Short Communication

Microlayertomography System

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Abstract

In common radiography, the images of all bodys' structures lying within the path of radiation overlap each other. Tomography separates the required image from the surrounding area. Preliminary mechanism of sectional radiography, called the longitudinal tomography, does enhance the quality of image, but because of the different velocity of unwanted images, lying nearer to or further from axis central point, tomographic blurring does occur. Microlayer tomography with high X-ray rotating velocity without tube movement provides images with depth perception of millimeter fraction, and there is no need for digital image reconstruction. The pace of the procedure is exceptional. Hence, the tomographic slices can be prepared in about less than 0.02 second. Besides, the cost of patient treatment as well as system maintenance is much less compared to those computed tomography (CT) and magnetic resonance (MRI) scans. This article will discuss the technology in the context of a phantom trial that was conducted at the Shahid Beheshti Medical University, Iran. The trial of the system prototype led to results that reflexted well on the procedure.

Keywords: Radiography, Microlayer tomography.

Introduction

Diagnostic imaging systems are an integral part of medical practice. Much attention is therefore paid to improve the ability of such systems to create proper image slices which may highlight even these lesions that sectional radiography may not be able to detect.[1]

Some deficiencies in the systems that are used commonly were: in non-digital tomography, the focus of the rotating axis fix point overlaps with a number of unwanted images, due to the inappropriate depth perception that ultimately causes obscurity;[2,3] beam divergence at the time of cone-shaped radiation emission allows image distortion; incomplete elimination of unwanted images causes partial blurring of the wanted slice, which is called non-digital tomographic blurring and which compromises its diagnostic value;[4-6] and, with the widening of rotating angulations, the blurring is increased, and the depth perception is not reasonable for confident diagnosis, and if the thickness of the tomographic slice is decreased, it causes blurring which is a deficiency of the tomographic system.

The computed tomography (CT) and magnetic resonance imaging (MRI) were major improvements on longitudinal tomography, but the devices are relatively costly in terms of purchase and maintenance, while patients also have to bear higher treatment expenses. Besides, some technical deficiencies are also there, like probable statistical error through several intermediary stages of image reconstruction processing.[7-9]

Thus, computerised imaging is uncertain, especially in medico-legal cases because of court controversy over optimum resolution.[10,11]

The Microlayer tomography system project was implemented at time period of about 4 years from April 25, 2004 to August 10, 2008. The main objective of this research was to eliminate some of the disadvantages of current tomography scanning.

The microlayer tomography system eliminates blurring, produces more reliable slices for accurate diagnosis, and has a shorter procedural time for patients' convenience. It has appropriate depth perception for small lesion distinction, and eliminates digital image reconstruction processing. All this together means it is cost-effective both for patients and in terms of maintenance.

Microlayer tomography is designed to amend two substantial disadvantages of longitudinal tomography through the modified mechanisms: relative elevation of radiation velocity, and reduction of radiation diversion angle.

In longitudinal tomography, x-ray tube displacement causes movement of rays, but its speed is restricted due to the weighted tube and high-voltage insulation accessories (often less than 10 rounds per minute).

Microlayer tomography is based on beam movement and the tube remains constant. Consequently, the beam rotation relative velocity could be increased up to 10,000 times per minute. Even the closer points to the rotation centre have such a high linear velocity that their associated images are obscured at once, and instead of gradual blurring, only a thin clear slice of certain tissue image stands out without any tomographic blurring that usually occurs in longitudinal tomography.

The reduction of the radiation diversion angle[5-9] is obtained by collimation of the emitting beam and by increasing the distance between radiation generator and the object. In terms of a field of 20x20 centimetres with the source-image-distance of 150 centimetres, and rotation speed of 2800 rounds per minute, slices of about 0.3mm for any plane of object can be obtained. With higher speed, even thinner slices are also possible. With focus film distance (FFD) of 70cm, the thickness of tomographic slices is 2.5mm, and by doubling the distance, the thickness of the tomographic slice gets to 1.4mm. Meanwhile, higher speed of beams, which allows more distance travelling of the moving constituted points of images lying closer to the rotating centre leads to tomographic slices as thin as 300µ.

