

Photon-counting CT: Image quality evaluation in patients with tibial plateau fracture treated with metallic osteosynthesis material

ELECTRONIC SUPPLEMENTARY MATERIAL

Table S1 Image evaluation criteria and interpretation of Likert scores in the second part of the evaluation.

Image quality criteria		Likert scale
Reduction of metal artifacts	The reduction of metal artifacts	1 = No apparent reduction 2 = Minimal 3 = Moderate 4 = Substantial 5 = Complete or almost complete
		99 = unevaluable
Overcorrections of artifacts or new artifacts	Presence of overcorrections of artifacts or new artifacts	1 = Yes 2 = No
		99 = unevaluable
Overcorrections of artifacts or new artifacts	The significance of overcorrections of artifacts or new artifacts is:	1 = very significant, severely affecting diagnostic confidence 2 = significant, affecting diagnostic confidence 3 = moderate, minor effect on diagnostic confidence 4 = negligible, not affecting diagnostic confidence 5 = none
		99 = unevaluable
Diagnostic value	The diagnostic value of the added information	1 = None or no added information 2 = Low 3 = Moderate 4 = High 5 = Very high
		99 = unevaluable

Table S2 Frequency table of scores from the first part of the image quality evaluation.

Metal artifacts																								
Scanner	Kernel	keV	iMAR	Several screws (M1)							Single screw (M2)							Metal-bone interface (M3)						
				1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
PCD-CT	Br44	70	iMAR	7	11	23	15	4	0	0	2	11	23	9	10	0	0	7	23	14	9	2	0	0
	Br44	110		12	25	18	5	0	0	0	8	15	17	14	1	0	0	12	14	11	15	3	0	0
	Br56	70	iMAR	8	14	22	14	2	0	0	7	7	24	10	7	0	0	6	13	24	11	1	0	0
	Br76	70		26	31	2	1	0	0	0	20	23	11	1	0	0	0	4	15	23	8	5	0	0
	Br76	110		7	24	25	3	1	0	0	3	14	20	13	5	0	0	0	4	13	16	19	3	0
	Br76	150		15	20	17	6	2	0	0	7	9	23	11	5	0	0	1	8	9	21	13	3	0
	Br80	T3D		13	25	20	1	1	0	0	10	16	24	4	1	0	0	3	10	20	16	6	0	0
EID-CT	Br40		iMAR	1	5	11	21	16	6	0	1	2	10	12	21	9	0	1	16	23	10	2	3	0
	Br59		iMAR	0	6	10	21	20	3	0	0	1	7	14	23	10	0	0	0	14	24	9	8	0
	Br64			1	19	27	9	4	0	0	0	10	16	21	6	2	0	0	1	8	19	21	6	0
Bone																								
Scanner	Kernel	keV	iMAR	Cortical bone (B1)							Trabecular bone (B2)							Fracture (B3)						
				1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
PCD-CT	Br44	70	iMAR	0	1	7	18	25	7	2	0	1	9	33	8	8	1	0	1	14	29	8	7	1
	Br44	110		0	5	15	29	9	2	0	1	15	26	14	3	0	1	3	13	23	13	7	0	1

	Br56	70	iMAR	0	0	0	5	29	24	2	0	0	4	20	20	12	4	0	0	4	14	27	12	3
	Br76	70		0	0	2	8	15	21	14	0	0	4	10	18	17	11	0	1	9	15	20	10	5
	Br76	110		0	0	6	17	21	10	6	1	3	17	17	11	6	5	0	3	20	17	11	6	3
	Br76	150		0	2	14	15	14	12	3	0	16	12	17	6	5	4	0	7	25	14	8	5	1
	Br80	T3D		0	0	0	4	12	18	26	0	1	0	4	10	23	22	0	1	3	9	12	21	14
	Br40		iMAR	0	0	6	26	24	2	2	1	1	8	38	11	1	0	0	0	9	26	24	1	0
EID-CT	Br59		iMAR	0	0	0	10	26	21	3	0	0	4	26	22	8	0	0	0	4	19	26	8	3
	Br64			0	0	1	6	31	19	3	0	0	10	19	23	6	2	0	0	7	19	28	6	0

