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Supplementary Materials

Fully Automatic Segmentation of Phalanges from Hand Radiographs for Bone Age Assessment

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In the supplement we have included the remaining illustrations of proposed technique also the quantitative and qualitative segmentation results have been added. The manuscript has results of 10 images and supplement has the results of 9 images of ages 0, 2, 4, 6, 8, 11, 13, 15 and 17 years old people. Table S.1 shows PSNR, MSE, SSIM performance comparison of results after each stage of the proposed technique on hand radiographs of ages 3, 7, 14, 18 year old person. Figures S.1 to S.4 show the output images from each stage of the proposed technique on hand radiograph. Table S.2 shows the comparison between state-of-art segmentation techniques and proposed technique based on quality metrics mentioned in the manuscript. Figures S.5 to S.13 display the segmentation results of all techniques that are compared with proposed technique. Figure S.14 shows the segmentation results obtained for DRLSE method.

Table S.1: PSNR, MSE, SSIM performance comparison of results after each stage of the proposed technique on hand radiographs of ages 3, 7, 14 and 18 year old person.

Image	PROI	QM	Edge Preservation	Segmentation	Post-processing
3 year, [6102.jpg]	Pinky	PSNR	16.693	46.112	57.376
		MSE	1392.319	1.592	0.119
		SSIM	0.916	0.837	0.987
	Ring	PSNR	18.647	46.039	57.212
		MSE	888.021	1.619	0.124
		SSIM	0.858	0.833	0.986
	Middle	PSNR	18.863	46.304	64.221
		MSE	844.852	1.523	0.025
		SSIM	0.871	0.843	0.998
	Index	PSNR	17.190	46.112	65.572
		MSE	1241.8	1.592	0.018
		SSIM	0.837	0.834	0.999
	Thumb	PSNR	17.425	45.650	65.818
		MSE	1176.5	1.771	0.017
		SSIM	0.832	0.820	0.999
7 year, [5154.jpg]	Pinky	PSNR	23.866	45.775	65.116
		MSE	267.004	1.720	0.020
		SSIM	0.845	0.824	0.999
	Ring	PSNR	25.057	46.214	64.891
		MSE	202.937	1.555	0.021
		SSIM	0.861	0.843	0.999
	Middle	PSNR	24.545	46.216	61.627
		MSE	228.335	1.554	0.045
		SSIM	0.870	0.840	0.996
	Index	PSNR	22.682	46.035	62.830
		MSE	350.672	1.620	0.034
		SSIM	0.849	0.835	0.997
	Thumb	PSNR	24.512	45.929	63.811
		MSE	230.090	1.660	0.027
		SSIM	0.857	0.832	0.997
14 year, [5237.jpg]	Pinky	PSNR	19.816	45.942	61.967
		MSE	678.402	1.655	0.041
		SSIM	0.822	0.830	0.996
	Ring	PSNR	22.251	46.297	62.339
		MSE	387.279	1.525	0.038
		SSIM	0.872	0.841	0.996
	Middle	PSNR	21.531	47.001	60.341
		MSE	457.053	1.297	0.060
		SSIM	0.872	0.863	0.994
	Index	PSNR	22.528	45.979	61.937
		MSE	363.288	1.641	0.042
		SSIM	0.871	0.832	0.996
	Thumb	PSNR	20.738	46.671	61.562
		MSE	548.690	1.400	0.045
		SSIM	0.898	0.854	0.996
18 year, [6145.jpg]	Pinky	PSNR	27.044	46.433	58.816
		MSE	128.433	1.478	0.085
		SSIM	0.925	0.851	0.990
	Ring	PSNR	26.311	46.779	59.265
		MSE	152.057	1.365	0.077
		SSIM	0.693	0.859	0.991
	Middle	PSNR	25.843	47.258	62.643
		MSE	169.349	1.223	0.035
		SSIM	0.556	0.870	0.996
	Index	PSNR	24.679	47.064	63.519
		MSE	221.416	1.278	0.029
		SSIM	0.908	0.865	0.997
	Thumb	PSNR	26.531	46.920	63.740
		MSE	144.551	1.322	0.027
		SSIM	0.918	0.861	0.997

