GAIT ABNORMALITIES ASSOCIATED WITH ANKLE OSTEOARTHRITIS

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Introduction
Severe ankle osteoarthritis is associated with pain, disability, and limitation in ankle motion. Few studies are available regarding the impact of arthritis on the ankle function during ambulation [1]. An objective and function-related evaluation of patients with ankle arthritis will provide important information for determining degree of impairment, and effects of treatment. The purpose of this study is to evaluate ankle function including kinematics, kinetics and time related-factors to characterize the abnormalities associated with ankle osteoarthritis during ambulation.

Materials and Methods
Seven patients with unilateral ankle osteoarthritis were evaluated, two females and five males, excluding patients who had previous ankle/hindfoot reconstruction, systemic rheumatic diseases, hindfoot arthritis, lower extremity joint replacement, or other disorders affecting gait. Patients ambulated on a level walkway. Ground reaction forces measurements obtained from a force plate (Kistler Instruments Corp., Amherst, NY) collected time-synchronized with kinematic measurements obtained from an eight-camera Motion Analysis System with eleven reflective markers applied to the skin in a specific foot marker set [2,3]. The three-dimensional coordinates of the markers and force plate data were used as input into a custom software program to calculate the ankle joints kinematics and kinetics as well as the time-related factors. The kinematics study focused on calcaneal-tibial (cal-tib) and metatarsal-calcaneal (met-cal) motion in the sagittal, coronal and transverse planes. We determined ground reaction forces between floor and foot during stance phase: vertical, fore-aft and mediolateral forces. A total of nine force parameters (peaks) expressed in percentage of cadence, duration of gait cycle and stance phase. Three trials for each patient between floor and foot during stance phase: vertical, fore-aft and mediolateral sagittal, coronal and transverse planes. We determined ground reaction forces collected time-synchronized with kinematic measurements obtained from an eight-camera Motion Analysis System with eleven reflective markers applied to the skin in a specific foot marker set [2,3]. The three-dimensional coordinates of the markers and force plate data were used as input into a custom software program to calculate the ankle joints kinematics and kinetics as well as the time-related factors. The kinematics study focused on calcaneal-tibial (cal-tib) and metatarsal-calcaneal (met-cal) motion in the sagittal, coronal and transverse planes. We determined ground reaction forces between floor and foot during stance phase: vertical, fore-aft and mediolateral forces. A total of nine force parameters (peaks) expressed in percentage of body weight (F1-F9) and their chronology expressed in percentage of stance phase. The third vertical peak (T3) occurred earlier (p=0.009) in the ankle arthritis patients. The decreased sagittal, coronal and transverse hindfoot motion, abnormal vertical force and decreased fore-aft force at the early stance as well as reduced vertical and aft forces at the late stance phase illustrate the disabling influence of ankle arthritis on the foot function in load response and push-off.

Results

Time-related factors: Ankle arthritis patients walked at a lower cadence (p=0.004). The absolute duration of gait cycle (p=0.003) and stance phase (p=0.009) was higher but relative duration of stance phase expressed in percentage of the gait cycle did not differ from the normals (Table 1).

Kinematics: Reduced cal-tib plantarfexion (p=0.012), total sagittal motion (p=0.003), inversion (p=0.035), total coronal motion (p=0.008), total transverse motion (p=0.0009) (Fig. 2), as well as reduced met-cal internal rotation (p=0.009) and total transverse motion (p=0.003) was observed by the ankle arthritis patients.

Ground reaction forces: The magnitude of the second vertical force (F2) was higher (p=0.042) by the arthritic patients. The magnitude of the third vertical force (F3) (p=0.0001) and of all three fore-aft shear forces (F4-6) (p=0.015, p=0.041, p=0.003) was reduced. The first vertical peak (T1) occurred later (p=0.042) and the third vertical peak (T3) occurred earlier (p=0.009) in the stance phase.

Discussion
A recent retrospective review of ankle arthrodesis operations concluded that the procedure caused hindfoot stiffness and arthritis. The present study demonstrated that hindfoot function was clearly impaired in patients with ankle arthritis who never had arthrodesis surgery, suggesting that arthrodesis is not be the critical factor contributing to development of late hindfoot arthritis. The present study demonstrated the value of gait analysis to objectively characterize ambulation abnormalities associated with ankle osteoarthritis. The decreased sagittal, coronal and transverse hindfoot motion, abnormal vertical force and decreased fore-aft force at the early stance as well as reduced vertical and aft forces at the late stance phase illustrate the disabling influence of ankle arthritis on the foot function in load response and push-off.

Table 1: Time-related factors

<table>
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<tr>
<th></th>
<th>Normals</th>
<th>Ankle arthritis</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gait Cycle (GC) (sec.)</td>
<td>1.10±0.08</td>
<td>1.26±0.15</td>
<td>.003</td>
</tr>
<tr>
<td>Stance phase (sec.)</td>
<td>0.69±0.06</td>
<td>0.80±0.10</td>
<td>.009</td>
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<td>Stance phase (%GC)</td>
<td>62.98±2.01</td>
<td>63.26±1.34</td>
<td>.745</td>
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<tr>
<td>Cadence (GC/min.)</td>
<td>54.50±3.61</td>
<td>47.91±5.58</td>
<td>.004</td>
</tr>
</tbody>
</table>

Fig. 1: Normative data for ground reaction forces [4].

Fig. 2: Vertical and fore-aft ground reaction forces: comparison between normals and patients with osteoarthritis.

Fig. 3: Cal-tib motion: significant differences between normals and patients with ankle osteoarthritis.

References

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