Soft tissue

Scanner	Kernel	keV	iMAR	Anterior cruciate ligament (S1)							Sartorius muscle (S2)						
				1	2	3	4	5	6	7	1	2	3	4	5	6	7
	Br44	70	iMAR	0	4	6	26	12	11	1	0	0	1	7	19	18	15
	Br44	110		2	5	8	16	14	10	4	0	3	5	16	10	11	15
	Br56	70	iMAR	0	5	15	20	10	10	0	0	0	0	8	25	13	14
PCD-CT	Br76	70		5	18	25	6	4	1	0	0	2	10	24	15	9	0
	Br76	110		3	15	27	14	1	0	0	1	6	14	22	12	5	0
	Br76	150		6	21	21	9	2	1	0	3	8	16	16	10	5	2
	Br80	T3D		20	22	12	4	2	0	0	2	15	19	15	6	3	0
EID-CT	Br40		iMAR	0	2	2	22	22	7	5	0	0	0	14	22	11	13

	Br59		iMAR	7	18	20	13	2	0	0	1	6	19	24	8	2	0
	Br64			19	23	11	5	2	0	0	5	10	25	14	5	1	0
Overall																	
				Bone (O1)							Soft tissue (O2)						
Scanner	Kernel	keV	iMAR	1	2	3	4	5	6	7	1	2	3	4	5	6	7
PCD-CT	Br44	70	iMAR	0	0	5	17	12	2	0	0	0	3	15	14	4	0
	Br44	110		0	5	13	16	2	0	0	0	4	7	15	8	2	0
	Br56	70	iMAR	0	0	2	9	21	4	0	0	0	1	22	10	3	0
	Br76	70		0	0	3	10	18	5	0	0	8	15	10	3	0	0
	Br76	110		0	1	9	19	5	2	0	0	8	17	11	0	0	0
	Br76	150		0	2	18	12	3	1	0	2	15	14	2	3	0	0
	Br80	T3D		0	0	2	6	12	14	2	5	19	9	2	0	1	0
EID-CT	Br40		iMAR	0	0	2	17	17	0	0	0	0	1	17	18	0	0
	Br59		iMAR	0	0	0	14	21	1	0	0	12	17	7	0	0	0
	Br64			0	0	3	16	13	4	0	2	22	7	4	1	0	0

Table S3 Frequencies and percentages of observer scores for the side-by-side comparison of image reconstruction types compared to the corresponding reference reconstruction (no iMAR, 70 keV).

			Reduction of metal artifacts						
Kernel	VMI (keV)	iMAR	1	2	3	4	5		
Br44	70	iMAR	0 (0%)	5 (14%)	12 (33%)	19 (53%)	0 (0%)		
Br44	110	no	0 (0%)	17 (47%)	17 (47%)	2 (6%)	0 (0%)		
Br56	70	iMAR	0 (0%)	9 (25%)	12 (33%)	15 (42%)	0 (0%)		
Br76	110	no	1 (3%)	14 (39%)	21 (58%)	0 (0%)	0 (0%)		
Br76	150	no	0 (0%)	13 (36%)	17 (47%)	6 (17%)	0 (0%)		
			Diagnostic value						
Kernel	VMI (keV)	iMAR	1	2	3	4	5		
Br44	70	iMAR	7 (19%)	9 (25%)	13 (36%)	7 (19%)	0 (0%)		
Br44	110	no	15 (42%)	15 (42%)	5 (14%)	1 (3%)	0 (0%)		
Br56	70	iMAR	3 (8%)	16 (44%)	14 (39%)	2 (6%)	1 (3%)		
Br76	110	no	4 (11%)	19 (53%)	12 (33%)	1 (3%)	0 (0%)		
Br76	150	no	5 (14%)	12 (33%)	12 (33%)	7 (19%)	0 (0%)		
Presence and significance of overcorrections and new artifacts									
Kernel	VMI (keV)	iMAR	Yes	No	1	2	3	4	5
Br44	70	iMAR	35 (97%)	1 (3%)	1 (3%)	4 (11%)	20 (56%)	10 (28%)	1 (3%)
Br44	110	no	34 (94%)	2 (6%)	5 (14%)	17 (47%)	8 (22%)	4 (11%)	2 (6%)

Br56	70	iMAR	34 (94%)	2 (6%)	0 (0%)	6 (17%)	22 (61%)	6 (17%)	2 (6%)
Br76	110	no	23 (64%)	13 (36%)	0 (0%)	8 (22%)	6 (17%)	9 (25%)	13 (36%)
Br76	150	no	30 (83%)	6 (17%)	1 (3%)	11 (31%)	7 (19%)	11 (31%)	6 (17%)

Scores and percentages of scores for each image quality criteria for the side-by-side comparison. Each image was compared to the corresponding reference image without iMAR at 70 keV.

