

CR and DR chest radiographic image parameters for the pneumoconioses: the Japanese approach and experience

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Introduction

- Digital alternatives of radiography, both the computed radiography (CR) and the digital radiography (DR), have been accepted well for the clinical use.
- Such trend has influenced to the medical screening and classification of pneumoconioses, which directly affect compensation of the patient.
- As the Japanese Pneumoconiosis Law uses the radiographic classification as scale to decide the administration class of dust-exposed workers which is the basis of the compensation, revision of this law concerning the screening method has been a socially sensitive issue.

Aim

- This presentation is aimed to describe the approach that the Scientific Committee on DR imaging parameters for pneumoconiosis (the DR Taskforce) for Japanese Ministry of Health, Welfare and Labour (MHWL-J) has taken to decide the appropriate imaging parameters of DR for the classification of pneumoconiosis as demanded by the Japanese Pneumoconiosis Law.
- The Taskforce's approach has been, firstly, to decide the appropriate DR parameters for the classification of pneumoconiosis through group review, and secondly to assess the appropriateness of the proposed parameter through independent reading trial.

I. Evaluation of appropriate DR parameters for the classification of pneumoconiosis using Canon DR system

- Four typical cases of silicosis were selected from the DR case archives, each representing the mid-category of profusion 0, 1, 2, and 3. Imaging parameters concerning the gray-scale processing and the spatial frequency processing were changed one by one to assess the difference caused by the parameter modification.
- Five experienced physicians, who are either radiologists or pulmonologists and serving as regional or central Pneumoconiosis Examination Physician, a position appointed by the MHWL-J, reviewed differently processed DR hard copies and gave consensus decision whether it was appropriate for classification of pneumoconiosis.

Table 1 Recommended imaging parameter of gray-scale and spatial frequency processing by the CR Taskforce (2001) and the DR Taskforce (2007)

	CR-TF	DR-TF
Gray- scale processing		
Lung field	1.6 - 2.0	1.6 - 2.0
Mediastinum, heart	0.15 - 0.25	not defined
Spatial frequency processing		
High frequency (> 0.2 cycle/mm)	1.0 - 1.2	OFF*
Low frequency (0 cycle/mm)		

Note: CR-TF is the CR Taskforce, while DR-TF is the DR Taskforce. *Spatial frequency processing was recommended to be basically OFF for the any FPD, except CXDI (Canon, Inc.). The range recommended by the CR Taskforce is equivalent to Enhancement 0-4 for CXDI as in the Vender's recommendation in Table 3. The DR Taskforce accepted the Enhancement 0 and 1 for CXDI after the group review (See Table 3).

Table 2 Corresponding parameters of image processing: CR and CXDI

	CR		DR
Fuji	Konica	Kodak	Canon (CXDI)
Gray-scale processing			
GA	G value	Contrast Factor	Contrast
GC		Upper Contrast Lower Contrast	
GS	Lung density	Density Shift Shoulder Shift Toe Shift	Brightness
GT	LUT		Curve shape
Spatial frequency processing			
RN	Mask size	Matrix size	Frequency
RE	Emphasized degree	High Density Boost Low Density Boost	Enhancement

Note: The parameters for the multi-frequency processing are not included in this table.

Table 3 Appropriate imaging parameter for legal medical judgment of pneumoconiosis for CXDI (Canon, Inc., Tokyo)

	Vender's Recommendation	DR-TF Recommendation
Contrast	14 - 17	14 - 17
Brightness	17 - 20	17 - 20
Curve shape	Chest	Chest
Frequency	7	7
Enhancement	0 - 4	0 - 1

Note: CR-TF is the CR Taskforce, while DR-TF is the DR Taskforce. *Spatial frequency processing was recommended to be basically OFF for the any FPD, except CXDI (Canon, Inc.). The range recommended by the CR Taskforce is equivalent to Enhancement 0-4 for CXDI as in the Vender's recommendation in Table 3. The DR Taskforce accepted the Enhancement 0 and 1 for CXDI after the group review.

