INTRODUCTION
• The ankle is one of the most common sites of injury for an occupant during a frontal vehicular collision [1] and damage to this region can result in a high level of impairment, accompanied by long-term healthcare costs and emotional distress.
• Understanding the factors which cause ankle injury will help in the design of suitable protective systems.
• Risk of ankle injury in different loading scenarios has been studied experimentally and numerically, with most of the emphasis being on the ankle in a neutral posture (e.g. [2]). However, the ankle can assume a wide variety of postures during injuries events.
• A concern with this type of experimental testing is the variability in joint alignment required to control the load path during impact, with fractures occurring in the tibia, talus and calcaneus.
• At the wrist, during falls, the orientation of the scaphoid and lunate has been shown to affect both the location of fracture and fracture load in the radius [3].

PURPOSE
• To determine the effect of ankle posture on the positions of the bones of the foot/ankle, which, in the event of a frontal vehicular collision, may alter the fracture threshold and location.
• To use strain gage data from the ankle loaded in different postures with the intention of generating a finite element model of the ankle.

METHODS
• A CT-compatible test frame (Fig. 1) was developed, which can adjust the angles of the ankle independently to varying degrees of flexion/extension, internal/external rotation and inversion/eversion (Fig. 2) and can apply force to a cadaveric lower leg fixed at the proximal tibia through pulleys and hanging weights.
• Soft tissues are removed only where necessary, from a 50th percentile male leg, in order to apply 5 strain gages to the specimen – 3 on the calcaneus bone and 2 on the talus bone (Fig. 3). For the gage attached to the medial talus, the tibiospring and tibionavicular ligaments are to be removed. For the gage attached to the posterior talus, some cartilage is removed, as well as part of the posterior talofibular ligament.
• The proximal tibia is potted and proper axial alignment is ensured. The potted tibia is then fixed to the test frame so that it is parallel with the CT bed.
• The ankle is attached to the ankle positioner at a neutral posture and is subject to two preconditioning cycles, in which loads are applied from 0 to 100 lbs in 20 lb increments.

Expected results
• It is anticipated that the posture of the ankle will affect the positions of the associated bones, and ultimately the load pathway and injury tolerance of the foot/ankle complex. To our knowledge, this effect has not been previously investigated in the literature.

Table 1: Ankle Postures to be Tested

<table>
<thead>
<tr>
<th>Ankle Postures</th>
<th>Eversion (°)</th>
<th>Inversion (°)</th>
<th>Dorsiflexion (°)</th>
<th>External Rotation (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Combined Eversion/External Rotation</td>
<td>20</td>
<td>n/a</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Combined Inversion/External Rotation</td>
<td>n/a</td>
<td>20</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Combined Dorsiflexion/Inversion</td>
<td>n/a</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

FUTURE WORK
• The locations of the attached strain gauges will be recorded in the CT scans so that a finite element model of the ankle in various positions can be developed and validated.
• The results from this study will be useful for research in determining injury limits of the ankle and for developing postural guidelines to minimize injury.

REFERENCES

ACKNOWLEDGEMENTS
This research is supported by McMaster University, The Ontario Graduate Scholarship (OGS), The Canada Foundation for Innovation (CFI), The Ontario Research Fund (ORF) and The Natural Sciences and Engineering Research Council of Canada (NSERC).