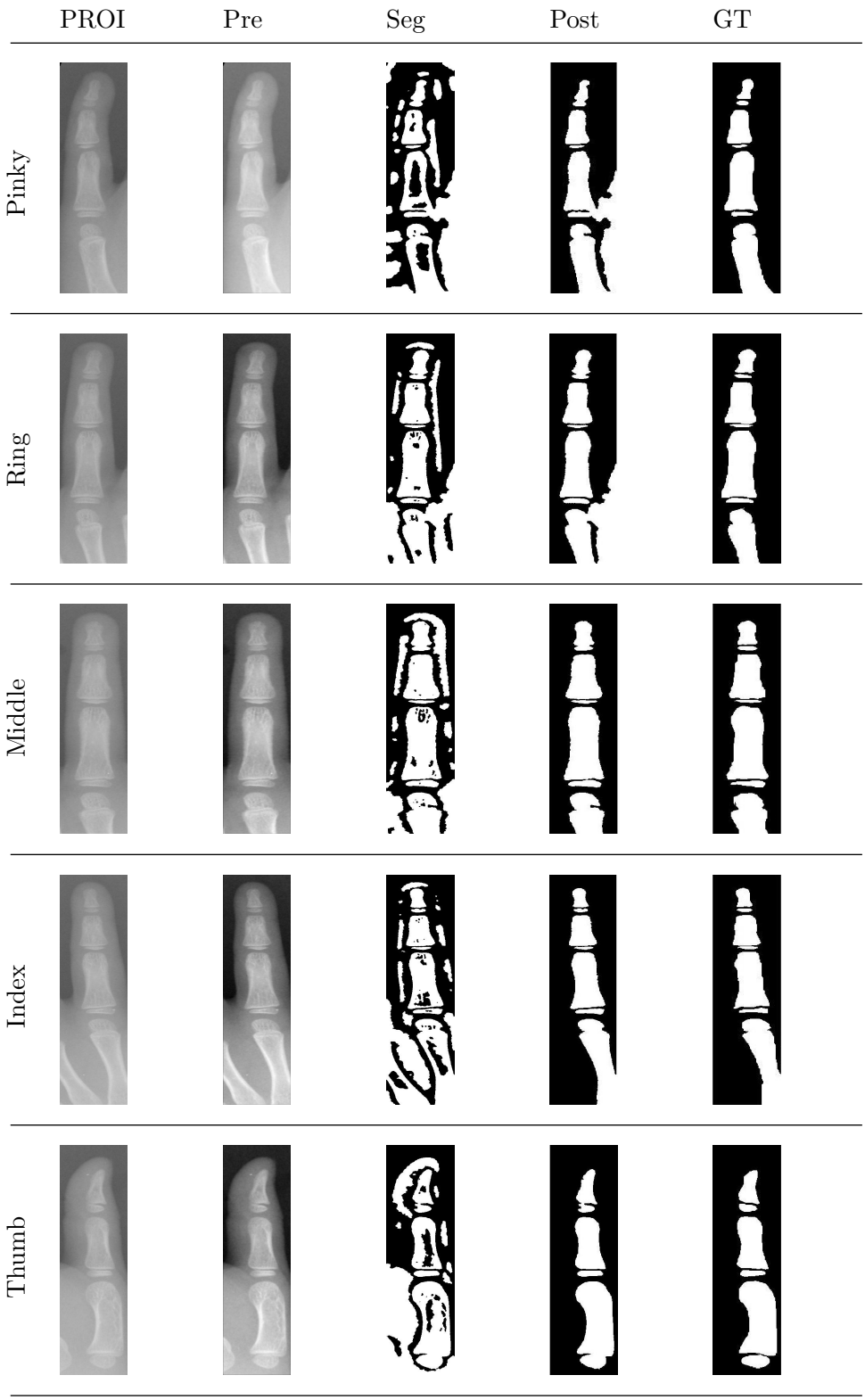

Figure S.1. Output images from each stage of the proposed technique on hand radiograph of 3 year old person [6102.jpg].