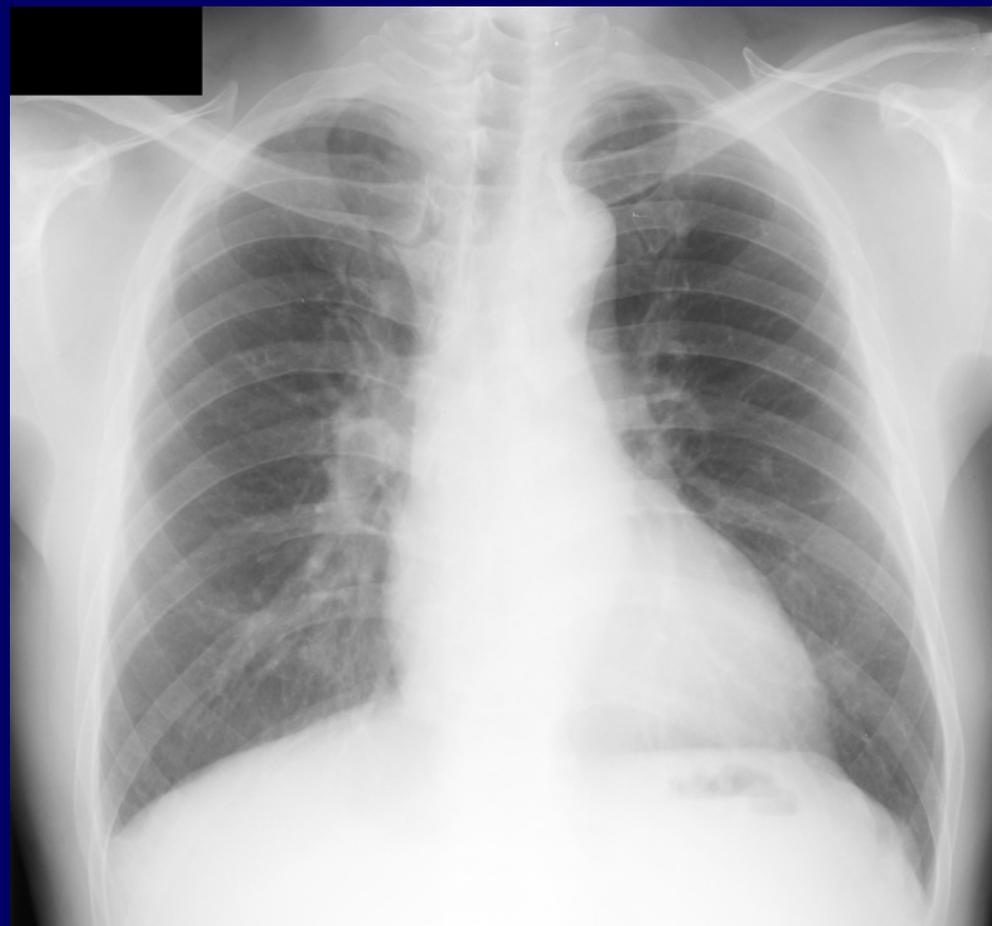
II. Comparison of classification of pneumoconiosis between film-screen system and Canon DR system in the same patient

- 35 pairs of the DR hard copy and the FS radiograph from the Occupational Safety and Health Compensation Hospitals, Fukui University Hospital and NHO-Kinki Chuo Chest Medical Center.
- Same 5 expert readers, independently reviewed 35 pairs of the DR hard copy and the FS radiograph.
- For the classification the 4 point-scale profusion (0, 1, 2, and 3) was used according to the Japan Classification, which is almost parallel to the ILO/ICRP.

