

Supplementary

Table S1 List of the clinical features of contrast-enhanced mammography used to construct the clinical Random Forest model in this study

Clinical Features	Description	Evaluation method
Age (y)	/	/
Lesion size (mm)	/	Measuring on either the CC or MLO view of the LE or DES images, depending on which kind of image showed the largest diameters
Breast composition	a b c d	By using the LE images.
Type of lesions		By using the LE images.
Mass	Present Absent	
Calcification	Present Absent	
Asymmetry	Present Absent	
Architectural distortion	Present Absent	
Not shown	Present Absent	
Suspicious skin/nipple findings	Present Absent	By using the LE images.
Suspicious axillary adenopathy	Present Absent	By using the LE images.
Degree of enhancement	No enhancement Slight enhancement Moderate enhancement Intense enhancement	By using the LE images.
Type of enhancement	Focal enhancement Mass enhancement Non-mass enhancement	By using the DES images.
Internal enhancement pattern	Homogeneous Heterogeneous Rim enhancement Internal septations Clumped Clustered ring	By using the DES images.

Table S1 (continued)

Table S1 (*continued*)

Clinical Features	Description	Evaluation method
Enhancing lesion margin	Circumscribed	By using the DES images.
	Not Circumscribed	
	Spiculated	
Degree of BPE	Minimal	By using the DES images.
	Mild	
	Moderate	
	Marked	

CC, craniocaudal; MLO, mediolateral oblique; LE, low-energy; DES, dual-energy subtraction; BPE, background parenchymal enhancement.