VMI Virtual Monoenergetic Images, *iMAR* iterative Metal Artefact Reduction

Table S4 Results of the VGC analysis for image criteria concerning metal artifacts.

Image criteria	Intended use	Reference image	Test image	Number of cases	AUC	95% CI	p-value	Sig.
M1	Soft tissue	EID-CT Br40 iMAR	PCD-CT Br44 iMAR	12	0.21	0.09 – 0.35	0.004	*
M1		EID-CT Br40 iMAR	PCD-CT Br44 110 keV	12	0.10	0.03 – 0.19	0.001	*
M1		EID-CT Br40 iMAR	PCD-CT Br56 iMAR	12	0.17	0.07 – 0.29	0.001	*
M2		EID-CT Br40 iMAR	PCD-CT Br44 iMAR	11	0.21	0.09 – 0.33	0.006	*
M2		EID-CT Br40 iMAR	PCD-CT Br44 110 keV	11	0.14	0.03 – 0.29	0.004	*
M2		EID-CT Br40 iMAR	PCD-CT Br56 iMAR	11	0.17	0.06 – 0.30	0.003	*
M1	Bone	EID-CT Br59 iMAR	PCD-CT Br56 iMAR	12	0.16	0.07 – 0.28	0.003	*
M1		EID-CT Br59 iMAR	PCD-CT Br76 110 keV	12	0.13	0.02 – 0.29	0.001	*
M1		EID-CT Br59 iMAR	PCD-CT Br76 150 keV	12	0.13	0.01 – 0.33	0.002	*
M1		PCD-CT Br56 iMAR	PCD-CT Br80	12	0.30	0.11 – 0.50	0.014	*
M1		PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	12	0.82	0.70 – 0.92	0.000	*
M1		PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	12	0.72	0.59 – 0.86	0.008	*
M2		EID-CT Br59 iMAR	PCD-CT Br56 iMAR	11	0.10	0.02 – 0.22	0.001	*
M2		EID-CT Br59 iMAR	PCD-CT Br76 110 keV	11	0.15	0.02 – 0.35	0.002	*
M2		EID-CT Br59 iMAR	PCD-CT Br76 150 keV	11	0.15	0.02 – 0.37	0.003	*
M2		PCD-CT Br56 iMAR	PCD-CT Br80	11	0.32	0.12 – 0.55	0.030	*
M2		PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	11	0.88	0.80 – 0.95	0.001	*
M2		PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	11	0.85	0.75 – 0.93	0.001	*

M2	PCD-CT Br76 110 keV	PCD-CT Br76 150 keV	11	0.47	0.34 – 0.61	0.674	
M3	EID-CT Br59 iMAR	PCD-CT Br56 iMAR	11	0.14	0.03 – 0.29	0.002	*
M3	EID-CT Br59 iMAR	PCD-CT Br76 110 keV	11	0.49	0.26 – 0.71	0.933	
M3	EID-CT Br59 iMAR	PCD-CT Br76 150 keV	11	0.42	0.17 – 0.69	0.336	
M3	EID-CT Br59 iMAR	PCD-CT Br80	11	0.25	0.08 – 0.43	0.014	*
M3	EID-CT Br64	PCD-CT Br76 110 keV	11	0.40	0.25 – 0.58	0.197	
M3	EID-CT Br64	PCD-CT Br80	11	0.18	0.05 – 0.32	0.004	*
M3	PCD-CT Br56 iMAR	PCD-CT Br80	11	0.63	0.47 – 0.77	0.107	
M3	PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	11	0.81	0.65 – 0.92	0.003	*
M3	PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	11	0.77	0.59 – 0.90	0.006	*
M3	PCD-CT Br76 110 keV	PCD-CT Br76 150 keV	11	0.43	0.28 – 0.57	0.313	

Values of AUC <0.5 indicate higher scores for the "Reference" image. AUC >0.5 indicate higher scores for the "Test" image. Significant differences are marked with *. and the image with the highest score is in bold.

VGC Visual Grading Characteristics. AUC Area under the curve. M1 Metal artifact streaks at the level of several screws. M2 Metal artifact streaks at the level of the distal screw. M3 Metal-bone interface

Table S5 Results of the VGC analysis for image criteria concerning bone.