profusion 0



DR

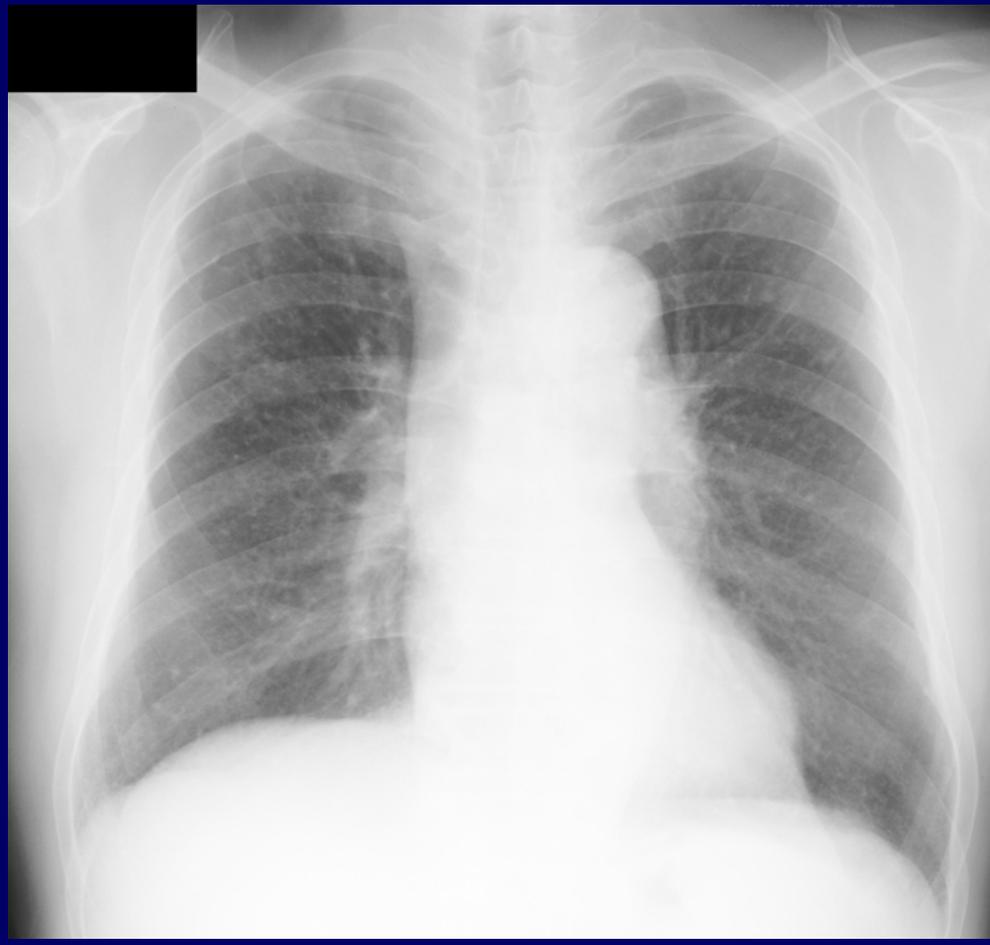


analog

profusion 1



DR



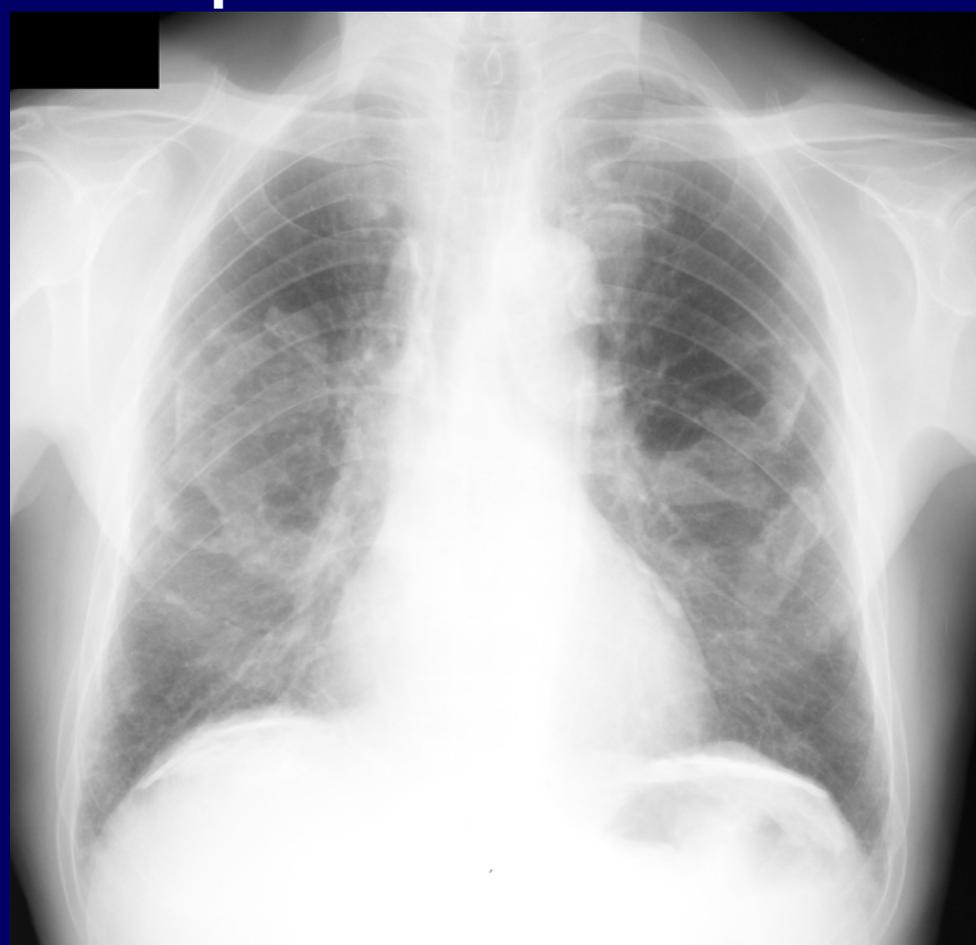
analog

Asbestosis, irregular opacity

profusion 1



DR



analog

Table 4 Comparison of the profusion between FS and DR chest radiography in 175 accumulated cases (5 readers, 35 patients)

