ABSTRACT

Background

Computed tomography (CT) has become a routine imaging modality for numerous clinical applications due to its extensive availability, less invasiveness, short scanning time, excellent anatomical resolution, and superior diagnostic value. CT phantoms constructed from bone and tissue-equivalent materials have historically been used to provide a physical representation of the body's anatomy and attenuation characteristics for image quality. Correct diagnosis depends on accurate calibration of the CT scanner and the image interpretation. However, the widespread clinical use of these phantoms has been limited by their prohibitive costs. Therefore, it is essentially to search for new cheap and available materials with tissue equivalent properties to construct a CT phantom for the image quality purposes.

Objectives

The main objectives of this study are to evaluate the radiological characteristics of the silicone rubber RTV (1 and 2), and silicone rubber RTV with $CaCO_3$ based on density and CT Hounsfield unit (HU). Also, to fabricate a CT phantom made of silicone rubber RTV, and silicone rubber RTV with $CaCO_3$ for applying image quality tests for CT machine.

Materials and Method

The first portion of this work centered on the development tissue-equivalent materials for use in CT phantom construction. The materials were to be equivalent to human tissue in density and x ray attenuation properties at adult abdomen protocol. Silicone rubber RTV 1 was used to mimic water and soft tissue, silicone rubber RTV 2 with $CaCO_3$ were used to mimic bone tissue, and hot melt adhesive was used to mimic fat tissue. After preparing each of the previous materials, physical density and HU were measured. The shape and design of the phantom modules were prepared by using three dimensions (3d) printer. Module one for assessment the alignment and HU accuracy, module two for assessment the contrast resolution and contrast-to-noise ratio (CNR), module three for assessment the uniformity and artifacts, and module four for assessment the spatial resolution.

Results

Physical density measurements were 1.053, 1.710, and 0.990 for tissue, bone, and water equivalent materials, respectively. In module one that it used to assess the alignment and HU accuracy, the average HU values were -2.5, 904.6, 127.3, and -65.2 for water, bone, acrylic, and fat, respectively. In module two that it used to assess the contrast resolution and CNR, there are the four cylinders can be seen with each diameter. The average CNR measurement was 1.04. The uniformity test in module three (in five positions; one in the center and the others on the edges) were

within the tolerance value (± 5HU). Also, there is no any artifact could be recorded on module three. The last module which is used to assess the spatial resolution, the group numbers 1, 2, 3, 4, 5, and 6 which correspond 4, 5, 6, 7, 8, and 9 lines per centimeters (lp/cm), respectively, were clearly visible. Finally, since passing all of the tests (based on ACR accreditation phantom) for image quality operated at the adult abdomen protocol by using the new phantom, the new phantom of image quality was accepted.

Conclusions

The main conclusions of this study are, new tissue, bone, and water equivalent materials were determined by assessing the physical density and HU CT. Also, a CT phantom was fabricated and constructed to evaluate the image quality.

Key words

Tissue equivalent materials, Computed tomography, Phantom, Image quality