Radiation dose of lumbar spine CT: analysis and comparison between different modes of acquisition in two European imaging centers

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Aims and objectives

Computed tomography (CT) of the lumbar spine is a widely performed examination for patients suffering from back pain or trauma. CT provides a fast and thorough assessment of the anatomy, especially in cases where magnetic resonance imaging (MRI) is not available. In addition, CT may be the modality of choice for examining intervertebral disc pathology in some countries due to state referral guidelines.

Patient safety and awareness of radiation exposure necessitates optimization of the radiation dose during a CT examination. In recent years scanning techniques and technical advances have have improved CT image quality using low radiation dose protocols. The goal of modern CT is to balance high diagnostic quality imaging with the lowest radiation dose possible. The radiologist must have optimal image quality to visualize of low-resolution structures, but iterative reconstruction methods must not be so heavily applied that the images are overly smoothed and thus may lack significant diagnostic information.

Image quality (IQ) is multi-parametric; technical elements such as equipment, physics and type of the examination may alter objective parameters but subjective IQ assessment by radiologists is also vital as they have clinical responsibility for interpretation.

The objective of this study was to analyze and compare the radiation dose to patients undergoing a lumbar spine CT performed in helical and incremental scanning modes. In order for this assessment to take place it was necessary to share information and images between different international centers by using modern cloud technology.

Methods and materials

Study design and patient selection

A retrospective study was performed of data collected from 120 patients that underwent a lumbar spine CT examination in two European centers of Affidea over a 10-month period. The patients have been categorized in two groups of 60, with the first group examinations from Evroiatriki Thessaloniki, Greece and the second group examinations from Péterfy Sándor Hospital, Budapest, Hungary. Mean age was 55,5 years, male/female ratio 42/78 and mean BMI was 27,6.

Inclusion and exclusion criteria

The study included patients who underwent a non-contrast lumbar spine CT scan for the investigation of disc pathology. Patients selected were referred for back pain or/and sciatic neuralgia as the main clinical indication. Patients with a history of trauma or surgery in the lumbar region, as well as those with known malignancy were excluded from this study. For the incremental mode scanning, the study only included examinations with slices oriented parallel to the last 4 intervertebral discs.

Scanning Procedure and Protocols

The two diagnostic centers use the same make and model CT scanner. Both scanners undergo monthly Quality Control (QC) tests by which the optimal performance of the scanner in terms of image quality and radiation dose is ensured. The protocol details for each center are presented in Table 1.

Table 1 Protocol parameters

CT Lumbar Spine	**GE 64-slice MDCT LightSpeed VCT (A)**	**GE 64-slice MDCT Lightspeed VCT (B)**
Mode of acquisition	Incremental	Helical
Scanning range	L2 - S1 vertebral bodies	T12 - S1 vertebral bodies
Tube potential (kV)	120 for (L2-L3, L3-L4, L4-L5) 140 for (L5-S1)	120
Automatic exposure control	ON	ON
Noise Index (NI)	15.86	21.45
Mean mA	134	127
Slice thickness (mm)	2.5	1.25
Interval (mm)	5	1.25
Pitch	-	0.52
Dose reduction (%)	30	30

Data collection and analysis

Both departments use GE HealthCare DoseWatch^{TM} software to assist them in patient dose tracking and dose management. The protocol parameters, CTDIvol, DLP and Effective Dose values of each examination were exported from DoseWatch™. The values and statistical analysis of the dosimetric data is summarized in Table 3.

Four experienced radiologists reviewed the coded CT data sets. The images were presented using Biotronics 3Dnet, a presentation and evaluation of medical images software. The radiologists working in Hungarian and Greek centers of the Affidea Group rated the images according to the criteria in Table 2. Fleiss kappa was used to rate inter-rater reliability, Visual Grading Analysis for observer performance evaluation and ordinal regression analysis to identify differences between the two protocols and their effect on the image quality.