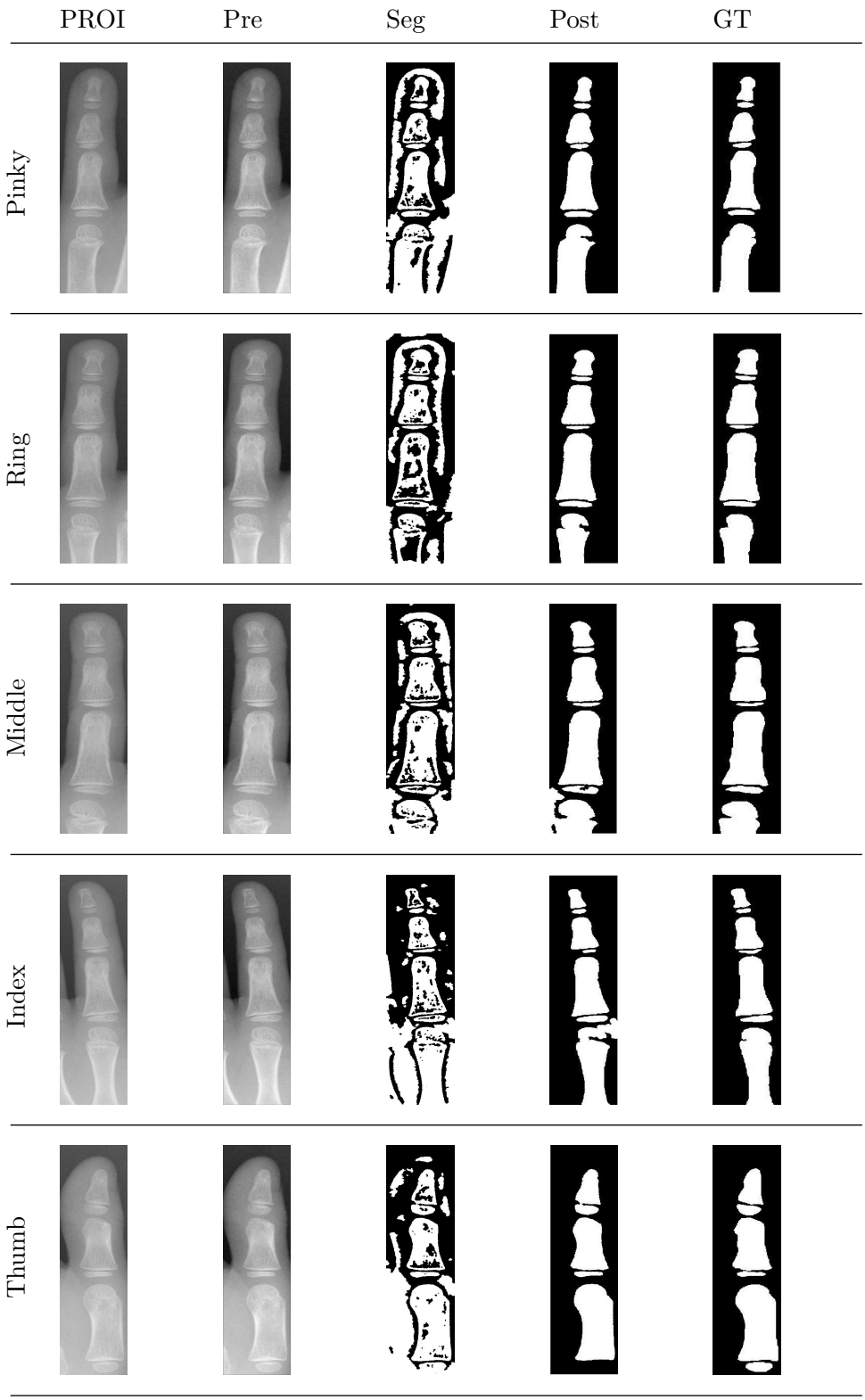

Figure S.2. Output images from each stage of the proposed technique on hand radiograph of 7 year old person [5154.jpg].