Methods and Results

To assess the new system, a phantom trial was conducted at the Shahid Baheshti Medical University, Iran, at terms rotation of 25 rounds per minute (RPM) (Figure-1) upto 2800 RPM (Figure-2).

Images derived from the phantom trial ascertained that at rotation of 2800 RPM, the image of thin wire with the diametre of less than 0.5mm remained clear without any overlapping or obscurity. The procedure was followed by different exposure times. For instance, a point presumed on circle with diametre of 0.5mm, circumference of about 3mm, and located less than 1mm from the centre of rotation axes: at 10,000 RPM, the velocity was calculated as $v = 0.1 \times 3.14 \times 10000 / 60$ thus, $v = 52.3$cm/sec.

At 3000 RPM, the images of nails, with rotation radial of 1.5 centimetre were entirely obscured, and the travelling distance measured about 14.13 centimetres at time of 0.03 in terms of $3 \times 3.14 \times 3000 / 60 = 471$ cm/sec. Thus for 0.03sec of exposure time, the travelling distance became, $x = 471 \times 0.0\ 3 = 14.13$ cm.

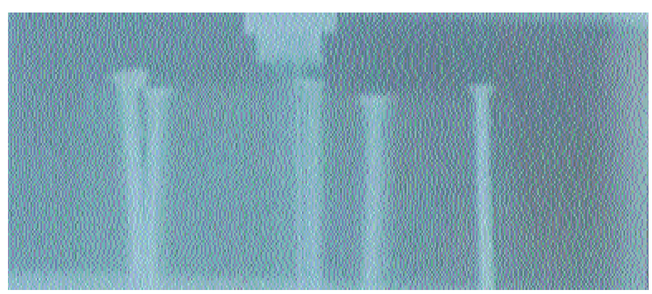

Figure-1: The image of the same phantom with velocity of 100 rotations per minute and the times of 0.03 seconds; the thin wire image can be seen overlapped by the nails.

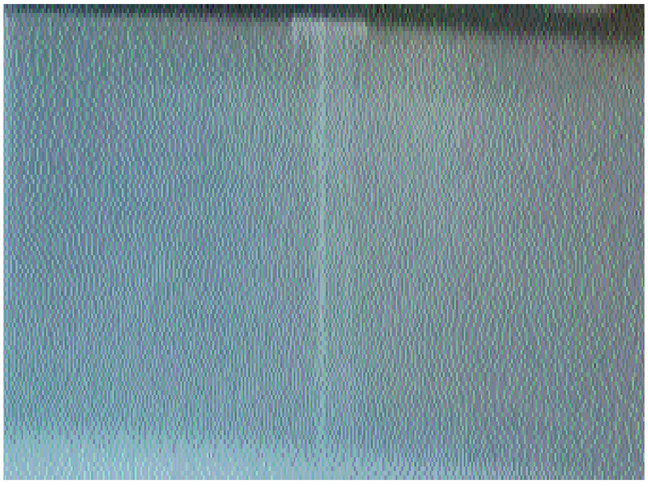

Figure-2: Microlayer tomography of the same phantom with velocity of 2800 rotations per minute revealed the obscurity of the images of all metal pieces, except the image of the thin wire lying on the rotation axis.

