COLLEGE OF ENGINEERING
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CT foot loader

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Problem Statement

While nearly all feet radiographs are shot with the patient bearing weight, computed tomography (CT) scans of the feet and ankles are currently done in non-weight bearing conditions. A device is needed that applies a load to the feet while the patient is lying on the CT table, thus better simulating the anatomic alignment of the bones and tissues under physiologic loading.

Background and Motivation

CT provides detailed, three-dimensional reconstructions of x-ray projections [2]. For the ankles and feet, CT is used to find anatomic subtleties that are not visible in normal radiographs. It is often used for patients suffering from chronic, unexplainable foot pain. Our client's areas of interest include the Lisfranc joint and the posterior tibial tendon.

The GE Lightspeed CT scanner that the device will be used with.

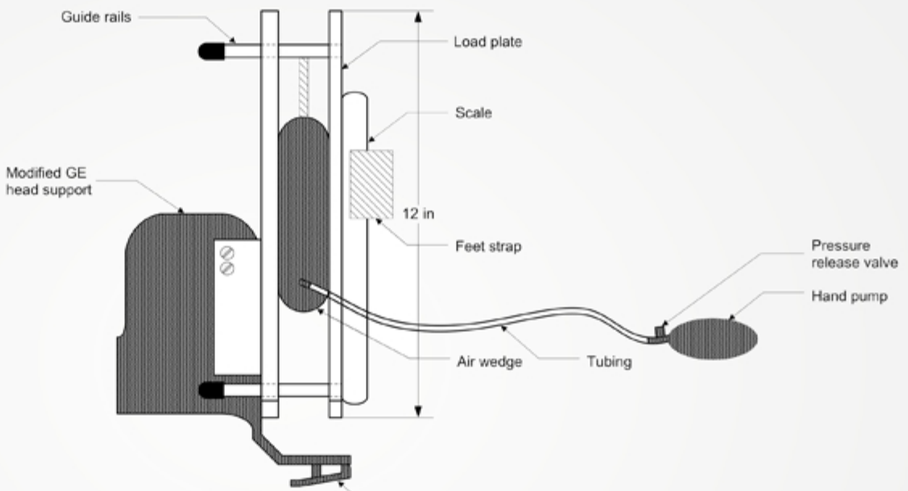
It is hypothesized that such anatomic subtleties may only be visible in load-bearing conditions. There is currently no standard protocol for CT imaging of the feet and ankles, making it difficult to compare images. This device would not only simulate load-bearing conditions but would also help establish a standard feet and ankle position, with the feet together and upright.

Requirements

The device must:

- have no radiopaque materials within the scanning field (from the ankle to bottom of foot).
- apply a force of up to 50 lbs. to the feet.
- measure the load with an accuracy of ± 1 lb.
- securely hold the feet in an upright position.
- be easily movable by one technician.
- be able to be cleaned with common disinfectants.

Final Design



Operation

Load is applied to the feet by manually inflating an air wedge, which pushes a free-sliding plate against the feet. The patient adjusts the load up to the onset of pain or discomfort. In the current prototype the load is measured by a mechanical scale.

Materials

The main structural components are made of ultra high molecular weight polyethylene (UHMW). It was chosen since it is radiolucent [1], durable, and has high chemical resistance. The scale is the only radiopaque component.

Pictures of the device attached to a GE CT table. The device loads the feet via a pneumatic mechanism that pushes a plate against them.

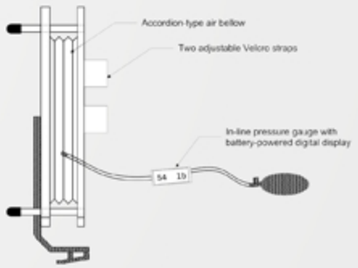
Components and costs

Component	Description	Price
Inflatable vinyl air wedge	Generates the load on feet; includes pump and valve	$34.22
12x12x1/2" UHMW sheet	Rear plate, mounted to head support	$10.94
12x12x3/8" UHMW sheet	Load plate	$8.48
1'x1.5'x1.5" UHMW bar	Connects rear plate to head support	$8.15
Strap	Secures feet in upright position	$6.99
Velcro	Fastens the strap	$5.99
Mechanical scale	Temporary force measurement mechanism	$5.97
10 ft long vinyl tubing	Allows patient to operate pump	$3.99
5'x3/8" diameter UHMW rod	Guide rails to prevent load plate torsion	$3.80
Shoe lace	Used to hang air wedge from top guide rails	$1.99
Electrical tape	Temporary nuts on guide rails	$1.99
GE carbon fiber head support*	Fits CT table with proprietary clip mechanism	$0.00
	Total cost:	**$92.51**

* The head support was donated by GE Healthcare. It is valued at $600.

Future Work

- Run device through CT scanner with a phantom to see how it affects the image.
- Replace air wedge with accordion-type bag for uniform pressure distribution.
- Implement an in-line pressure gauge connected to a battery-powered LCD display for more accurate load measurement.
- Replace modified head support with an assembly that takes up less space yet maintains clip mechanism for easy attachment and alignment to table.
- Conduct research study to determine the benefits of CT imaging under load.
- Adapt device for magnetic resonance imaging (MRI) of the knee under load.



Drawing of the next prototype with improved force generation and measurement.

References and Acknowledgements

1. Schneider, U., Pedroni, E. & Lomax, A. The calibration of CT Hounsfield units for radiotherapy treatment planning. *Phys. Med. Biol.* **41**, 111-124 (1996).

2. Smith, H. Computed tomography. GE Healthcare Medcyclopaedia **2006**, 3 (2006) http://www.medcyclopaedia.com/library/radiology/chapter04/4_2.aspx.

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