Table 2 Image assessment criteria

Parameters	Description	Scales
Visualisation	Structures that must be included within the examination FOV, vizualized and discriminated according on the pathology being investigated.	0: Intervertebral disc, vertebral body, spinal canal, intervertebral foramen and surrounding soft tissues are all present and clearly discriminated for evaluation -2: Intervertebral disc, vertebral body, spinal canal, intervertebral foramen and surrounding soft tissues are not all present and not all are clearly discriminated for evaluation -1: Intervertebral disc, vertebral body, spinal canal, intervertebral foramen and surrounding soft tissues are present but are not all clearly discriminated for evaluation,

		1: Intervertebral disc, vertebral body, spinal canal, intervertebral foramen and surrounding soft tissues are present and have superior visibility for evaluation
Pathology	Defined as disc herniation/ bulging, osseous-spinal cords lesions.	1: Pathological findings present 0: Pathological findings absent
Localisation	Specification of pathology location. **A**: Disc, **B**: Osseous, **C**: Contents of the spinal canal, **D**: Surrounding tissues. If combination of A-D found, then mark as eg: A +C etc accordingly.	**A**: Disc, **B**: Osseous, **C**: Contents of the spinal canal, **D**: Surrounding tissues. If combination of A-D found, then mark as eg: A +C etc accordingly.
Confidence level	Level of confidence that pathology found is present.	**0:** not confident **1**: confident **2:** very confident

Images for this section:

