Artificial Reproduction of the Weight-Bearing State for Foot and Ankle Using an Original Loading Device for Use in CT Scans.

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Tadashi Kimura

My disclosure is in the Final AOFAS Mobile App. I have no potential conflicts with this presentation.
<Introduction>

Foot and ankle disease (ex, Flat foot, Hallux valgus, Ankle OA)

When these patients are standing:

- The relationships between bones of the feet change
- Symptoms develop (Pain, Instability, etc.)

Weight-bearing plain radiographs are used for diagnosis and pre-operative planning.
Advantages of CT scans over plain radiographs:

◎ Clearer visualization of the bone outlines

◎ More easy three-dimensional rendering of bony structures
  (Alignment changes in a three-dimensional fashion under weight-bearing)

◎ Possible evaluation of bone axis displacement and rotation

Weight-bearing CT is necessary to assess minute changes in osseous alignment.
<Weight-Bearing CT>

These scanners have been developed in recent years.

- High costs & space requirements.
- Advantageous only for orthopaedic patients (specifically in some lower limb conditions)

Not widely used, loading devices needed!

<Loading Device>

Previous studies with loading devices that mimic standing conditions.

Few have assessed how well a loading device can reproduce standing conditions.

We designed a new loading device and evaluated its usability.
Designed a new loading device for use with currently available CT scanners.
No metal parts to avoid artifacts in the areas close to feet and ankles.
Evaluation of our loading device in reproduction of standing conditions.

**Patients**
- 10 feet of 5 healthy volunteers
- No history of foot or ankle disorders
- No foot pain.

**Method 1**  Standing conditions
Footscan® (RSscan, Olen, Belgium)
- Plantar contact area
  - Entire foot (cm²)
- Plantar Pressure (N)
  - Percentages of the forefoot, midfoot, and hindfoot comprising the total area
  - Overall
    - Forefoot
    - Midfoot
    - Hindfoot
<Method 2> On the loading device

- Supine position with legs extended.
- Ankles in a neutral position.

① A Scale placed between the foot plate and the soles.
② Weight plates hung from the hook until the load reached roughly the subject’s body weight.

③ The scale removed, the footscan Placed between the foot plate and the soles.
④ Same measurements taken during standing.
Comparison Between Standing and Loading Device

- Measurements for each subject were repeated 5 times. (Standing and on loading devices)
- The mean values were recorded.
- Differences between two groups measurements were assessed using the paired $t$ test.
- A two-sided significance level of 5% was used.

Footscan
## Result

No subjects complained of pain or experienced discomfort. No significant difference was detected for each parameter.

<table>
<thead>
<tr>
<th></th>
<th>Standing</th>
<th>With loading device</th>
<th>Variation between measurements</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantar Contact Area (cm²)</td>
<td>132.77 ± 18.04</td>
<td>128.62 ± 23.48</td>
<td>-4.15</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Percentage in Contact (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forefoot</td>
<td>53.45 ± 1.65</td>
<td>52.84 ± 3.33</td>
<td>-0.61</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Midfoot</td>
<td>25.41 ± 2.5</td>
<td>25.24 ± 2.87</td>
<td>-0.17</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Hindfoot</td>
<td>21.13 ± 1.72</td>
<td>21.92 ± 1.86</td>
<td>0.79</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Plantar Pressure (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>426.15 ± 110.02</td>
<td>419.75 ± 115.9</td>
<td>-6.40</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Forefoot</td>
<td>154.82 ± 57.18</td>
<td>155.45 ± 51.13</td>
<td>0.63</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Midfoot</td>
<td>75.24 ± 25.25</td>
<td>64.34 ± 14.77</td>
<td>-10.90</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Hindfoot</td>
<td>196.09 ± 68.97</td>
<td>199.96 ± 72.25</td>
<td>3.87</td>
<td>P &gt; 0.05</td>
</tr>
</tbody>
</table>
<Conclusion>

Our device reproduced standing conditions well.

The features of our product are:

- Full weight-bearing.
- Hand-made
- Low cost

<Future Study>

Using this load apparatus, we could approximate load distribution and strength to standing position. Then, we suggest that CT scanning with this apparatus allows good reproducing image of standing position. Furthermore, by comparing patients and healthy humans, we also suggest that we can obtain useful information about the cause and condition of foot diseases.