Characteristics of Multislice CT

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Introduction

The multislice CT (MSCT), or multi-detector-row CT (MDCT), is a CT system equipped with multiple rows of CT detectors to create images of multiple sections. This CT system has different characteristics from conventional CT systems, which have only one row of CT detectors. The introduction of this advanced detector system and its combination with helical scanning has markedly improved the performance of CT in terms of imaging range, time for examination, and image resolution. At the same time, the time for scanning (the time required for one revolution) has been shortened to 0.5 sec., and the width of the slice (tomographic plane) reduced to 0.5 mm. Thus, dramatic improvements have been made in CT-based diagnostic techniques. Since its excellent clinical effects have been demonstrated, MSCT has become rapidly widespread: more than 500 systems are now in use in Japanese medical institutions. This paper outlines the basics and characteristics of MSCT.

Basics of MSCT

The most important aspect of MSCT is the detectors (multislice detectors). The multislice CT systems with 2 or 4 rows of detectors are widely used, however, those systems with 8 and 16 rows of detectors are now to be released. The most basic 4-row MSCT detectors are divided into 3 types (Fig. 1), although they are structurally divided into 2 types. One is known as the matrix type in which small detectors (cells) are arranged at equal intervals in grid formation. The other is the adaptive array type, in which detector units with increasing widths toward both ends are arranged symmetrically. Multiple slice widths can be selected with both types, by combining the number of rows of detectors used.

MSCT is also different from conventional single slice CT in terms of the image (reconstruction algorithm) calculation method it employs. The helical scanning with 4-row detectors provides data which are several times as large as those of conventional single slice CT and have higher density. These data are used to calculate a high-resolution section image of the target site using a technique called Z-axis multiple-point weighted interpolation.

To obtain high image quality with multislice helical scanning, it is important to determine the distance moved by the patient table during one rotation of the scanner. A concept known as pitch (helical pitch) is usually used as an index of the distance of table movement. The
helical pitch is determined by dividing the distance of the table movement per rotation of the X-ray tube by the detector width equivalent to 1 slice. In conventional helical scanning, the table moves for a distance equal to the slice width during 1 rotation of the X-ray tube (that is, pitch 1). In contrast, the pitch can be adjusted up to 6 in MSCT: the table can be moved by a half channel per rotation (pitch 3.5 or 4.5) or by 1 channel per rotation (pitch 3). The pitch is closely correlated with image quality and exposure dose. In general, image quality is improved and exposure dose is increased as the pitch is reduced, while image quality is worsened and the exposure dose is reduced as the pitch is increased.\(^3\)

**Characteristics of MSCT**

The defining characteristic of MSCT is the dramatic increase in the imaging range per rotation due to the combination of multiple rows of detectors with helical scanning. This allows clinical technicians to obtain an image for a range...
exceeding 1 meter during single breath holding (Fig. 2). At the same time, the scanning time of MSCT can be reduced by up to one-tenth that of single slice CT when an image with the same scanning range is required.

Another characteristic of MSCT is its excellent Z-axis resolution. Single slice CT covers only a narrow range when helical scanning is performed with a thin slice (for example, a 1-mm slice). In contrast, MSCT can fully cover the whole target organ even with a thin slice because it has a wider scanning range per scan, as described above. These characteristics have enhanced the usefulness of MSCT in three-dimensional imaging diagnosis using computer graphics (Fig. 3). Since a very thin slice of 0.5 mm can be used, MSCT can visualize microstructures which could not be achieved with conventional scan techniques (Fig. 4).

When MSCT is used with thin slices of 1 or 0.5 mm, resolution is equal among the directions of X, Y, and Z axis of a voxel that is the minimum unit of an image. This minimum unit is called an isotropic voxel.\(^1\) The partial volume effect based on slice width, which was a serious problem with conventional CT diagnosis, can be avoided in images based on the isotropic voxels. Therefore, reproducible images can be obtained, irrespective of the direction and size of the target structure of diagnosis. MSCT has other advantages including reduced artifacts,
improved reliability of CT values, and reformatted sagittal or coronal sections that can be obtained with the same axial resolution as axial sections (Fig. 5). Thus, MSCT with isotropic volumetric data has revolutionized imaging diagnosis.

Problems with MSCT

The most significant shortcomings with MSCT are the increase in the volumetric data produced by the increased use of thin slices. The increase in data directly influences the patient throughput because it prolongs the time required for image reconstruction and transferring and indicating data. Therefore, MSCT requires processing units, network environment, and display systems with higher speed capacities. It also requires hard disks, memories, and image storage devices with much larger capacities. As MSCT images have increased the number of images, it has become unrealistic to observe them on films. Instead, diagnosis with the images displayed on the monitor (so-called CRT or monitor diagnosis) has become essential. Furthermore, as the use of sagittal and coronal sections has increased, it has become necessary for clinicians to have a knowledge of both axial anatomy and longitudinal anatomy. The increased burden on radiologists who are required to interpret a large number of images is also a serious problem.

Future of MSCT

Although 4-row MSCT systems have just started to become widespread, the development of next-generation MSCT systems is already in progress and it is considered certain that 8- or 16-row multislice systems will be released at the end of 2001. What is the true clinical significance of these advanced multi-row detectors? Since current 4-row systems have already provided sufficient scanning range and speed, the primary significance of the 8- or 16-row detector system is to improve the Z-axis resolution with thin slices. It is possible that very thin slices of 0.5 or 1 mm, which are now limited due to small coverage, will be used as a standard parameter.

Another issue of clinical significance in introducing the 8- or 16-row systems is to simplify scanning conditions. With the existing 4-row systems, it is necessary to select the scanning parameters on the basis of the clinical situation. However, the next-generation multislice detectors system will be able to employ scan parameters that will continually ensure optimum image quality thanks to their dramatically increased speed. In emergency situations at night, for example, even those not specialized in CT can use the system since the operator is not required to execute complicated parameter selection. Initial images can be provided as a thick slice and, if necessary, re-processed to generate high resolution images for further investigation using the raw data. That is, one scanning enables both screening and detailed examination. This is one of the most significant advances in the history of CT.

Apart from the above commercially available products, a CT system with multiple-row detectors has been developed for research purposes. This is an experimental system equipped with 256-row area detectors and developed under the project of the “High-speed Cone Beam 3-dimensional X-ray CT (Energy Use Rationalization) Development Committee” supported by the New Energy and Industrial Technology Development Organization (NEDO). A clinical study on the experimental system is scheduled to be conducted at the end of 2001 in order to develop a “four-dimensional scanner” that obtains real-time three-dimensional information. It is considered promising as a prototype of the next-generation systems.

Conclusion

The diagnostic ability of MSCT systems is far higher than that of conventional single slice CT systems. Such systems have been developed and are now more widespread than ever, and
the advances have been much more rapid than was expected by most physicians. The present 4-row systems are clinically quite useful, but only represent the earliest stage of MSCT development. After its clinical application, area detector CT employing several-hundred rows of detectors will have the potential to replace conventional radiography in a number of examinations, and as a consequence, it is currently difficult to accurately define the indications and limitations of MSCT. All clinicians will need to watch closely the future of the diagnostic revolution that has been brought about by MSCT.

REFERENCES