# Ultra Helical Scanning – Fast Acquisition of CT Images

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## Introduction

Since the introduction of clinical CT great improvements in scan time, patient comfort and resolution have been made. The first clinical CT scanner dates from 1972 and was developed by Godfrey Hounsfield. It required an acquisition time of 5 minutes and reconstruction of one image took 7 minutes[1]. In the following years CT systems improved rapidly and by 1976 acquisition time for one CT image had decreased to 5 seconds with a reconstruction time of 40 seconds[2].

Scanning entire body parts was still difficult at that time due to the long scan time, and image quality was limited by the thick slices of the traditional CT systems. Helical CT scanning was realized by introducing continuous table motion during the scan. Helical acquisitions improved the performance of traditional CT by offering larger coverage and better 3D image quality. With helical CT entire organs can be scanned within a single breath-hold.

In 2007, Toshiba introduced the Aquilion ONE™ system which allows for volumetric scanning. The volumetric 320-detector row CT scanner has a coverage of 160 mm and can be used to scan entire organs within one axial acquisition that takes 0.35 s. There are two options for scanning a larger range than 160 mm with the Aquilion ONE:
1 – wide volume acquisition
2 – helical acquisition.

Helical scanning can be performed with acquisition configurations of 64 x 0.5, 100 x 0.5 and 160 x 0.5 mm (number of active detector row times scanned slice thickness). The last two are known as ultra-helical acquisition configurations.

Helical CT is still generally applied in clinical practice with rotation times of about 0.35 s and a scanned slice thickness of 0.5 mm. Scanning a region of 1400 mm would take with a 4, 16, 64 and 160 detector row CT scanner at equal pitch 350, 88, 22 and 9 seconds respectively (Fig. 1).

Overranging is a well known phenomenon in helical CT and originally caused some unnecessary radiation exposure, particularly when acquisition

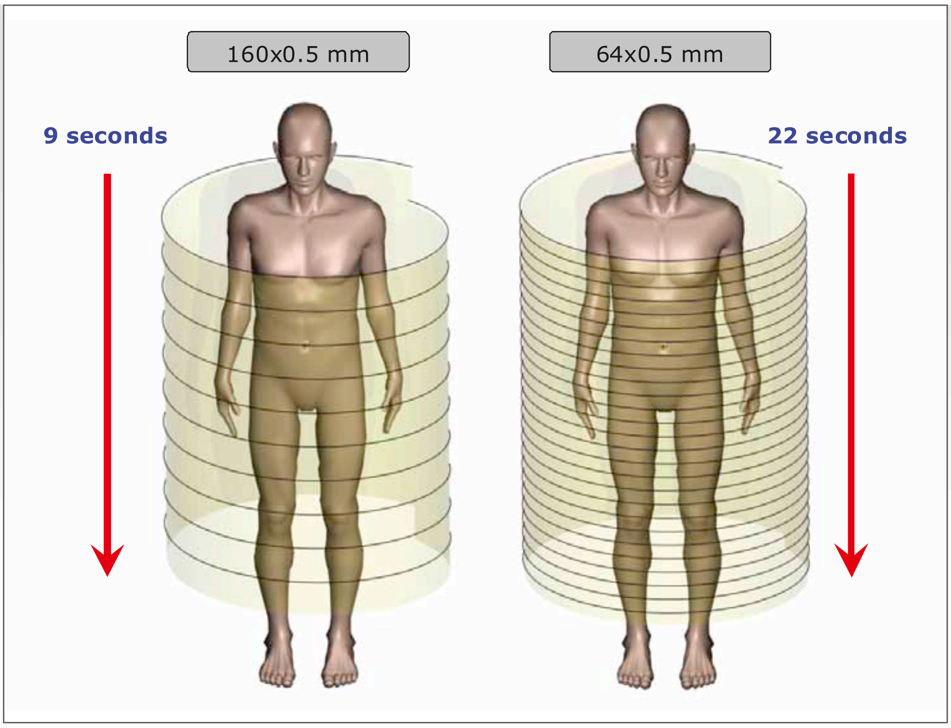


Fig. 1: Illustration of 64 x 0.5 mm and 160 x 0.5 mm scanning. With ultra-helical (left) the same region can be scanned with fewer rotations and less time.