Table S2 Radiomic features from different categories

Histogram features		Texture features		
		GLCM features	GLRLM features	GLSZM features
1	Percentile5	ClusterProminence_AllDirection_offset1	HighGreyLevelRunEmphasis_AllDirection_offset1	GreyLevelNonuniformity_AllDirection_offset1
2	Percentile10	ClusterProminence_AllDirection_offset1_SD	HighGreyLevelRunEmphasis_AllDirection_offset1_SD	GreyLevelNonuniformity_AllDirection_offset1_SD
3	Percentile15	ClusterProminence_AllDirection_offset4	HighGreyLevelRunEmphasis_AllDirection_offset4	GreyLevelNonuniformity_AllDirection_offset4
4	Percentile20	ClusterProminence_AllDirection_offset4_SD	HighGreyLevelRunEmphasis_AllDirection_offset4_SD	GreyLevelNonuniformity_AllDirection_offset4_SD
5	Percentile25	ClusterProminence_AllDirection_offset7	HighGreyLevelRunEmphasis_AllDirection_offset7	GreyLevelNonuniformity_AllDirection_offset7
6	Percentile30	ClusterProminence_AllDirection_offset7_SD	HighGreyLevelRunEmphasis_AllDirection_offset7_SD	GreyLevelNonuniformity_AllDirection_offset7_SD
7	Percentile35	ClusterProminence_angle0_offset1	HighGreyLevelRunEmphasis_angle0_offset1	GreyLevelNonuniformity_angle0_offset1
8	Percentile40	ClusterProminence_angle0_offset4	HighGreyLevelRunEmphasis_angle0_offset4	GreyLevelNonuniformity_angle0_offset4
9	Percentile45	ClusterProminence_angle0_offset7	HighGreyLevelRunEmphasis_angle0_offset7	GreyLevelNonuniformity_angle0_offset7
10	Percentile50	ClusterProminence_angle135_offset1	HighGreyLevelRunEmphasis_angle135_offset1	GreyLevelNonuniformity_angle135_offset1
11	Percentile55	ClusterProminence_angle135_offset4	HighGreyLevelRunEmphasis_angle135_offset4	GreyLevelNonuniformity_angle135_offset4
12	Percentile60	ClusterProminence_angle135_offset7	HighGreyLevelRunEmphasis_angle135_offset7	GreyLevelNonuniformity_angle135_offset7
13	Percentile65	ClusterProminence_angle45_offset1	HighGreyLevelRunEmphasis_angle45_offset1	GreyLevelNonuniformity_angle45_offset1
14	Percentile70	ClusterProminence_angle45_offset4	HighGreyLevelRunEmphasis_angle45_offset4	GreyLevelNonuniformity_angle45_offset4
15	Percentile75	ClusterProminence_angle45_offset7	HighGreyLevelRunEmphasis_angle45_offset7	GreyLevelNonuniformity_angle45_offset7
16	Percentile80	ClusterProminence_angle90_offset1	HighGreyLevelRunEmphasis_angle90_offset1	GreyLevelNonuniformity_angle90_offset1
17	Percentile85	ClusterProminence_angle90_offset4	HighGreyLevelRunEmphasis_angle90_offset4	GreyLevelNonuniformity_angle90_offset4
18	Percentile90	ClusterProminence_angle90_offset7	HighGreyLevelRunEmphasis_angle90_offset7	GreyLevelNonuniformity_angle90_offset7
19	Percentile95	ClusterShade_AllDirection_offset1	LowGreyLevelRunEmphasis_AllDirection_offset1	Size zone variability
20	Quantile0.025	ClusterShade_AllDirection_offset1_SD	LowGreyLevelRunEmphasis_AllDirection_offset1_SD	High intensity emphasis
21	Quantile0.250	ClusterShade_AllDirection_offset4	LowGreyLevelRunEmphasis_AllDirection_offset4	High intensity large area emphasis
22	Quantile0.500	ClusterShade_AllDirection_offset4_SD	LowGreyLevelRunEmphasis_AllDirection_offset4_SD	High intensity small area emphasis
23	Quantile0.750	ClusterShade_AllDirection_offset7	LowGreyLevelRunEmphasis_AllDirection_offset7	Low intensity emphasis
24	Quantile0.975	ClusterShade_AllDirection_offset7_SD	LowGreyLevelRunEmphasis_AllDirection_offset7_SD	Low intensity large area emphasis
25	Energy	ClusterShade_angle0_offset1	LowGreyLevelRunEmphasis_angle0_offset1	Low intensity small area emphasis
26	Entropy	ClusterShade_angle0_offset4	LowGreyLevelRunEmphasis_angle0_offset4	Intensity variability
27	Frequency size	ClusterShade_angle0_offset7	LowGreyLevelRunEmphasis_angle0_offset7	Large area emphasis
28	Kurtosis	ClusterShade_angle135_offset1	LowGreyLevelRunEmphasis_angle135_offset1	Small area emphasis
29	Max intensity	ClusterShade_angle135_offset4	LowGreyLevelRunEmphasis_angle135_offset4	Zone percentage
30	Min intensity	ClusterShade_angle135_offset7	LowGreyLevelRunEmphasis_angle135_offset7	
31	Mean deviation	ClusterShade_angle45_offset1	LowGreyLevelRunEmphasis_angle45_offset1	
32	Mean value	ClusterShade_angle45_offset4	LowGreyLevelRunEmphasis_angle45_offset4	
33	Median intensity	ClusterShade_angle45_offset7	LowGreyLevelRunEmphasis_angle45_offset7	
34	Range	ClusterShade_angle90_offset1	LowGreyLevelRunEmphasis_angle90_offset1	
35	Relative deviation	ClusterShade_angle90_offset4	LowGreyLevelRunEmphasis_angle90_offset4	
36	Root mean square	ClusterShade_angle90_offset7	LowGreyLevelRunEmphasis_angle90_offset7	
37	Skewness	Correlation_AllDirection_offset1	LongRunEmphasis_AllDirection_offset1	
38	Standard deviation	Correlation_AllDirection_offset1_SD	LongRunEmphasis_AllDirection_offset1_SD	
39	Uniformity	Correlation_AllDirection_offset4	LongRunEmphasis_AllDirection_offset4	
40	Variance	Correlation_AllDirection_offset4_SD	LongRunEmphasis_AllDirection_offset4_SD	
41	Volume count	Correlation_AllDirection_offset7	LongRunEmphasis_AllDirection_offset7	
42	Voxel value sum	Correlation_AllDirection_offset7_SD	LongRunEmphasis_AllDirection_offset7_SD	
43		Correlation_angle0_offset1	LongRunEmphasis_angle0_offset1	
44		Correlation_angle0_offset4	LongRunEmphasis_angle0_offset4	
45		Correlation_angle0_offset7	LongRunEmphasis_angle0_offset7	
46		Correlation_angle135_offset1	LongRunEmphasis_angle135_offset1	