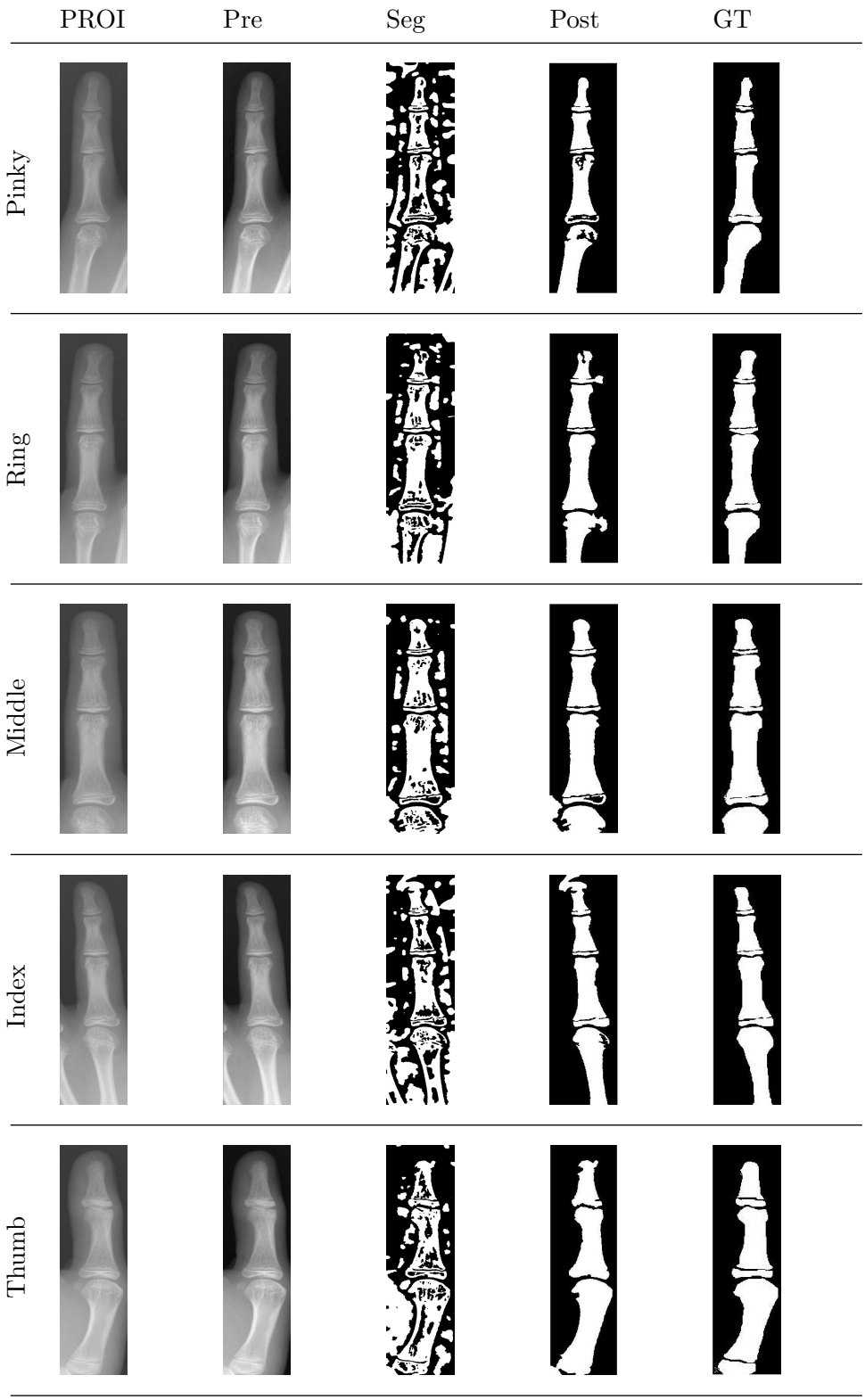

Figure S.3. Output images from each stage of the proposed technique on hand radiograph of 14 year old person [5237.jpg].