configurations were used with a wide acquisition collimation and high numbers of active detector rows. The excessive radiation exposure that resulted from overranging limited the development of helical scanning using more than 64 active detector rows. Therefore a helical acquisition with for example 160 x 0.5 mm was previously undesirable.

To overcome this issue, the Toshiba Aquilion ONE CT scanner is equipped with an active collimator which eliminates unnecessary radiation exposure caused by overranging in helical acquisitions. The active collimator optimizes the collimation width during the acquisition; starting and finalizing the scan with a closed collimator and at optimized collimation width during the scan. With the implementation of the active collimator it became possible to develop the ultra helical acquisition techniques.

Purpose of this study was to compare radiation dose of standard helical scanning with ultra helical scanning and to demonstrate the performance of ultra helical acquisitions with a clinical case.

## Materials and methods

### Acquisition protocol

Acquisitions were performed on the Aquilion ONE CT scanner (Toshiba Medical Systems, Nasu, Japan) at three helical acquisition configurations: 64 x 0.5 mm (normal helical), 100 x 0.5 mm (ultra-helical 1), 160 x 0.5 mm (ultra-helical 2). The imaged scan ranges were 200, 400 and 600 mm for each acquisition configuration. Acquisition protocols were the same as those used in clinical practice, and the effective tube current (mAs per slice) was kept constant for each acquisition. The acquisition parameters are shown in Table 1.

### Dose measurements

Dose measurements were made free-in-air with a 102 mm pencil ionization chamber (model CP-4C; Capintec, Ramsey, NJ) connected to a dosimeter (model 35050A; Keithley Instruments, Cleveland, Ohio). The ionization chamber was fixed to a supporting stand that was positioned on the floor. The ionization chamber was aligned along the central axis of the scanner so that the axis of rotation of the scanner coincided with the center of the ionization chamber. Dose measurements were similar as those described in the paper by Van der Molen et al.[3].

## Results

Differences in scan time for these three acquisition configurations are provided in Fig. 2 which shows that the scan time decreased substantially for the ultra-helical acquisitions, it decreased with 64 % using 160 x 0.5 mm compared to 64 x 0.5 mm at

