$$F1score = \frac{2TP}{2TP + FP + FN} \tag{5}$$

where TP is a true-positive value, FP is a false-positive value, TN is a true-negative value and FN is a false-negative value.

Results

Tables 2 and 3 show the results of training VGG19 using the original and different enhanced versions of full X-ray images and of segmented versions respectively. As it is shown in Table 2, applying different image enhancement techniques has improved the performance of the classification model. The accuracy of classification for the model trained using the original images' version was 0.913, however, it has been improved for the enhanced versions to reach 0.94, 0.95, and 0.9475 for histeq, CLAHE, and complement respectively. The detailed results including TP, TN, FP, FN, sensitivity, specificity, precision, F1 score, test accuracy, and AUC of the proposed full X-ray images using VGG19 are shown in Table 2. The performance of the model trained using the CLAHE version is the best.

Regarding the segmented versions, as it is shown in Table 3 the accuracy of classification of the model trained using the original segmented dataset version was 0.887. However, the accuracy has been improved for the enhanced segmented dataset versions to reach 0.91 using Histeq techniques, 0.9049 for CLAHE and 0.9075 for the complement version. It is clear that the accuracies using different enhanced versions are close to each other, and they are better than that of the original segmented version. The detailed results using the different metrics are shown in Table 3.

Table 4 shows the results of training EfficientNetB0 using the original and different enhanced versions of full X-ray images. The accuracy of classification using the original full images' version was 0.915, it reached 0.94, 0.938, and 0.94 for histeq, CLAHE, and complement versions respectively. The accuracies for the models trained using different enhanced versions are better than that of the original version. The detailed results using the different metrics are shown in Table 4.

Regarding the segmented versions, as shown in Table 5 the accuracy of the classification for the Efficient-NetB0 model trained using the original segmented lung dataset version was 0.885. However, the accuracy has been improved to 0.905, 0.905, and 0.9075 for Histeq, CLAHE and complement versions respectively. As with VGG19, the accuracies of training EfficientNetB0 using different enhanced segmented versions are close to each other, but they are all better than that of the original segmented version. The detailed results using the different metrics are shown in Table 5.

It is clear that the performance of all enhanced versions is better than that of their associated original version using either VGG19 or EfficientNetB0 models and for both full and segmented versions. By comparing the results

Dataset	Tn	Fp	Tp	Fn	Sensitivity	Specificity	Precision	F1 score	Test acc	AUC
Original	170	30	195	5	0.975	0.85	0.8667	0.9176	0.913	0.9125
Histeq	192	8	184	16	0.92	0.96	0.9583	0.9388	0.94	0.94
CLAHE	188	12	192	8	0.96	0.94	0.9412	0.9505	0.95	0.95
Complement	187	13	192	8	0.96	0.935	0.93659	0.9482	0.9475	0.9475

Table 2. The results of applying VGG19 to original and different enhanced versions of the used dataset.

Dataset	Tn	Fp	Tp	Fn	Sensitivity	Specificity	Precision	F1 score	Test acc	AUC
Segmented original	157	43	198	2	0.99	0.785	0.8216	0.898	0.887	0.8875
Segmented Histeq	173	27	191	9	0.955	0.865	0.876	0.9139	0.91	0.91
Segmented CLAHE	173	27	189	11	0.945	0.865	0.875	0.9086	0.905	0.9049
Segmented complement	169	31	194	6	0.97	0.845	0.862	0.9129	0.908	0.9075

Table 3. The results of applying VGG19 to original and different enhanced versions of the used dataset after segmentation.

Dataset	Tn	Fp	Tp	Fn	Sensitivity	Specificity	Precision	F1 score	Test acc	AUC
Original	173	27	193	7	0.965	0.865	0.877	0.91905	0.915	0.915
Histeq	192	8	184	16	0.92	0.96	0.9583	0.9387	0.94	0.94
CLAHE	194	6	181	19	90.5	0.97	0.9679	0.9354	0.938	0.9375
Complement	193	7	183	17	0.915	0.965	0.963	0.9385	0.94	0.94

Table 4. The results of applying EfficientNetB0 to original and different enhanced versions of the used dataset.