Table S2 (continued)

Table S2 (continued)

	Texture features	
	Histogram features	
	GLCM features	GLRLM features
		GLSZM features
47	Correlation_angle135_offset4	LongRunEmphasis_angle135_offset4
48	Correlation_angle135_offset7	LongRunEmphasis_angle135_offset7
49	Correlation_angle45_offset1	LongRunEmphasis_angle45_offset1
50	Correlation_angle45_offset4	LongRunEmphasis_angle45_offset4
51	Correlation_angle45_offset7	LongRunEmphasis_angle45_offset7
52	Correlation_angle90_offset1	LongRunEmphasis_angle90_offset1
53	Correlation_angle90_offset4	LongRunEmphasis_angle90_offset4
54	Correlation_angle90_offset7	LongRunEmphasis_angle90_offset7
55	GLCMEnergy_AllDirection_offset1	ShortRunEmphasis_AllDirection_offset1
56	GLCMEnergy_AllDirection_offset1_SD	ShortRunEmphasis_AllDirection_offset1_SD
57	GLCMEnergy_AllDirection_offset4	ShortRunEmphasis_AllDirection_offset4
58	GLCMEnergy_AllDirection_offset4_SD	ShortRunEmphasis_AllDirection_offset4_SD
59	GLCMEnergy_AllDirection_offset7	ShortRunEmphasis_AllDirection_offset7
60	GLCMEnergy_AllDirection_offset7_SD	ShortRunEmphasis_AllDirection_offset7_SD
61	GLCMEnergy_angle0_offset1	ShortRunEmphasis_angle0_offset1
62	GLCMEnergy_angle0_offset4	ShortRunEmphasis_angle0_offset4
63	GLCMEnergy_angle0_offset7	ShortRunEmphasis_angle0_offset7
64	GLCMEnergy_angle135_offset1	ShortRunEmphasis_angle135_offset1
65	GLCMEnergy_angle135_offset4	ShortRunEmphasis_angle135_offset4
66	GLCMEnergy_angle135_offset7	ShortRunEmphasis_angle135_offset7
67	GLCMEnergy_angle45_offset1	ShortRunEmphasis_angle45_offset1
68	GLCMEnergy_angle45_offset4	ShortRunEmphasis_angle45_offset4
69	GLCMEnergy_angle45_offset7	ShortRunEmphasis_angle45_offset7
70	GLCMEnergy_angle90_offset1	ShortRunEmphasis_angle90_offset1
71	GLCMEnergy_angle90_offset4	ShortRunEmphasis_angle90_offset4
72	GLCMEnergy_angle90_offset7	ShortRunEmphasis_angle90_offset7
73	GLCMEntropy_AllDirection_offset1	RunLengthNonuniformity_AllDirection_offset1
74	GLCMEntropy_AllDirection_offset1_SD	RunLengthNonuniformity_AllDirection_offset1_SD
75	GLCMEntropy_AllDirection_offset4	RunLengthNonuniformity_AllDirection_offset4
76	GLCMEntropy_AllDirection_offset4_SD	RunLengthNonuniformity_AllDirection_offset4_SD
77	GLCMEntropy_AllDirection_offset7	RunLengthNonuniformity_AllDirection_offset7
78	GLCMEntropy_AllDirection_offset7_SD	RunLengthNonuniformity_AllDirection_offset7_SD
79	GLCMEntropy_angle0_offset1	RunLengthNonuniformity_angle0_offset1
80	GLCMEntropy_angle0_offset4	RunLengthNonuniformity_angle0_offset4
81	GLCMEntropy_angle0_offset7	RunLengthNonuniformity_angle0_offset7
82	GLCMEntropy_angle135_offset1	RunLengthNonuniformity_angle135_offset1
83	GLCMEntropy_angle135_offset4	RunLengthNonuniformity_angle135_offset4
84	GLCMEntropy_angle135_offset7	RunLengthNonuniformity_angle135_offset7
85	GLCMEntropy_angle45_offset1	RunLengthNonuniformity_angle45_offset1
86	GLCMEntropy_angle45_offset4	RunLengthNonuniformity_angle45_offset4
87	GLCMEntropy_angle45_offset7	RunLengthNonuniformity_angle45_offset7
88	GLCMEntropy_angle90_offset1	RunLengthNonuniformity_angle90_offset1
89	GLCMEntropy_angle90_offset4	RunLengthNonuniformity_angle90_offset4
90	GLCMEntropy_angle90_offset7	RunLengthNonuniformity_angle90_offset7
91	HaralickCorrelation_AllDirection_offset1	LongRunHighGreyLevelEmphasis_AllDirection_offset1
92	HaralickCorrelation_AllDirection_offset1_SD	LongRunHighGreyLevelEmphasis_AllDirection_offset1_SD