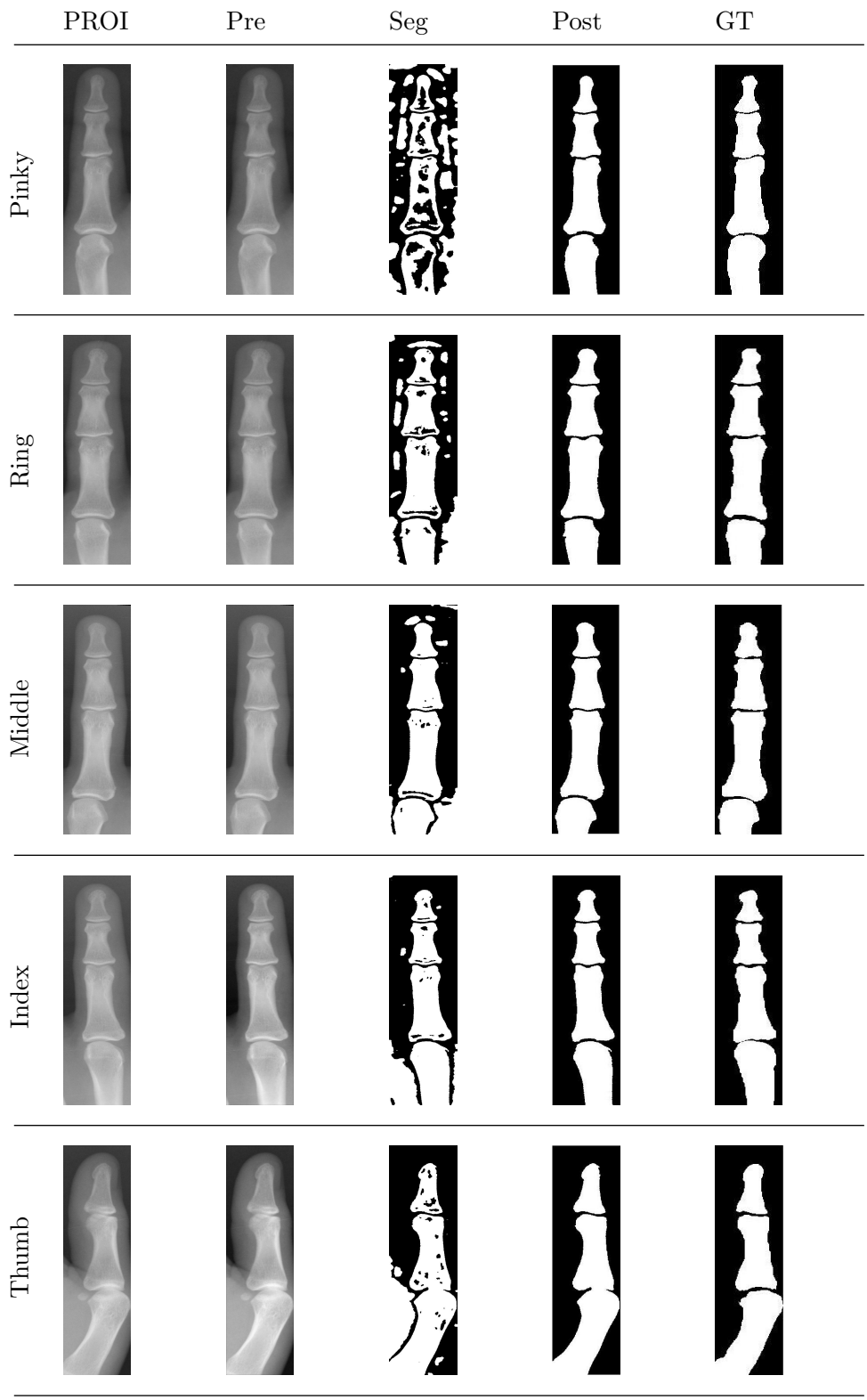

Figure S.4. Output images from each stage of the proposed technique on hand radiograph of 18 year old person [6145.jpg].

