanced, end-stage ankle OA. All subjects signed informed consent forms prior to participation in the study.

Procedures
Each subject performed level walking at a self-selected pace on two occasions in a gait laboratory: pre and three months post TAR surgery. Three dimension kinematics and kinetics data were collected using a 12-camera motion capture system (100 Hz) (VICON Nexus, Oxford Metric, London, England) and two AMTI force platforms (1000 Hz) (Advanced Mechanical Technologies Inc., Watertown, MA, USA). Spherical retro-reflective markers were placed bilaterally on specific lower extremity anatomical landmarks following the plug-in-gait protocol.

Calculations
One-tailed Student t-tests were used to examine if the TAR system improved gait parameters and ankle joint mechanics after three months of surgery. Significant level was set at 0.05.

RESULTS

• Gait tempo-spatial parameters and involved ankle joint mechanics were presented in table 1.
• All patients showed significant increases in stride length and walking speed and decrease of double support time after three months of surgery (P<0.05).
• Compared to pre-surgical condition, at three months of post TAR surgery, four out of five patients showed an increase in peak ankle plantar-flexion (P = 0.193); and all patients showed significant increases in ankle range of motion (from peak dorsiflexion to peak plantar-flexion) during terminal stance (P < 0.05).
• Three month after the surgery, the TAR ankle demonstrated increased power absorption and production during stance (P<0.05) (Figure 2).
• In addition, three out of five patients displayed increased ankle plantar-flexor moment at push-off at three months post TAR.

Table 1: Gait parameters and involved ankle joint mechanics during walking pre and three months post TAR surgery [mean (standard deviation)].

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Conditions</th>
<th>Pre-TAR</th>
<th>Post-TAR</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporo-Spatial parameters</td>
<td>Walking speed (m/s)</td>
<td>0.74 (0.12)</td>
<td>0.93 (0.11)</td>
<td>0.005</td>
</tr>
<tr>
<td>Stride length (m)</td>
<td>0.87 (0.11)</td>
<td>1.04 (0.08)</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>Stance time (% GC)</td>
<td>66 (4.16)</td>
<td>63.42 (2.78)</td>
<td>0.055</td>
<td></td>
</tr>
<tr>
<td>Double support (% GC)</td>
<td>0.34 (0.05)</td>
<td>0.29 (0.04)</td>
<td>0.043</td>
<td></td>
</tr>
<tr>
<td>Involved ankle joint mechanics</td>
<td>Peak ankle plantar-flexion (°)</td>
<td>3.52 (3.93)</td>
<td>1.02 (7.30)</td>
<td>0.193</td>
</tr>
<tr>
<td>Ankle RROM (°)</td>
<td>15.18 (7.86)</td>
<td>19.91 (5.97)</td>
<td>0.045</td>
<td></td>
</tr>
<tr>
<td>Ankle plantar-flexor moment (Nm/kg)</td>
<td>0.85 (0.17)</td>
<td>1.04 (0.26)</td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>Ankle absorption power (W/kg)</td>
<td>-0.43 (0.17)</td>
<td>-0.69 (0.15)</td>
<td>0.023</td>
<td></td>
</tr>
<tr>
<td>Ankle production power (W/kg)</td>
<td>1.08 (0.63)</td>
<td>1.81 (0.73)</td>
<td>0.039</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION

The pre TAR surgery data indicated that patients had impaired ankle joint function, which limited their ability to perform daily activity such as level walking. Three months after TAR surgery, patients were able to depend on their TAR ankle to produce increased ankle joint power, stride length, and walking speed. The increased stride length and walking speed appeared to be results of increased TAR ankle range of motion and ankle joint power during stance.

CONCLUSIONS

The STAA TAR appears to help patients regain ankle range of motion and strength. With a STAA TAR, in as little as three months of surgery, patients were able to increase ankle joint range of motion and joint power and subsequently increase walking speed significantly.

Future research should look into examining the longevity of the STAA TAR in order to eliminate a further revision and to firmly establish its long-term benefits and functionality.

REFERENCES

3. www.torner-us.com