Table S2 (continued)

Table S2 (continued)

	Texture features			
	Histogram features	GLCM features	GLRLM features	GLSZM features
93		HaralickCorrelation_AllDirection_offset4	LongRunHighGreyLevelEmphasis_AllDirection_offset4	
94		HaralickCorrelation_AllDirection_offset4_SD	LongRunHighGreyLevelEmphasis_AllDirection_offset4_SD	
95		HaralickCorrelation_AllDirection_offset7	LongRunHighGreyLevelEmphasis_AllDirection_offset7	
96		HaralickCorrelation_AllDirection_offset7_SD	LongRunHighGreyLevelEmphasis_AllDirection_offset7_SD	
97		HaralickCorrelation_angle0_offset1	LongRunHighGreyLevelEmphasis_angle0_offset1	
98		HaralickCorrelation_angle0_offset4	LongRunHighGreyLevelEmphasis_angle0_offset4	
99		HaralickCorrelation_angle0_offset7	LongRunHighGreyLevelEmphasis_angle0_offset7	
100		HaralickCorrelation_angle135_offset1	LongRunHighGreyLevelEmphasis_angle135_offset1	
101		HaralickCorrelation_angle135_offset4	LongRunHighGreyLevelEmphasis_angle135_offset4	
102		HaralickCorrelation_angle135_offset7	LongRunHighGreyLevelEmphasis_angle135_offset7	
103		HaralickCorrelation_angle45_offset1	LongRunHighGreyLevelEmphasis_angle45_offset1	
104		HaralickCorrelation_angle45_offset4	LongRunHighGreyLevelEmphasis_angle45_offset4	
105		HaralickCorrelation_angle45_offset7	LongRunHighGreyLevelEmphasis_angle45_offset7	
106		HaralickCorrelation_angle90_offset1	LongRunHighGreyLevelEmphasis_angle90_offset1	
107		HaralickCorrelation_angle90_offset4	LongRunHighGreyLevelEmphasis_angle90_offset4	
108		HaralickCorrelation_angle90_offset7	LongRunHighGreyLevelEmphasis_angle90_offset7	
109		Angular second moment	LongRunLowGreyLevelEmphasis_AllDirection_offset1	
110		Contrast	LongRunLowGreyLevelEmphasis_AllDirection_offset1_SD	
111		Haralick entropy	LongRunLowGreyLevelEmphasis_AllDirection_offset4	
112		Haralick variance	LongRunLowGreyLevelEmphasis_AllDirection_offset4_SD	
113		Sum average	LongRunLowGreyLevelEmphasis_AllDirection_offset7	
114		Sum entropy	LongRunLowGreyLevelEmphasis_AllDirection_offset7_SD	
115		Sum variance	LongRunLowGreyLevelEmphasis_angle0_offset1	
116		Difference entropy	LongRunLowGreyLevelEmphasis_angle0_offset4	
117		Difference variance	LongRunLowGreyLevelEmphasis_angle0_offset7	
118		Inverse difference moment	LongRunLowGreyLevelEmphasis_angle135_offset1	
119		InverseDifferenceMoment_AllDirection_offset1	LongRunLowGreyLevelEmphasis_angle135_offset4	
120		InverseDifferenceMoment_AllDirection_offset1_SD	LongRunLowGreyLevelEmphasis_angle135_offset7	
121		InverseDifferenceMoment_AllDirection_offset4	LongRunLowGreyLevelEmphasis_angle45_offset1	
122		InverseDifferenceMoment_AllDirection_offset4_SD	LongRunLowGreyLevelEmphasis_angle45_offset4	
123		InverseDifferenceMoment_AllDirection_offset7	LongRunLowGreyLevelEmphasis_angle45_offset7	
124		InverseDifferenceMoment_AllDirection_offset7_SD	LongRunLowGreyLevelEmphasis_angle90_offset1	
125		InverseDifferenceMoment_angle0_offset1	LongRunLowGreyLevelEmphasis_angle90_offset4	
126		InverseDifferenceMoment_angle0_offset4	LongRunLowGreyLevelEmphasis_angle90_offset7	
127		InverseDifferenceMoment_angle0_offset7	ShortRunHighGreyLevelEmphasis_AllDirection_offset1	
128		InverseDifferenceMoment_angle135_offset1	ShortRunHighGreyLevelEmphasis_AllDirection_offset1_SD	
129		InverseDifferenceMoment_angle135_offset4	ShortRunHighGreyLevelEmphasis_AllDirection_offset4	
130		InverseDifferenceMoment_angle135_offset7	ShortRunHighGreyLevelEmphasis_AllDirection_offset4_SD	
131		InverseDifferenceMoment_angle45_offset1	ShortRunHighGreyLevelEmphasis_AllDirection_offset7	
132		InverseDifferenceMoment_angle45_offset4	ShortRunHighGreyLevelEmphasis_AllDirection_offset7_SD	
133		InverseDifferenceMoment_angle45_offset7	ShortRunHighGreyLevelEmphasis_angle0_offset1	
134		InverseDifferenceMoment_angle90_offset1	ShortRunHighGreyLevelEmphasis_angle0_offset4	

