Quantitative Measurements of 3-D Imaging with Computed Tomography using Human Skull Phantom

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ABSTRACT

As an advancement of medical imaging modalities and analyzing software with multi-function, active researches to acquire high contrast and high resolution image being done. In recently, development of medical imaging modalities like as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) is aiming to display anatomical structure more accuracy and faster. Thus, one of the important areas in CT today is the use of CT scanner for the quantitative evaluation of 3-D reconstruction images from 2-D tomographic images. In CT system, the effective slice thickness and the quality of 3-D reconstructed image will be influenced by imaging acquisition parameters (e.g. pitch and scan mode). In diagnosis and surgical planning, the accurate distance measurements of 3-D anatomical structures play an important role and the accuracy of distance measurements will depend on the acquisition parameters such as slice thickness, pitch, and scan mode. The skull phantom was scanned with SDCT for various acquisition parameters and acquisition slice thicknesses were 3 and 5 mm, and reconstruction intervals were 1, 2, and 3 mm to each pitch. 3-D visualizations and distance measurements were performed with PC based 3-D rendering and analyzing software. Results showed that the image quality and the measurement accuracy of 3-D SDCT images are independent to the reconstruction intervals and pitches.

Keywords: Computed Tomography, 3D Imaging, measurement, acquisition parameters, skull phantom

INTRODUCTION

As an advancement of medical imaging modalities and analyzing software with multi-function, active researches to acquire high contrast and high resolution image being done. In recently, development of medical imaging modalities is aiming to display anatomical structure more accuracy and faster and application of CT imaging techniques has improved the accuracy of diagnosis and treatment. In diagnosis and surgical planning, the accurate distance measurements of 3-D anatomical structures play an important role and the accuracy of distance measurements will depend on the acquisition parameters such as slice thickness, pitch, and scan mode. But it is necessary to study the correlation with radiation dose, scan time, and effective slice thickness in image quality. This study was to evaluate the relations between image quality and diagnostic efficacy of single-detector CT (SDCT) by comparing the accuracy of distance measurement on 3-D CT images controlling reconstruction intervals of CT image with a human skull phantom. We tried to evaluate the accuracies of 3-D reconstruction images for various acquisition parameters using CT and skull phantom.

MATERIALS AND METHODS

The direct distances between the clinically significant facial points on the skull surface, measured with a digital vernier caliper (Mitutoyo Co., Tokyo, Japan), were defined gold standard to assess the measuring errors. Then the skull phantom was immersed in a rectangular acrylic block filled with water for compensating the value of soft tissues, and the skull phantom was scanned with SDCT (Hispeed Advantage, GE Medical System, Milwaukee, U.S.A.) for acquisition parameters at 200 ㎃, 120 kVp and 1.0 sec gantry rotation time in helical mode (three pitch modes: 1:1, 1.5:1, and 2:1). Acquisition slice thicknesses were 3 and 5 mm, and reconstruction intervals were 1, 2, and 3 mm to each pitch. 2-D tomographic images were processed to high resolution with an enhanced resolution function. The tomographic data reconstructed in CT consol were transferred to GE workstation systems thorough network for the further processing and data saving with DICOM file format. During the 3-D image visualizations, maximum opacity value in an opacity control step was specified to 66% for all images, and minimum threshold value in a 3-D rendering

Table 1. Imaging protocols of slice thicknesses, pitches and reconstruction intervals with SDCT

Scan type	Gantry rotation time (sec)	Acquisition slice thickness (mm)	Scan mode (pitch)	Reconstruction slice thickness (mm)	kVp / mA
Helical	1.0	3.0	1:1	1, 2, 3	120 / 200
			1.5:1	1, 2, 3	
			2:1	1.5, 2, 3	
		5.0	1:1	2, 3, 5	
			1.5:1	2, 3, 5	
			2:1	2, 3, 5	

step was controlled to 58, and applied keep object function to eliminate other soft tissues except bone. 3-D visualizations and distance measurements were performed with PC based 3-D rendering and analyzing software, V-works^{TM} 4.0 (CyberMed Inc., Seoul, Korea).

