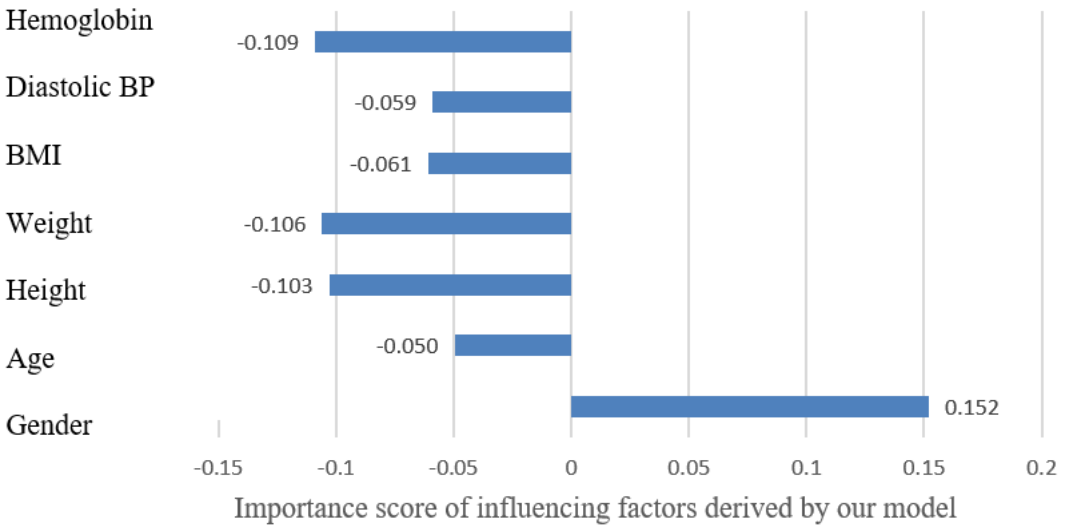
Supplementary document/ Appendix

Appendix Table S1. Details of CT protocols

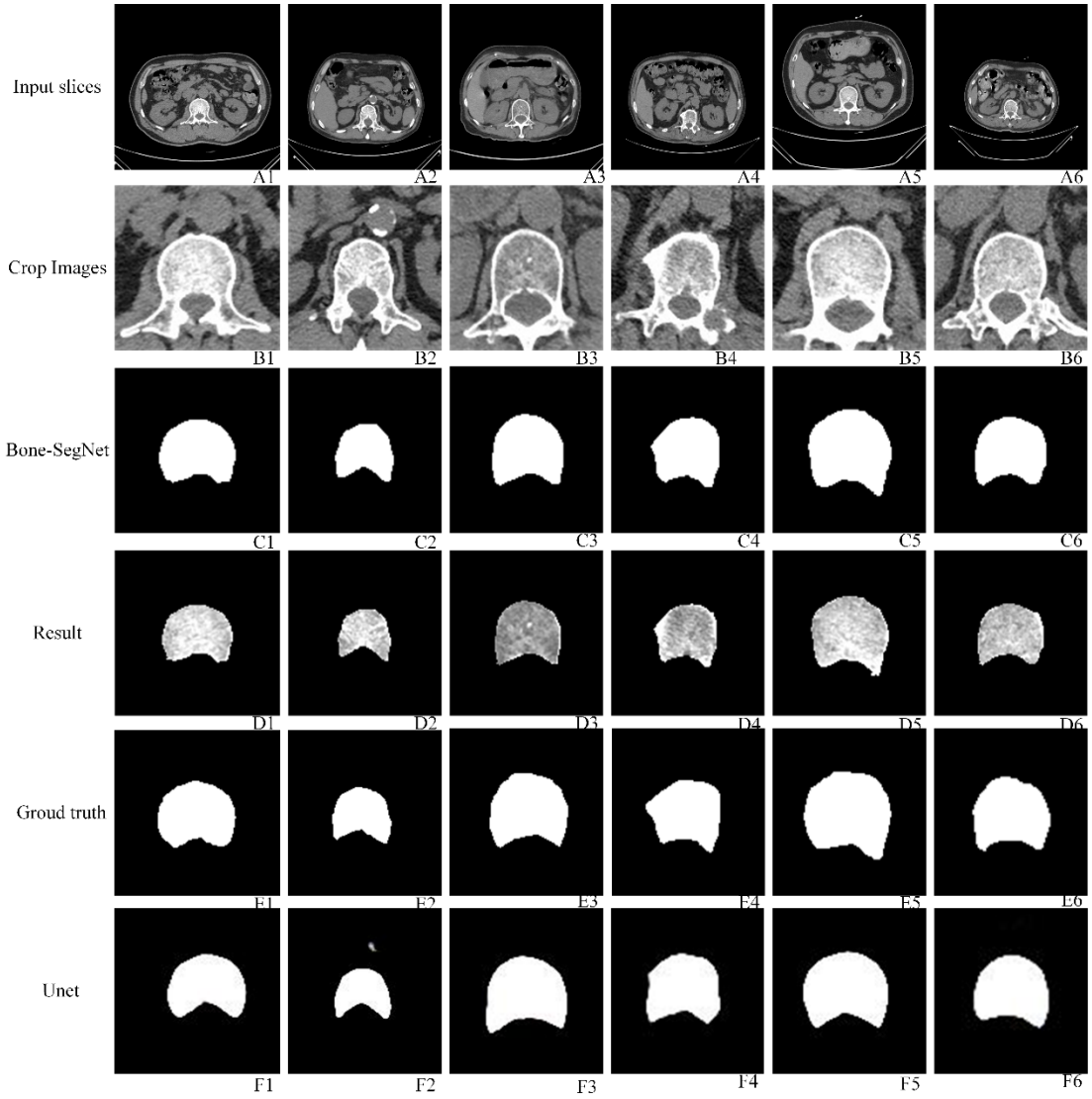
CT information		Parameters	
		Internal scanner	External scanner
CT system		Ingenuity Core 128 CT	SOMATOM Force CT
CT scan	Tube voltage	120kVp	120kVp
	Time–current product	iPatient range: 100~300 mAs	CARE Dose4D
	Detector collimation	64×0.625mm	192×0.6mm
CT image	Image matrix	512×512	512×512
	Field of view	500×500mm	500×500mm
	Reconstruction section thickness	2.0mm	2.0mm