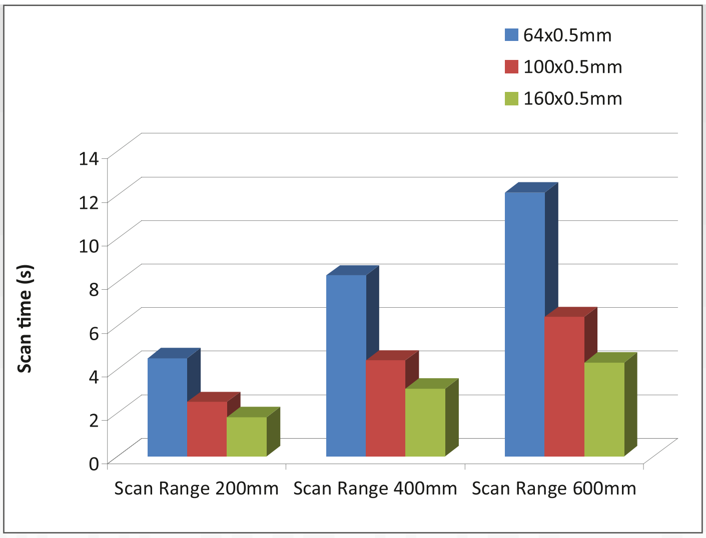


Fig. 2: Scan time of three scan lengths at normal and ultra-helical

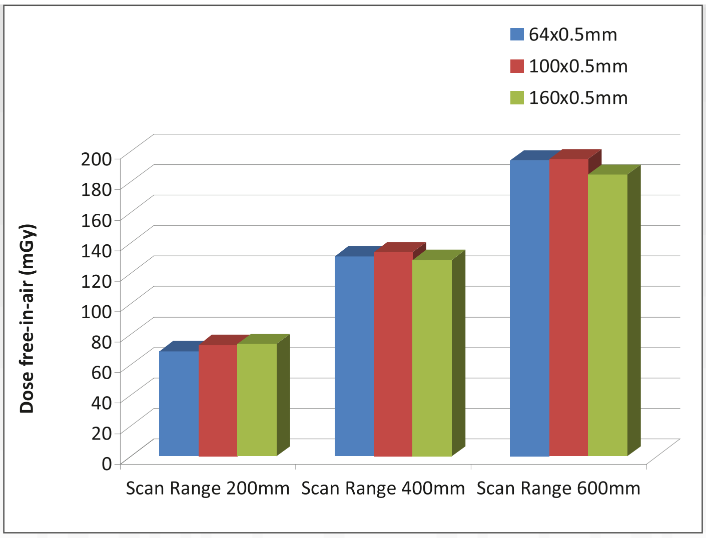


Fig. 3: Measured dose during acquisitions at different scan lengths and acquisition collimations

| Acquisition Collimation (mm) | Tube Voltage (kV) | FOV (mm) | Rot Time (s) | Tube Current (mA) | Eff mAs | Pitch |
|---|---|---|---|---|---|---|
| 64 x 0.5 | 120 | 400 (L) | 0.5 | 200 | 121 | 0.83 |
| 100 x 0.5 | 120 | 400 (L) | 0.5 | 250 | 121 | 1.03 |
| 160 x 0.5 | 120 | 400 (L) | 0.5 | 240 | 121 | 0.99 |

Table 1: Acquisition parameters

a scan length of 600 mm. Ultra-helical acquisitions provide coverage of entire body parts within a few seconds. The dose free-in-air increases as expected for longer scan lengths but the effect of overranging, which is predominantly expected for ultra helical acquisitions, was not observed in the measurement results. This indicates excellent performance of the active collimator. Moreover, dose measurements showed similar dose levels for acquisitions using ultra-helical acquisition collimations (Fig. 3).

## Clinical case

Fig. 4 shows a scan of a patient which was used as reference for the initial condition before treatment by chemotherapy. The scan was performed from the shoulders to the pelvis with a scan length of 680 mm. Acquisition collimation was 160 x 0.5 mm at a scanning Field of View of 400 mm and the scan time was less than 5 seconds.

## Conclusion

Ultra-helical scanning with 160 x 0.5 mm is now an attractive option since whole body scanning of trauma patients can be performed in less time compared to helical acquisitions. But also CT angiography scans can be performed with the same image resolution but less contrast injection and with minimized patient motion.

Results have shown that measured dose for 160 x 0.5 mm ultra-helical is similar to 64 x 0.5 mm helical scanning. Also for small scan lengths, similar radiation dose was observed for ultra-helical.

Previously, the only possibility to minimize overranging was by selecting a smaller acquisition collimation and a low pitch. Now, with the active collimator, overranging is no longer a limiting factor for helical CT scanning. Fast scanning with acquisition collimation of 160 x 0.5 mm can be performed at optimized radiation exposure to patients.

## References


[1] Data sheet EMI scanner, EMI, 1972

[2] Data sheet Pho/Trax 4000, Searle, 1976

[3] van der Molen AJ, Geleijns J. Overranging in multisection CT: quantification and relative contribution to dose- comparison of four 16-section CT scanners. Radiology. 2007 Jan; 242(1):208–16.


Fig. 4: Application of ultra helical in clinical practice. This scan was performed within 5 seconds using an ultra helical acquisition.

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