RESULTS

62%, 28%, and 10% of total measurements were in error range of less than 1, 2 and 3 mm as compared with gold standard, respectively. In case of pitch 1:1, 1.5:1, and 2:1, the results in error range of less than 1 mm were 64%, 54% and 71%, respectively. When retro reconstruction intervals were 1, 2, and 3 mm having no connection with all pitches, the results in error range of less than 1 mm appeared in the ratio of 60%, 70%, and 56%.

CONCLUSION

It showed that the image quality and the measurement accuracy of 3-D SDCT images are independent to the reconstruction intervals and pitches. In these cephalometric 3-D analyses, these results indicated that it can be considered clinically acceptable to use the protocol of pitch 2:1 with 3 mm reconstruction interval decreasing radiation dose for patients and obtaining same results with reference parameters.

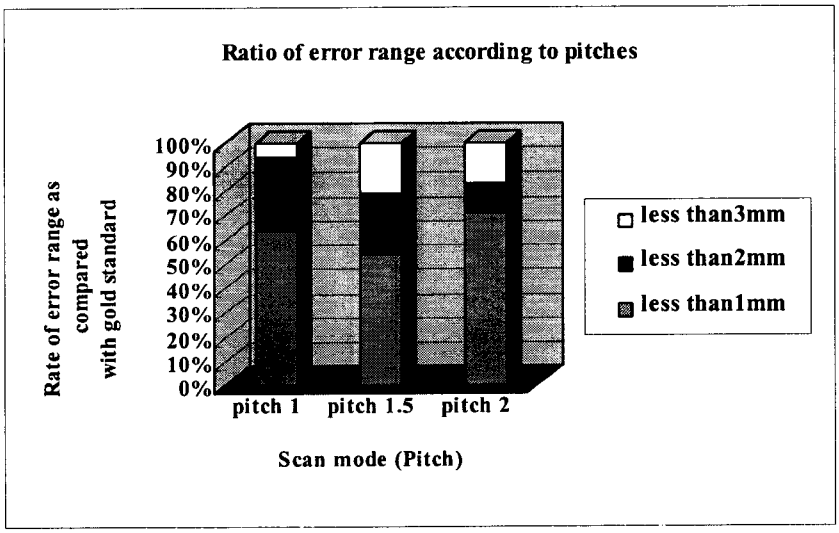

Fig. 1. It shows that the ratio of measurements accuracy is regardless of pitch.

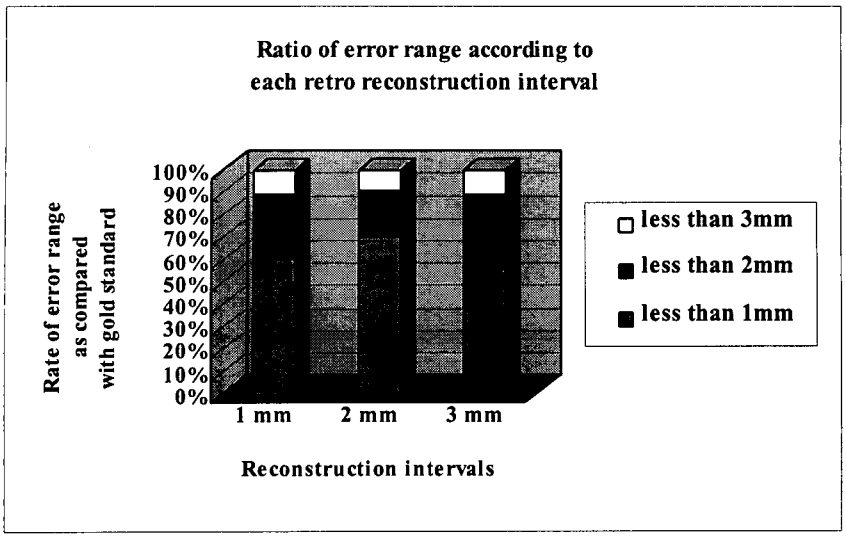

Fig. 2. The graphs in all reconstruction intervals are similar to the ratio of error ranges.

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