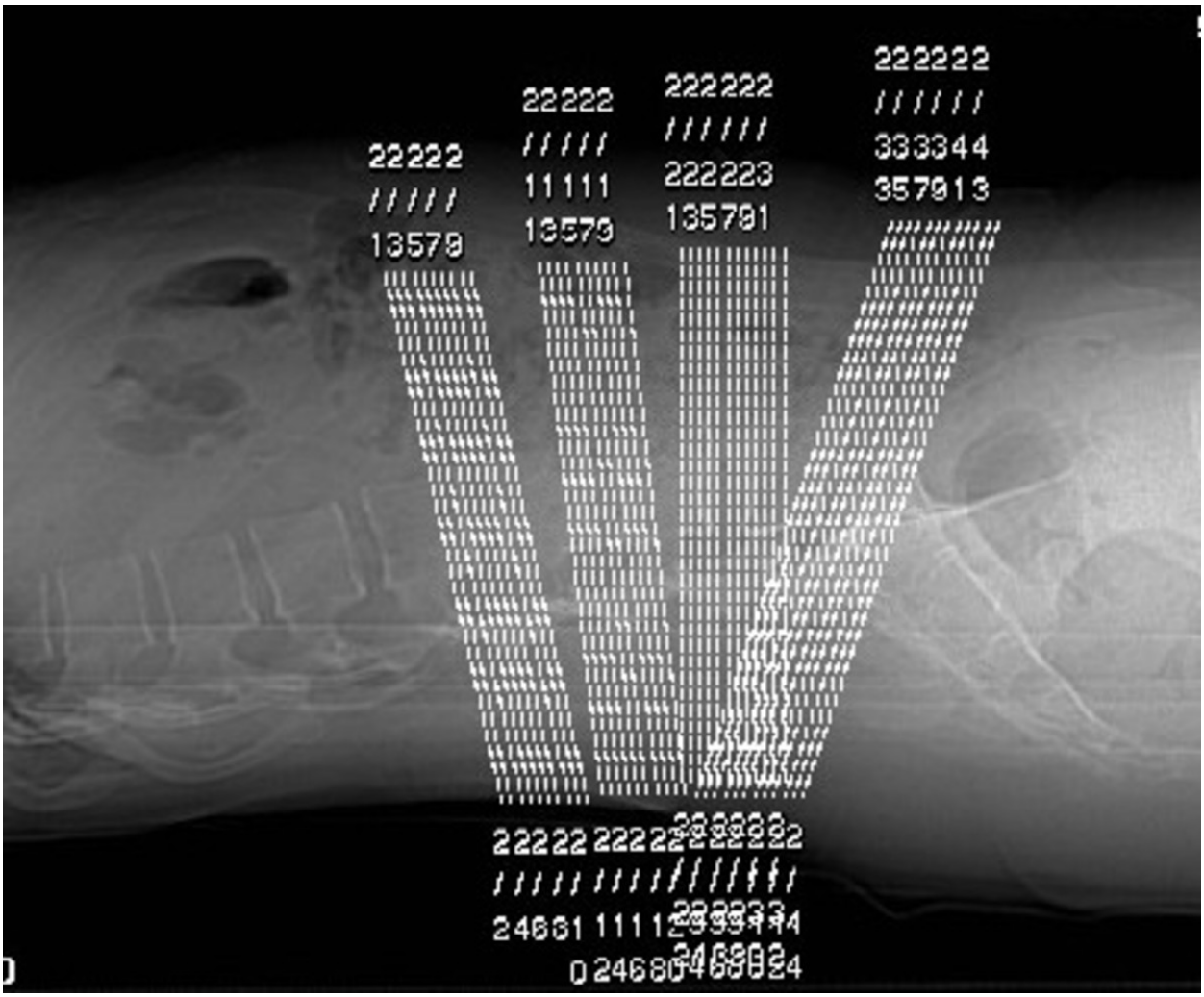

Fig. 1: Scout image of incremental scanning mode (Group A)