Table S2 (continued)

Table S2 (continued)

Histogram features	Texture features		
	GLCM features	GLRLM features	GLSZM features
135	InverseDifferenceMoment_angle90_offset4	ShortRunHighGreyLevelEmphasis_angle0_offset7	
136	InverseDifferenceMoment_angle90_offset7	ShortRunHighGreyLevelEmphasis_angle135_offset1	
137	Inertia_AllDirection_offset1	ShortRunHighGreyLevelEmphasis_angle135_offset4	
138	Inertia_AllDirection_offset1_SD	ShortRunHighGreyLevelEmphasis_angle135_offset7	
139	Inertia_AllDirection_offset4	ShortRunHighGreyLevelEmphasis_angle45_offset1	
140	Inertia_AllDirection_offset4_SD	ShortRunHighGreyLevelEmphasis_angle45_offset4	
141	Inertia_AllDirection_offset7	ShortRunHighGreyLevelEmphasis_angle45_offset7	
142	Inertia_AllDirection_offset7_SD	ShortRunHighGreyLevelEmphasis_angle90_offset1	
143	Inertia_angle0_offset1	ShortRunHighGreyLevelEmphasis_angle90_offset4	
144	Inertia_angle0_offset4	ShortRunHighGreyLevelEmphasis_angle90_offset7	
145	Inertia_angle0_offset7	ShortRunLowGreyLevelEmphasis_AllDirection_offset1	
146	Inertia_angle135_offset1	ShortRunLowGreyLevelEmphasis_AllDirection_offset1_SD	
147	Inertia_angle135_offset4	ShortRunLowGreyLevelEmphasis_AllDirection_offset4	
148	Inertia_angle135_offset7	ShortRunLowGreyLevelEmphasis_AllDirection_offset4_SD	
149	Inertia_angle45_offset1	ShortRunLowGreyLevelEmphasis_AllDirection_offset7	
150	Inertia_angle45_offset4	ShortRunLowGreyLevelEmphasis_AllDirection_offset7_SD	
151	Inertia_angle45_offset7	ShortRunLowGreyLevelEmphasis_angle0_offset1	
152	Inertia_angle90_offset1	ShortRunLowGreyLevelEmphasis_angle0_offset4	
153	Inertia_angle90_offset4	ShortRunLowGreyLevelEmphasis_angle0_offset7	
154	Inertia_angle90_offset7	ShortRunLowGreyLevelEmphasis_angle135_offset1	
155		ShortRunLowGreyLevelEmphasis_angle135_offset4	
156		ShortRunLowGreyLevelEmphasis_angle135_offset7	
157		ShortRunLowGreyLevelEmphasis_angle45_offset1	
158		ShortRunLowGreyLevelEmphasis_angle45_offset4	
159		ShortRunLowGreyLevelEmphasis_angle45_offset7	
160		ShortRunLowGreyLevelEmphasis_angle90_offset1	
161		ShortRunLowGreyLevelEmphasis_angle90_offset4	
162		ShortRunLowGreyLevelEmphasis_angle90_offset7	