Image criteria	Reference image	Test image	AUC	95% CI	p-value	Sig.
B1	EID-CT Br59 iMAR	PCD-CT Br56 iMAR	0.53	0.33 – 0.73	0.565	
B1	EID-CT Br59 iMAR	PCD-CT Br80	0.79	0.60 – 0.93	0.005	*
B1	EID-CT Br64	PCD-CT Br80	0.80	0.63 – 0.94	0.004	*
B1	PCD-CT Br56 iMAR	PCD-CT Br80	0.77	0.52 – 0.94	0.007	*
B1	PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	0.28	0.18 – 0.38	0.001	*
B1	PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	0.20	0.11 – 0.28	0.000	*
B1	PCD-CT Br76 110 keV	PCD-CT Br76 150 keV	0.38	0.27 – 0.51	0.044	*
B1	PCD-CT Br76 70 keV	PCD-CT Br80	0.66	0.55 – 0.77	0.007	*
B2	EID-CT Br59 iMAR	PCD-CT Br56 iMAR	0.59	0.42 – 0.75	0.183	
B2	EID-CT Br59 iMAR	PCD-CT Br80	0.92	0.80 – 0.99	0.001	*
B2	EID-CT Br64	PCD-CT Br80	0.91	0.81 – 0.98	0.000	*
B2	PCD-CT Br56 iMAR	PCD-CT Br80	0.84	0.68 – 0.95	0.001	*
B2	PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	0.22	0.12 – 0.32	0.001	*
B2	PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	0.13	0.03 – 0.25	0.000	*
B2	PCD-CT Br76 110 keV	PCD-CT Br76 150 keV	0.37	0.25 – 0.48	0.027	*
B2	PCD-CT Br76 70 keV	PCD-CT Br80	0.73	0.62 – 0.83	0.002	*
B3	EID-CT Br59 iMAR	PCD-CT Br56 iMAR	0.53	0.35 – 0.70	0.631	
B3	EID-CT Br59 iMAR	PCD-CT Br80	0.70	0.48 – 0.90	0.016	*
B3	EID-CT Br64	PCD-CT Br80	0.79	0.61 – 0.93	0.004	*
B3	PCD-CT Br56 iMAR	PCD-CT Br80	0.71	0.52 – 0.88	0.010	*

B3	PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	0.32	0.18 – 0.45	0.009	*
B3	PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	0.21	0.09 – 0.33	0.002	*
B3	PCD-CT Br76 110 keV	PCD-CT Br76 150 keV	0.39	0.28 – 0.50	0.043	*
B3	PCD-CT Br76 70 keV	PCD-CT Br80	0.76	0.64 – 0.85	0.004	*
O1	EID-CT Br59 iMAR	PCD-CT Br56 iMAR	0.56	0.40 – 0.71	0.360	
O1	EID-CT Br59 iMAR	PCD-CT Br80	0.72	0.50 – 0.92	0.018	*
O1	EID-CT Br64	PCD-CT Br80	0.76	0.57 – 0.91	0.003	*
O1	PCD-CT Br56 iMAR	PCD-CT Br80	0.67	0.44 – 0.92	0.023	*
O1	PCD-CT Br76 70 keV	PCD-CT Br76 110 keV	0.27	0.15 – 0.39	0.007	*
O1	PCD-CT Br76 70 keV	PCD-CT Br76 150 keV	0.16	0.06 – 0.28	0.001	*
O1	PCD-CT Br76 110 keV	PCD-CT Br76 150 keV	0.35	0.23 – 0.46	0.023	*
O1	PCD-CT Br76 70 keV	PCD-CT Br80	0.68	0.49 – 0.86	0.045	*

Values of AUC <0.5 indicate higher scores for the "Reference" image, AUC >0.5 indicate higher scores for the "Test" image. Significant differences are marked with *, and the image with the highest score is in **bold**.

VGC Visual Grading Characteristics, AUC Area under the curve, B1 Cortical bone, B2 Trabecular architecture, B3 Fracture, O1 Overall bone

Table S6 Results of the VGC analysis for image criteria concerning soft tissue for each compared pair of image type.