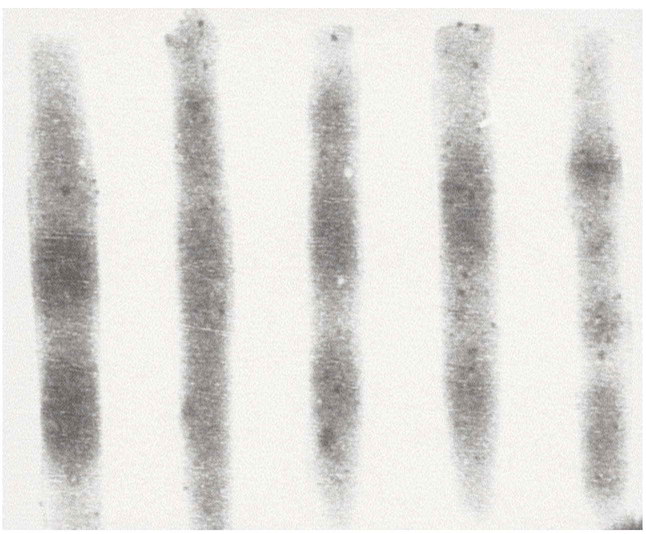

Figure-3: The radiographic image of the phantom sheet. The density difference between the strips and the sheet was similar to that between bone and muscle tissues.

Therefore, exposure time for exact obscurity of any structure lying about 1mm from the certain tomographic slice, at the speed of 10000 beam RPM was obtained from proportion of $52.3/14.3 = 1/t = 0.286$ sec.

In common X-ray tubes, by increasing source-image-distance, irradiation intensity gets reduced. Compensation of the low-intensity emission via elevation of exposure factors causes the tube life diminution. Nature of the new X-ray generator creates compatibility with microlayer tomography technique (Intro Spinning X-Ray Generator Disk) which was used in the trial.

The procedure was carried out through the diluted barium sulfate strips pasted on compacted cellulose boardsheet, with different thicknesses. For the soft tissue experience, the barium sulfate strips matched with atomic number 9 and density of $1.2gr/cm^3$. The effective atomic number for cellulose sheet was 7.5, with density of $1gr/cm^3$. The atomic number and density of materials that were used were very close to those of the natural tissues of the body. The effective atomic number difference between muscle and fat is about 1.5 and the density difference is about 0.1. The thickness of strips for the soft tissue was 300µ. The exposure factor for soft tissue was selected 40kvp and 1.5mA.s. It was the same as the common exposure factors for actual soft tissue. The next exposure was carried out for the supposed bone tissue. Hence, cellulose sheet of 250µ thickness was prepared. Diluted barium sulfate strips were then pasted on a sheet having atomic number of 13.5 and density of $1.9gr/cm^3$, which was close to the actual bone tissue. The exposure factor for supposed bone radiography was selected as 70kvp and 1mA.s. The tomographic layer was acceptable for both bone and soft tissue study, but to reach a more desirable resolution, the thinner slice for bone and soft tissue could be obtained even at 150µ to 200µ (Figure-3).

Discussion

The device used had a wide, large, cylindrical tungsten target that has higher heat capacity, compared to the conventional X-ray generator tube. Thus, source-image-distance could be simply increased to obtain a tomographic thinner slice and proper depth perception. Besides, the radiation field can widen up to 35x35cm.

To initiate the phantom trial, it was necessary to first know the minimum thickness of the radiographic slice of the exposed subject that could possibly create the contrast.

The radiographic contrast of the exposed subject depends on its structural nature, with different thickness and radiation absorption indices. The absorption index is related to the subject thickness, and the composer substance atomic number of the subject.

The outcome showed several advantages over MRI and CT scans: its depth perception was at least 200µ for bone tissue and 300µ for soft tissue; the images could be prepared without digital reconstruction; the possibility of imaging in three dimensions — coronal, sagital and transverse section — was possible which is limited in CT scans; the time of imaging was shorter than that in MRI. The trial showed a number of advantages of microlayer tomography over MRI and CT scans. The tomographic layer was acceptable for both, bone and soft tissue study, but to reach more desirable resolution, the thinner slice for bone and soft tissue could be obtained even at 150µ and 200µ.

Conclusion

The results of the phantom trial proved that microlayer tomography had clear advantages over conventional procedures. Besides, it is inexpensive in terms of maintenance, and cost-effective for the patients.

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