Appendix Table S2. Bone-ClassNet structure diagram

Layer Name	Output Size	Architecture
Conv 1	112×112	7×7,64, stride 2
Conv 2_x	56×56	3×3, maxpool, stride 2 $\begin{bmatrix}1\times1,64\\3\times3,64\\1\times1,256\end{bmatrix}\times1+\begin{bmatrix}1\times1,64\\3\times3,64\\1\times1,256\end{bmatrix}\times2$ 1×1,64, stride 1
Conv 3_x	28×28	$\begin{bmatrix}1\times1,128\\3\times3,128\\1\times1,512\end{bmatrix}\times1+\begin{bmatrix}1\times1,128\\3\times3,128\\1\times1,512\end{bmatrix}\times3$ 1×1,512, stride 1
Conv 4_x	14×14	$\begin{bmatrix}1\times1,256\\3\times3,256\\1\times1,1024\end{bmatrix}\times1+\begin{bmatrix}1\times1,256\\3\times3,256\\1\times1,1024\end{bmatrix}\times22$ 1×1,1024, stride 1
Conv 5_x	7×7	$\begin{bmatrix}1\times1,512\\3\times3,512\\1\times1,2048\end{bmatrix}\times1+\begin{bmatrix}1\times1,512\\3\times3,512\\1\times1,2048\end{bmatrix}\times2$ 1×1, 2048, stride 1
	1×1	Average pool,2048-d fc, softmax



Appendix Fig. S1. 7 Influencing factors of Osteoporosis.



Appendix Fig.S2. Partial segmentation results. Fig. A1-F1: The female was 53 years old, who was diagnosed as normal bone mass with BMD $_{individual}$=140.7mg/cm^3. Fig. A2-F2: The male was 81

years old, who was diagnosed as normal bone mass with BMD $_{individual}$=133.8mg/cm^3. Fig. A3-F3: The female was 64 years old, who was diagnosed as osteoporosis with BMD $_{individual}$=54.3mg/cm^3. Fig. A4-F4: The male was 67 years old, who was diagnosed as osteoporosis with BMD $_{individual}$= 77.5 mg/cm^3. Fig. A5-F5: The male was 50 years old, who was diagnosed as osteopenia with BMD $_{individual}$=116.4 mg/cm^3. Fig. A6-F6: The male was 73 years old, who was diagnosed as osteopenia with BMD $_{individual}$= 102 mg/cm^3. Fig. A1-A6: The axial CT images of the central slice of lumbar 1 vertebral body of 6 subjects successively. Fig.B1-B6: Local magnification of the vertebral body in order to see the effect of the network; Fig. C1-C6: Bone-SegNet segmented images. Fig. D1-D6: Extracted ROI. Fig. E1-E6: Groud truth images. Fig. F1-F6: U-net segmented image.