FS – DR	Number of cases	Difference of the Profusion		
		FS>DR	FS<DR	FS=DR
0 - 0	45			45
0 - 1	11		11	
1 - 0	3	3		
1 - 1	63			63
1 - 2	8		8	
2 - 1	3	3		
2 - 2	22			22
2 - 3	8		8	
3 - 2	4	4		
3 - 3	8			8
Total (%)	175 (100)	10 (5.7)	27 (15.4)	138 (78.9)

Table 5 Summary of the median profusion of five readers: FS vs DR

FS	DR				Total
	0	1	2	3	
0	9	3	0	0	12
1	0	14	1	0	15
2	0	0	4	1	5
3	0	0	1	2	3
Total	9	17	6	3	35

Crude agreement = 82.86, $\kappa = 0.7448$

Comparison of judgment between FS and DR within each reader

reader value	Kappa
A	0.7881
B	0.6335
C	0.4909
D	0.7863
E	0.7886
average	

Variability of judgment between two readers

FS radiograph
kappa value

DR
radiograph

kappa value

A-B 0.4776

A-C 0.5328

A-D 0.6038

A-E 0.6246

B-C 0.5133

B-D 0.5167

B-E 0.7592

C-D 0.6438

C-E 0.6598

D-E 0.7404

A-B 0.5729

A-C 0.7488

A-D 0.6259

A-E 0.7009

B-C 0.5797

B-D 0.7878

B-E 0.7854

C-D 0.6316

C-E 0.7861

D-E 0.7488

average 0.6072

average 0.6968

Summary of reading trial

- Crude agreement of classification of pneumoconiosis between FS and DR radiography was 82.8% and kappa value was 0.7448.
- Inter-reader agreement using average kappa value for FS and DR radiography was 0.6072 and 0.6968, respectively.
- DR chest radiography is considered to have the same capability in classifying the radiographic changes of pneumoconiosis as FS chest radiography has.

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III. Evaluation of appropriate DR parameters in other DR systems

- The DR systems produced by Philips, Siemens, GE, Toshiba, Hitachi, and Shimazu were available in Japan. Each of these vendors was asked to submit a few typical pneumoconiosis cases for the taskforce's evaluation.
- After the evaluation in section II, the taskforce concluded that the spatial frequency processing should be off for the pneumoconioses screening.
- The multi-frequency processing that enable differential processing at the areas with the high and the low frequency was not allowed for the classification of pneumoconiotic opacities.
- Also recommended value for the gray-scale processing on the mediastinum was omitted in the new recommendation.

Manufacturer	Parameter	Value
Canon	E	* or 1
	D	*****
	Brightness	17 - 20
	Contrast	14 - 17
Philips	Density (D)	15 - 17
	Gamma (G)	40 - 45
	NC (N)	00 - 03
	DCE	0.0
Siemens	SF	0/***
	H	0/***
	LUT	8
	W	2300 – 3300
GE	C	1900 – 2300
	Contrast (C)	119 - 130
	Brightness (B)	152 - 157
	Edge (E)	1
Toshiba	WL	1800 - 2400
	WW	1200 - 2800
	G	7
	E	0
	D	0
	I	0
Hitachi	Filter	0 - 3
	Mask size	5
	DRC	0
	g	3
	WL	2100
	WW	3850
Shimazu	W	11500 - 12500
	L	6000 - 6500
	E	0

Discussion

- Gray-scale processing and Spatial Frequency Processing, both are pre-storage parameters affects the image of DR or CR, standardization of these parameters are needed to maintain the scale of classification.
- Similar study including comparison with CR using 10 definite, 10 borderline and 10 negative cases with HRCT proof. The DR could produce more similar image as the FS radiograph than CR, but the study did not detect the difference among the three modalities' AUC of the ROC analyses when the HRCT proven FS reading results were considered as the gold standard.