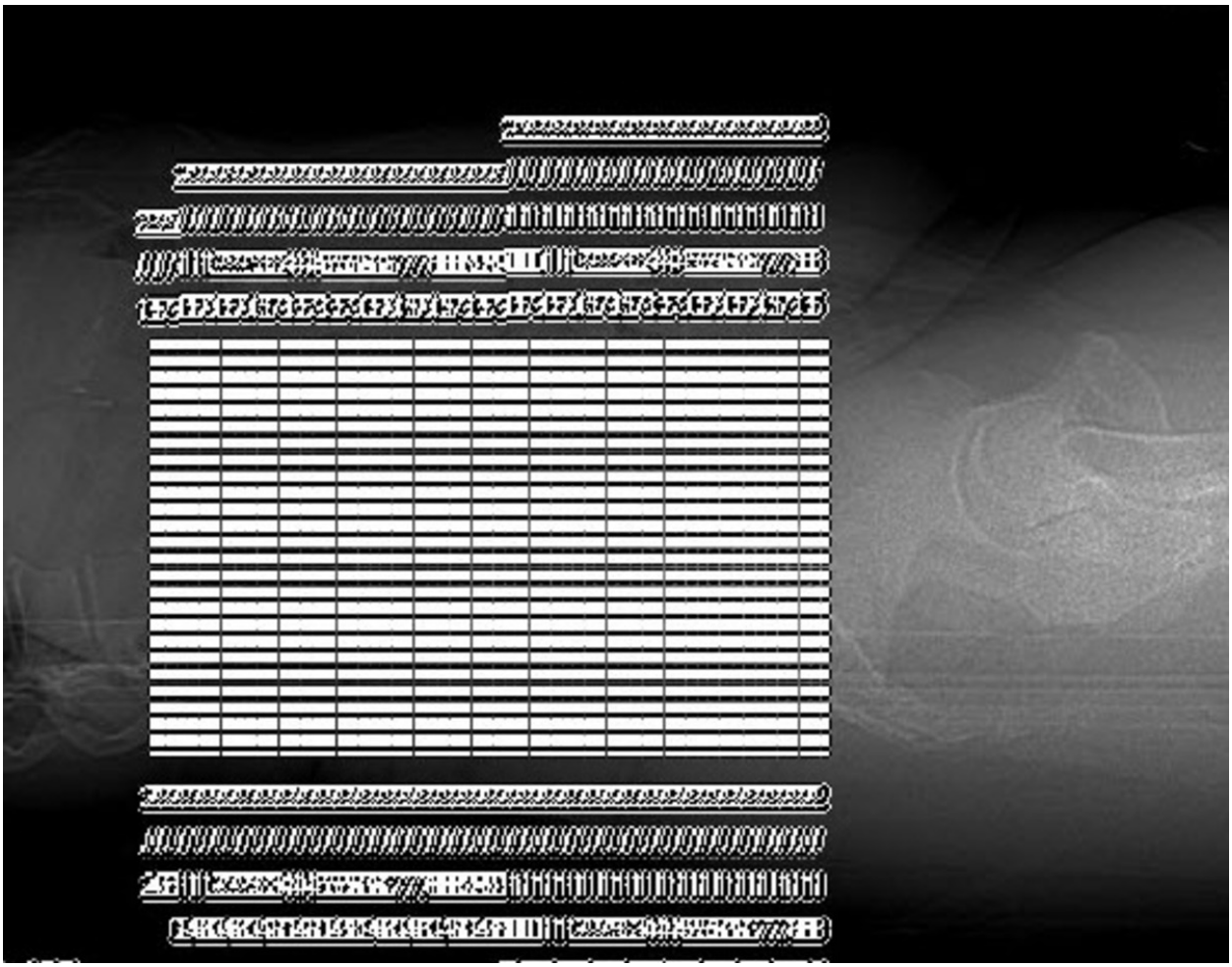

Fig. 2: Scout image of helical scanning mode (Group B)