Image criteria	Reference image	Test image	AUC	95% CI	p-value	Sig.
S1	EID-CT Br40 iMAR	PCD-CT Br44 iMAR	0.38	0.24 – 0.53	0.049	*
S1	EID-CT Br40 iMAR	PCD-CT Br56 iMAR	0.29	0.19 – 0.40	0.006	*
S1	PCD-CT Br44 iMAR	PCD-CT Br44 110 keV	0.51	0.40 – 0.65	0.741	
S1	PCD-CT Br44 iMAR	PCD-CT Br56 iMAR	0.41	0.26 – 0.54	0.101	
S2	EID-CT Br40 iMAR	PCD-CT Br44 iMAR	0.59	0.46 – 0.73	0.125	
S2	EID-CT Br40 iMAR	PCD-CT Br56 iMAR	0.57	0.43 – 0.71	0.303	
S2	PCD-CT Br44 iMAR	PCD-CT Br44 110 keV	0.37	0.22 – 0.53	0.038	*
S2	PCD-CT Br44 iMAR	PCD-CT Br56 iMAR	0.46	0.30 – 0.62	0.477	
O2	EID-CT Br40 iMAR	PCD-CT Br44 iMAR	0.50	0.31 – 0.67	0.948	
O2	EID-CT Br40 iMAR	PCD-CT Br56 iMAR	0.45	0.31 – 0.63	0.521	
O2	PCD-CT Br44 iMAR	PCD-CT Br44 110 keV	0.31	0.18 – 0.48	0.024	*
O2	PCD-CT Br44 iMAR	PCD-CT Br56 iMAR	0.45	0.28 – 0.65	0.330	

Values of AUC <0.5 indicate higher scores for the "Reference" image, AUC >0.5 indicate higher scores for the "Test" image. Significant differences are marked with *, and the image with the highest score is in **bold**.

VGC Visual Grading Characteristics, AUC Area under the curve, S1 Anterior cruciate ligament, S2 Sartorius muscle, O2 Overall soft tissue

Fig. S1 Representative example of VOI placement.

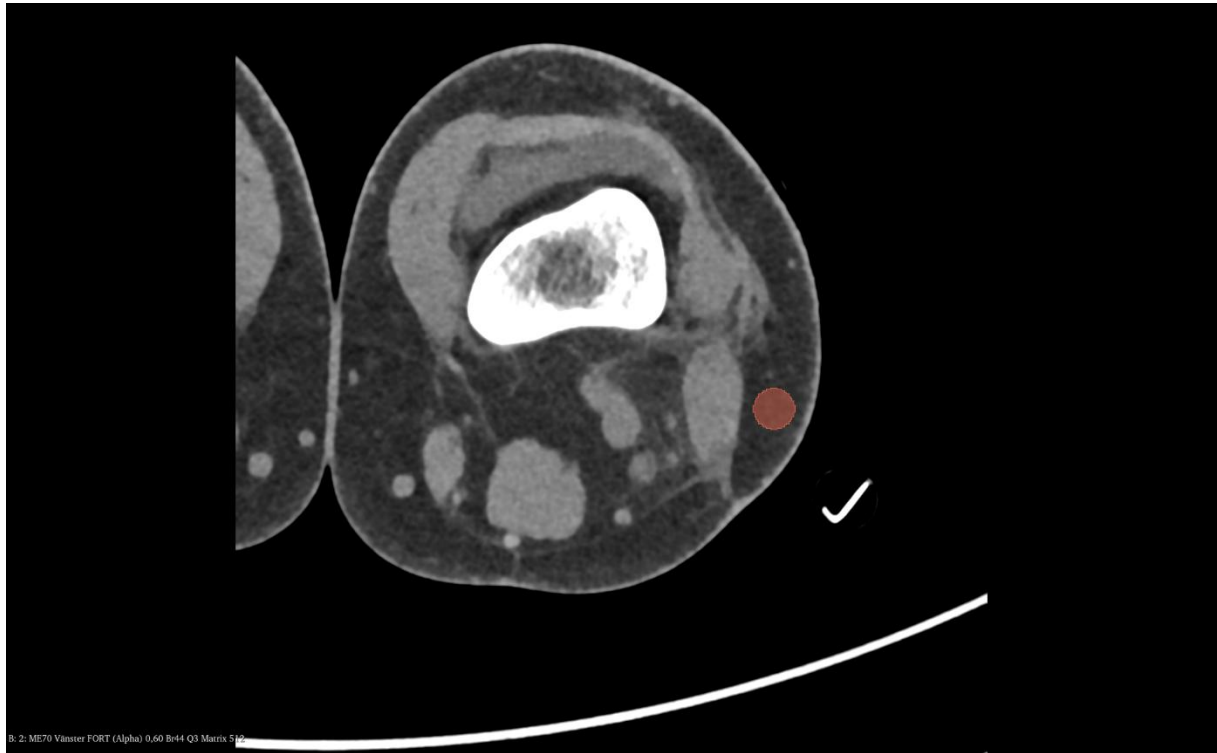


Fig. S2 Representative axial CT images of smooth-kernel reconstructions at the level of the distal femur.