Table 5. Inter-reader agreement among the 3 readers of the classified profusion category by κ coefficient

Outcome	AR			FPD			SR		
	κ	Z	<i>p</i> -value	κ	Z	<i>p</i> -value	κ	Z	<i>p</i> -value
Category 0	0.64	6.11	<0.001	0.69	6.50	<0.001	0.83	7.91	<0.001
Category 1	0.48	4.55	<0.001	0.53	5.06	<0.001	0.58	5.53	<0.001
Category 2	0.29	2.71	0.003	0.66	6.29	<0.001	0.15	1.45	0.073
Category 3	0.74	7.00	<0.001	0.49	4.64	<0.001	0.49	4.64	<0.001
combined	0.55	6.80	<0.001	0.62	7.88	<0.001	0.64	7.82	<0.001

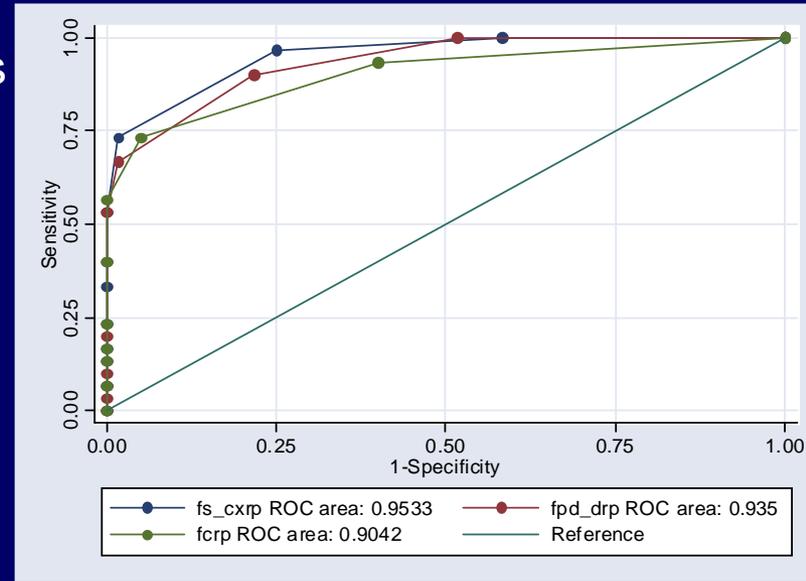
Table 6. Difference between the integer of 12-point ILO/ICRP category among AR, FDP and SR by readers

	AR-FPD			AR-SR			FPD-SR		
	Difference	SD	<i>p</i> -value	Difference	SD	<i>p</i> -value	Difference	SD	<i>p</i> -value
Reader 1	0.167	0.592	0.134	0.567	0.858	0.001	0.400	0.770	0.008
Reader 2	0.167	0.874	0.305	0.600	0.675	<0.001	0.433	0.728	0.003
Reader 3	0.133	0.629	0.255	0.567	0.626	<0.001	0.433	0.679	0.002

SD: standard deviation, *p*-values were calculated by the paired t test.

Pneumoconiosis Law and Digital X-ray

- Since 1960, Administrative class (PR0,1,2,3) has been decided according to Pneumoconiosis Law
- In 2001, CR was introduced into legitimate screening
- FPD DR is now on the table:
 - F/S CXR, FPD DR, FCR were almost same in sensitivity, specificity and profusion of detected small opacities. (Takashima Y, Suganuma N et al. JOH 2007)
 - Governmental Study Group is now performing further analysis.



FPD DR



F/S CXR

Discussion (cont')

- The pre-storage parameter setting that is more critical than the window level or width of the stored image to the visualization of the appropriate image, though most of the physicians using CR or DR at their clinics may not realize the difference.
- It will not be practical to demand all the CR or DR data should be stored as raw data, but it is essential to demand all the digital radiograph data to be stored using P-value as defined in DICOM Part 14.

Conclusion

- The MHWL-J taskforce concluded that the DR with appropriate settings can be used in the legal management of patients with pneumoconiosis, and officially approved its use for the pneumoconiosis classification on 16 November 2007 in Japan.
- The pre-storage parameters, both gray scale and spatial frequency processing, are important to decide the image output more than the post-storage parameters like WL and WW. Those influences on the output image are universal to both hard copy and or soft copy. The DICOM Part 14 will standardize visualization regarding the gray scale.
- Evaluation of the image or soft copy on the CRT or LCD monitors was not in the scope of this evaluation. For its use as soft copy, rigorous evaluation of monitor spec, maintenance and calibration of the monitor, data storage, data compression rate, and pre-storage data processing should be done before implementation.

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