Appendix Table S3. Introduction of eight classification models

Model name	Model type	Model description	Data source
Model 1	radiomics model, based on random forest classifier	ML model (nonlinear tree-based model) integrated learning method	L1 + L2
Model 2	radiomics model, based on naive Bayes	ML model based on Bayes theorem and independent assumption of feature conditions	L1 + L2
Model 3	DCNN model, based on Bone-ClassNet	convolutional neural network (CNN)	L1 + L2
Model 4	fusion model, radiomics features + DL	filtered omics features were fused with the DL features extracted by CNN-Net, and the full connection layer was used for classification	L1 + L2
Model 5	multi-feature fusion model clinical information + DL	DL features extracted from CNN-Net and clinical information were fused, and the full connectivity layer was used for classification	L1 + L2
Model 6	multi-feature fusion model clinical information + radiomics features + DL	filtered omics features, the DL features extracted by CNN-Net and clinical information were fused, and the full connectivity layer was used for classification	L1 + L2
Model 7	DCNN model, based on Bone-ClassNet	extracts DL features through CNN, uses the full connection layer for classification	L1*
Model 8	multi-feature fusion model clinical information + radiomics features + DL	integrates the filtered omics features, the DL features extracted by CNN-Net and clinical information, and uses the full connectivity layer for classification	L1*

Appendix Table S4. Effectiveness evaluation of different models on the testing datasets

categories	Se	Sp	PPV	NPV	Ac	AUC
Model 1						
normal	0.932	0.982	0.987	0.906	0.952	0.991
osteopenia	0.862	0.934	0.833	0.946	0.914	0.966
osteoporosis	0.941	0.964	0.787	0.991	0.962	0.993
Model 2						
normal	0.876	0.994	0.995	0.842	0.923	0.995
osteopenia	0.853	0.891	0.750	0.941	0.880	0.951
osteoporosis	0.961	0.956	0.753	0.994	0.956	0.993
Model 3						
normal	0.900	0.982	0.986	0.868	0.933	0.991
osteopenia	0.905	0.891	0.760	0.961	0.894	0.968
osteoporosis	0.843	0.978	0.843	0.978	0.962	0.987
Model 4						
normal	0.920	0.964	0.975	0.889	0.938	0.993
osteopenia	0.905	0.927	0.826	0.962	0.899	0.951
osteoporosis	0.961	0.986	0.907	0.995	0.962	0.988
Model 5						
normal	0.916	0.988	0.991	0.887	0.916	0.986
osteopenia	0.922	0.921	0.817	0.967	0.883	0.948
osteoporosis	0.941	0.980	0.873	0.992	0.966	0.986
Model 6						
normal	0.924	0.976	0.983	0.896	0.938	0.990
osteopenia	0.931	0.934	0.844	0.972	0.914	0.970
osteoporosis	0.980	0.989	0.926	0.997	0.976	0.989
Model 7						
normal	0.959	0.904	0.936	0.938	0.921	0.983
osteopenia	0.807	0.940	0.836	0.928	0.866	0.940
osteoporosis	0.852	0.983	0.885	0.978	0.944	0.978
Model 8						
normal	0.920	0.970	0.978	0.890	0.935	0.992
osteopenia	0.922	0.923	0.823	0.968	0.904	0.973
osteoporosis	0.941	0.989	0.923	0.992	0.968	0.989
Model 8 external validation						
normal	0.879	0.983	0.966	0.938	0.946	0.986
osteopenia	0.873	0.898	0.802	0.937	0.890	0.930
osteoporosis	0.918	0.956	0.910	0.960	0.943	0.975

Note: AUC-area under the ROC curve; 95%CI-95 % confidence interval; Se-sensitivity; Sp-specificity; PPV- positive predictive value; NPV- negative predictive value; Ac- accuracy.

Appendix Table S5. Comparison of the efficacy of different models on the testing datasets

	normal	*Z*	*P*	osteopenia	*Z*	*P*	osteoporosis	*Z*	*P*
Model 1	0.991	0.225	0.822	0.966	0.974	0.330	**0.993**	0.923	**0.356**
Model 2	**0.995**	1.703	**0.089**	0.951	2.897	0.004	**0.993**	1.318	**0.187**
Model 3	0.991	0.207	0.836	0.961	1.129	0.259	0.987	1.235	0.217
Model 4	0.993	1.703	0.089	0.951	2.897	0.004	0.988	1.318	0.187
Model 5	0.986	1.688	0.091	0.948	3.071	0.002	0.986	1.142	0.254
Model 6	0.983	2.248	0.025	0.940	3.245	0.001	0.978	2.045	0.041
Model 7	0.990	0.924	0.356	0.970	0.623	0.533	0.989	0.046	0.963
Model 8	0.992			**0.973**			0.989		

Note: Bold show the highest value of each performance indicator.