GLCM, gray level cooccurrence matrix; GLRML, gray level run length matrix; GLSZM, gray level size zone matrix.

Table S3 Selected radiomic features for constructing the radiomics Random Forest model

Number	Selected radiomics features
1	MLO_HE_GLCMEnergy_AllDirection_offset1_SD
2	MLO_LE_sumAverage
3	MLO_LE_HaralickCorrelation_angle90_offset1
4	MLO_LE_ClusterProminence_AllDirection_offset1_SD
5	MLO_LE_Correlation_AllDirection_offset1_SD
6	CC_LE_sumAverage
7	CC_DES_LowIntensityLargeAreaEmphasis
8	CC_DES_LongRunLowGreyLevelEmphasis_AllDirection_offset1_SD
9	MLO_DES_GLCMEnergy_angle0_offset1
10	MLO_LE_GLCMEntropy_angle45_offset7
11	CC_LE_GLCMEnergy_AllDirection_offset1_SD
12	CC_DES_ClusterProminence_AllDirection_offset1_SD
13	MLO_LE_GLCMEnergy_AllDirection_offset1_SD
14	CC_LE_GLCMEntropy_angle45_offset7
15	MLO_HE_ShortRunLowGreyLevelEmphasis_AllDirection_offset7_SD
16	MLO_HE_GLCMEntropy_angle135_offset7
17	MLO_LE_Correlation_AllDirection_offset7_SD
18	MLO_HE_LongRunEmphasis_AllDirection_offset7_SD
19	MLO_DES_ShortRunEmphasis_AllDirection_offset1_SD
20	MLO_DES_sumAverage
21	MLO_HE_LongRunEmphasis_AllDirection_offset1_SD
22	CC_DES_ClusterProminence_angle45_offset7
23	MLO_DES_LongRunEmphasis_AllDirection_offset4_SD
24	CC_HE_LongRunLowGreyLevelEmphasis_AllDirection_offset4_SD
25	MLO_LE_SmallAreaEmphasis
26	CC_LE_LargeAreaEmphasis
27	CC_HE_SmallAreaEmphasis
28	CC_LE_SmallAreaEmphasis
29	MLO_HE_sumAverage
30	CC_DES_Correlation_AllDirection_offset1_SD
31	MLO_LE_GLCMEnergy_AllDirection_offset4_SD
32	CC_LE_Correlation_AllDirection_offset7_SD
33	MLO_LE_Quantile0.25
34	MLO_LE_InverseDifferenceMoment_angle135_offset7
35	CC_HE_Inertia_angle135_offset7
37	MLO_DES_ClusterProminence_AllDirection_offset1_SD
38	CC_HE_InverseDifferenceMoment_angle0_offset7
39	CC_DES_Percentile70
40	CC_LE_Percentile20
41	MLO_DES_RunLengthNonuniformity_angle135_offset7