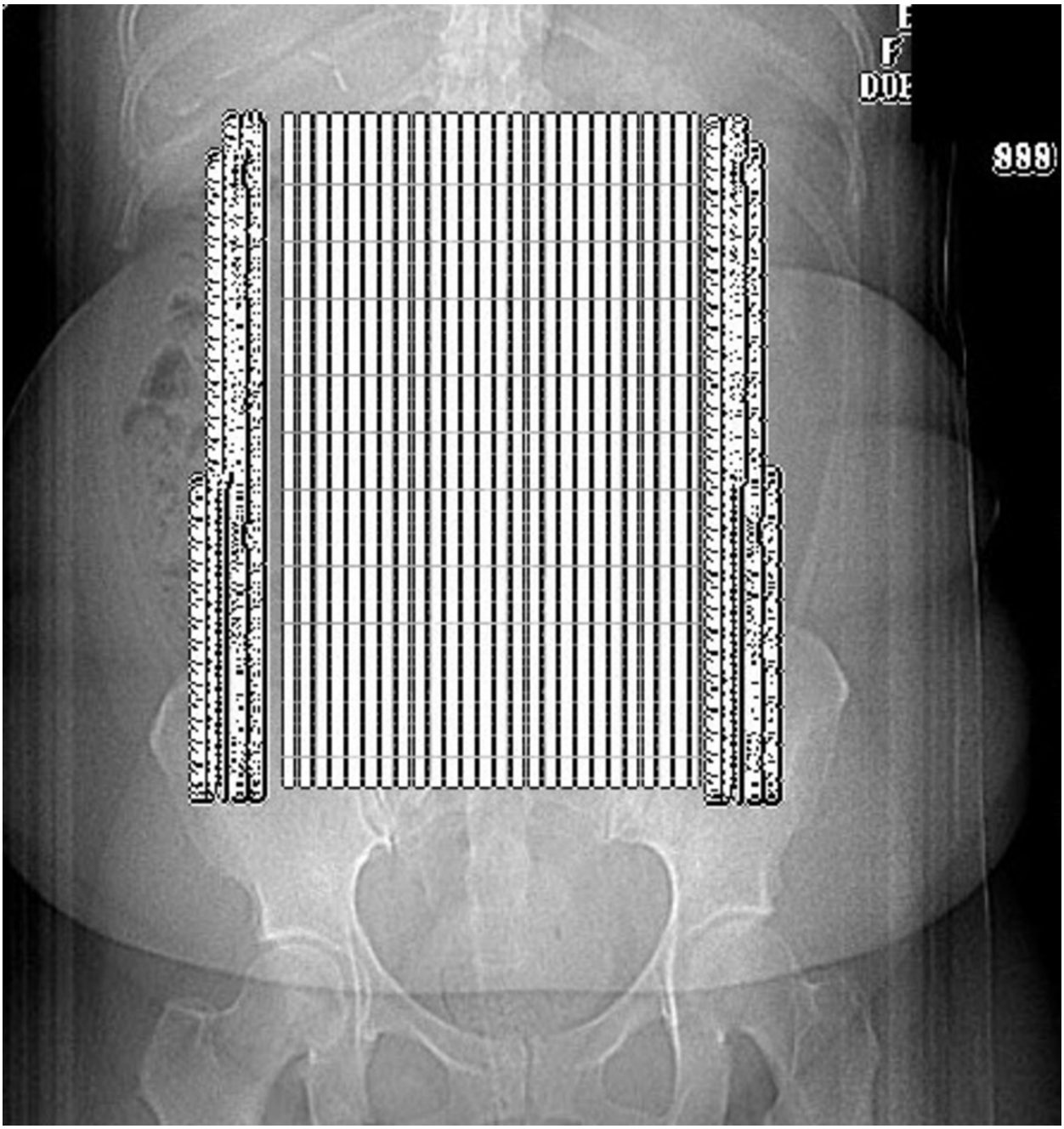

Fig. 3: Scout image of helical scanning mode (Group B)

Results

CT dose evaluation:

Table 3 Comparison of mean CT doses between Scanner A and B t-test assuming unequal variances

Parameters	GE LightSpeed VCT 64sl. (A)n = 60	GE LightSpeed VCT 64sl. (B)n = 60	p
$CTDI_{vol}$ (mGy)	23.7	20.1	0.13
DLP (mGy.cm)	309.1	473.4	0.01
Effective Dose (mSv)	4.6	7.1	0.00

Based on the results demonstrated in Table 3, the was no significant difference in $CTDI_{vol}$, meaning that the radiation dose per slice is comparable between the incremental and spiral scanning modes. Scanner B DLP and Effective Dose values are significantly higher than Scanner A.

Inter-rater reliability evaluation

The Fleiss' kappa scores on visualization, pathology and localization for both scanners showed moderate to substantial agreement between the observers, based on Landis and Koch interpretation criteria [7].

Image quality evaluation: ordinal regression

The image quality evaluation of the data from Scanner A and from Scanner B, showed a significant difference in the visualization of structures ($p<0.00$), with Scanner A data receiving a higher score. The evaluation of pathology and localization did not have significant differences ($p>0.05$).

Ordinal regression was applied to further identify differences between the protocols and their effect on image quality. Results presented in Table 4 show that DLP and criteria have no significant impact on the quality of the images. Therefore, the lowest dose values from Scanner A protocol compared to that of Scanner B, do not have a negative impact on the image quality.

Table 4 Ordinal regression analysis

Parameter Estimates

		Odds Ratio	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[VGC_Score = -2.00]	0,009	,00499356	70,817	1	,000	0,001	0,017
	[VGC_Score = -1.00]	0,027	,00272029	103,486	1	,000	0,014	0,054
	[VGC_Score = .00]	0,281	,05982965	22,514	1	,000	0,167	,475
Location	DLP	0,999	,00082201	,139	1	,710	,999	1,001
	[Scanner=A]	1,661	,85021665	3,667	1	,055	,988	2,795
	[Scanner=B]	1,318	,71737135	1,387	1	,239	,832	2,088
	[Reference=a]	0			0			

Conclusion

Optimization of lumbar spine CT protocols for the investigation of disc pathology can significantly reduce radiation exposure to the patient. It has been demonstrated that the incremental mode of acquisition can both reduce the exposure of patients and improve the visualization of anatomic components compared to spiral acquisition mode for this specific clinical investigation. The use of advanced analytic software such as DoseWatch™ to monitor patient dose levels makes it possible to continuously optimize the CT acquisition methods, resulting in equivalent diagnostic accuracy and reduced patient dose. Cloud technology and image sharing software permits radiologists in an international environment to share and compare images as well as technical information for benchmarking various CT protocols.

Personal information

On behalf of the autors I would like to express our appreciation to our Affidea IT staff and Biotronics 3Dnet support service to make it possible the anonymous data transfer between the participating centers.

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