A COMPARISON OF THE EFFECT OF FOAM-BOX CASTED AND PLASTER-CASTED ORTHOTICS ON THE NORMAL FOOT POPULATION USING BI-PLANAR X-RAY FLUOROSCOPY

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INTRODUCTION

Orthotics are frequently prescribed for the conservative treatment of musculoskeletal disorders of the foot and ankle such as pes cavus or pes planus. Pes cavus is defined as having a high arch whereas pes planus is defined as having a low arch in the foot. The normal population is considered to have an arch in between pes cavus and pes planus. Orthotics are thought to alter the motion of the bones of the foot by applying constraint or support to various structures on the plantar surface.

Two commonly used techniques for casting the foot for an orthotic include: plaster wrap and foam box. The foam box technique has the practitioner guide the patient’s foot into a foam tray that takes a negative impression of the foot while in the subtalar neutral position [1]. The plaster casting technique requires the patient lie prone in a figure four position during the process. A negative impression of the foot is taken while being locked in the subtalar neutral position [1]. While plaster casting has historically been the standard method, foam box has increased in popularity.

Bi-planar x-ray fluoroscopy has been demonstrated to be a feasible method for measuring foot bone motions during in-vivo weight bearing gait [2]. To the authors’ knowledge, a three-dimensional (3D) bi-planar x-ray fluoroscopy study of the foot during orthotic use in the normal population has not yet been done. Bi-planar x-ray fluoroscopy is used to compare the motion of the calcaneus in 3D to determine overall pronation of the foot during gait. Pronation is defined as the combination of external rotation, dorsi-flexion, and eversion. Five conditions were tested: barefoot, soft and rigid foam box orthotics, and soft and rigid plaster casted orthotic. It was hypothesized that the greatest pronation would occur during barefoot walking and the least during the rigid orthotic conditions. It was also hypothesized that there would be no statistical difference in the foam box and plaster casted orthotics ability in reducing foot pronation.

METHODS

Six (6) volunteers with normal arches were fitted with four pairs of custom-made orthotics by the same Canadian Certified Pedorthist using the foam box and the plaster casting technique. The orthotics were made with both a 4mm plastazote (soft) and 3mm RCH-500 (rigid) material as per usual clinical practice. Each volunteer walked along a custom-made wooden platform that raised their feet to the height of the two fluoroscopy units (SIREMOBIL; Compact-L; Siemens, Malvern, PA). On the platform each volunteer was able to walk normally and fully weight bearing past the fluoroscopes. The left foot was imaged during stance phase from an oblique, dorsal-medial to plantar-lateral view while simultaneously imaged from a sagittal plane view.

Each volunteer was instructed to walk along the platform at their preferred pace while the fluoroscopes recorded the images simultaneously at 30 frames per second. Each trial condition was repeated twice, ensuring that the entire hindfoot and tarsus were visible at all times. Five conditions were tested in a randomized order: 1) barefoot, 2) soft foam box orthotic, 3) rigid foam box orthotic, 4) soft plaster casted orthotic, 5) rigid plaster casted orthotic. The four custom-made orthotics were constructed with a deep heel cup intended to limit the pronation of the calcaneus during stance. Each volunteer had a computer tomography (CT) scan completed on their left foot.

The fluoroscope images were digitized on the control PC and stored as a tiff format. Each frame was post-processed using custom-written software...
(MATLAB; Mathworks Inc., Natick, MA). A calibration algorithm allowed the experimental set-up to be recreated in the virtual environment (Rhinoceros; Robert McNeel & Associates, Seattle WA, USA). Using the CT image the calcaneus, tibia and fibula were segmented and bony landmarks were identified and marked (OsiriX; Advanced Open-Source PACS Workstation DICOM Viewer, Antoine Rosset, USA). The individual bone coordinate systems for the calcaneus and tibia/fibula (Fig. 1) were based on the International Society of Biomechanics standard. The change in pronation can then be determined during each condition using the barefoot (control) condition as the baseline value [3]. Using custom-written software internal rotation, plantar-flexion, and inversion angles were calculated. The bones involved in this calculation were the calcaneus, tibia, and fibula.

Each data set was evaluated for statistical significance using an ANOVA repeated measures test using SPSS (SPSS; IBM Corp., Armonk, NY).

RESULTS AND DISCUSSION

The effect of the foam hard/soft orthotic as well as the plaster hard/soft orthotic is summarized in table 1. Both orthotic types show a significant change in alignment with p<0.05 in the ANOVA two repeated measures test. This means that these variables should follow a normal distribution pattern where 99.5% of all cases will fall within two standard deviations (SD) [4].

When the effect of the foam casted orthotics was analyzed it is evident that a reduction in pronation occurs. However, the internal rotation measurement for the foam hard orthotic is not statistically significant. A reduction in pronation was also evident in the plaster casted orthotics. However the change associated with the plantar-flexion angle does not have statistical significance in the plaster hard orthotic.

A comparison of the foam rigid and the plaster rigid showed there was no statistical difference with the change in pronation between the casting method. A comparison of the foam soft and plaster soft showed there was no statistical difference between the casting methods when measuring the change in pronation. The statistical analysis is to be revisited when all potential patients have been fully analyzed to ensure the model is as accurate as possible.

CONCLUSIONS

The results indicate orthotics reduce calcaneal pronation as the foot is in mid-stance during gait. The method of casting and material chosen does not change the amount of pronation by a statistically significant value.

REFERENCES


Table 1: Change in the internal/external rotation, plantar-flexion/dorsi-flexion, and inversion/eversion angle by comparison to the barefoot (control) condition. All entries in degrees.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Internal Rotation</th>
<th>Plantar-flexion</th>
<th>Inversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foam Hard</td>
<td>3.20±3.71</td>
<td>36.85±6.29</td>
<td>17.07±6.80</td>
</tr>
<tr>
<td>Foam Soft</td>
<td>7.56±2.31</td>
<td>23.54±5.80</td>
<td>17.57±7.34</td>
</tr>
<tr>
<td>Plaster Hard</td>
<td>4.54±1.48</td>
<td>7.45±11.6</td>
<td>8.74±6.06</td>
</tr>
<tr>
<td>Plaster Soft</td>
<td>1.70±1.51</td>
<td>14.17±6.65</td>
<td>5.76±4.07</td>
</tr>
</tbody>
</table>

Note: A negative value represents the opposite motion (i.e. negative inversion would mean the foot is actually experiencing eversion).