Table S.2: Performance comparison of different segmentation techniques on PROI

Image	QM	Otsu	KMS	KGRF	PSO	AKFM	BFV	PT
Under 1 year [5591.jpg]	SSIM	0.964	0.961	0.964	0.965	0.965	0.967	**0.999**
	JSI	0.425	0.390	0.423	0.416	0.408	0.435	**0.915**
	DICE	0.589	0.551	0.589	0.581	0.576	0.602	**0.956**
	ACC	0.712	0.695	0.712	0.708	0.704	0.718	**0.958**
	GM	0.740	0.716	0.748	0.738	0.727	0.741	**0.957**
	MCC	0.431	0.397	0.440	0.424	0.406	0.436	**0.916**
2 years [5588.jpg]	SSIM	0.969	0.970	0.969	0.971	0.968	0.969	**0.997**
	JSI	0.448	0.438	0.453	0.429	0.441	0.497	**0.883**
	DICE	0.613	0.607	0.618	0.594	0.609	0.664	**0.938**
	ACC	0.724	0.719	0.726	0.715	0.721	0.749	**0.941**
	GM	0.731	0.720	0.742	0.711	0.739	0.802	**0.940**
	MCC	0.436	0.442	0.454	0.412	0.448	0.552	**0.885**
4 years [5073.jpg]	SSIM	0.975	0.975	0.975	0.976	0.975	0.964	**0.998**
	JSI	0.541	0.541	0.536	0.533	0.500	0.469	**0.885**
	DICE	0.700	0.701	0.696	0.693	0.663	0.638	**0.939**
	ACC	0.771	0.771	0.768	0.766	0.750	0.734	**0.942**
	GM	0.801	0.801	0.804	0.797	0.767	0.807	**0.941**
	MCC	0.563	0.564	0.566	0.555	0.517	0.552	**0.886**
6 years [5056.jpg]	SSIM	0.972	0.973	0.973	0.973	0.973	0.958	**0.998**
	JSI	0.523	0.518	0.518	0.514	0.503	0.442	**0.914**
	DICE	0.684	0.678	0.680	0.676	0.665	0.611	**0.955**
	ACC	0.762	0.759	0.759	0.757	0.752	0.721	**0.957**
	GM	0.801	0.789	0.798	0.796	0.780	0.801	**0.956**
	MCC	0.557	0.538	0.552	0.546	0.524	0.531	**0.914**
8 years [3806.jpg]	SSIM	0.976	0.977	0.976	0.977	0.975	0.966	**0.998**
	JSI	0.589	0.579	0.585	0.585	0.512	0.533	**0.906**
	DICE	0.740	0.731	0.737	0.736	0.664	0.694	**0.951**
	ACC	0.794	0.789	0.793	0.792	0.756	0.766	**0.953**
	GM	0.814	0.797	0.816	0.814	0.740	0.825	**0.952**
	MCC	0.599	0.574	0.600	0.597	0.502	0.601	**0.907**
11 years [5387.jpg]	SSIM	0.978	0.978	0.977	0.978	0.977	0.968	**0.997**
	JSI	0.596	0.594	0.594	0.590	0.567	0.531	**0.881**
	DICE	0.743	0.741	0.742	0.738	0.720	0.693	**0.936**
	ACC	0.798	0.797	0.797	0.795	0.809	0.766	**0.941**
	GM	0.817	0.815	0.822	0.815	0.797	0.825	**0.939**
	MCC	0.605	0.602	0.613	0.600	0.583	0.600	**0.883**
13 years [4502.jpg]	SSIM	0.967	0.968	0.967	0.968	0.969	0.964	**0.998**
	JSI	0.478	0.412	0.478	0.474	0.395	0.495	**0.904**
	DICE	0.644	0.575	0.644	0.639	0.553	0.660	**0.950**
	ACC	0.739	0.706	0.739	0.737	0.697	0.748	**0.952**
	GM	0.760	0.677	0.765	0.758	0.660	0.809	**0.951**
	MCC	0.480	0.363	0.487	0.475	0.347	0.562	**0.905**
15 years [4116.jpg]	SSIM	0.978	0.976	0.978	0.978	0.968	0.977	**0.997**
	JSI	0.669	0.672	0.661	0.660	0.602	0.686	**0.920**
	DICE	0.799	0.801	0.793	0.793	0.750	0.807	**0.958**
	ACC	0.834	0.836	0.830	0.830	0.801	0.843	**0.960**
	GM	0.846	0.862	0.843	0.842	0.838	0.864	**0.959**
	MCC	0.674	0.700	0.667	0.665	0.642	0.706	**0.921**
17 years [5581.jpg]	SSIM	0.983	0.983	0.984	0.984	0.982	0.970	**0.998**
	JSI	0.643	0.655	0.650	0.641	0.648	0.566	**0.918**
	DICE	0.778	0.788	0.782	0.776	0.781	0.722	**0.957**
	ACC	0.822	0.827	0.825	0.821	0.824	0.783	**0.959**
	GM	0.821	0.827	0.813	0.816	0.833	0.835	**0.958**
	MCC	0.643	0.652	0.639	0.637	0.657	0.628	**0.918**

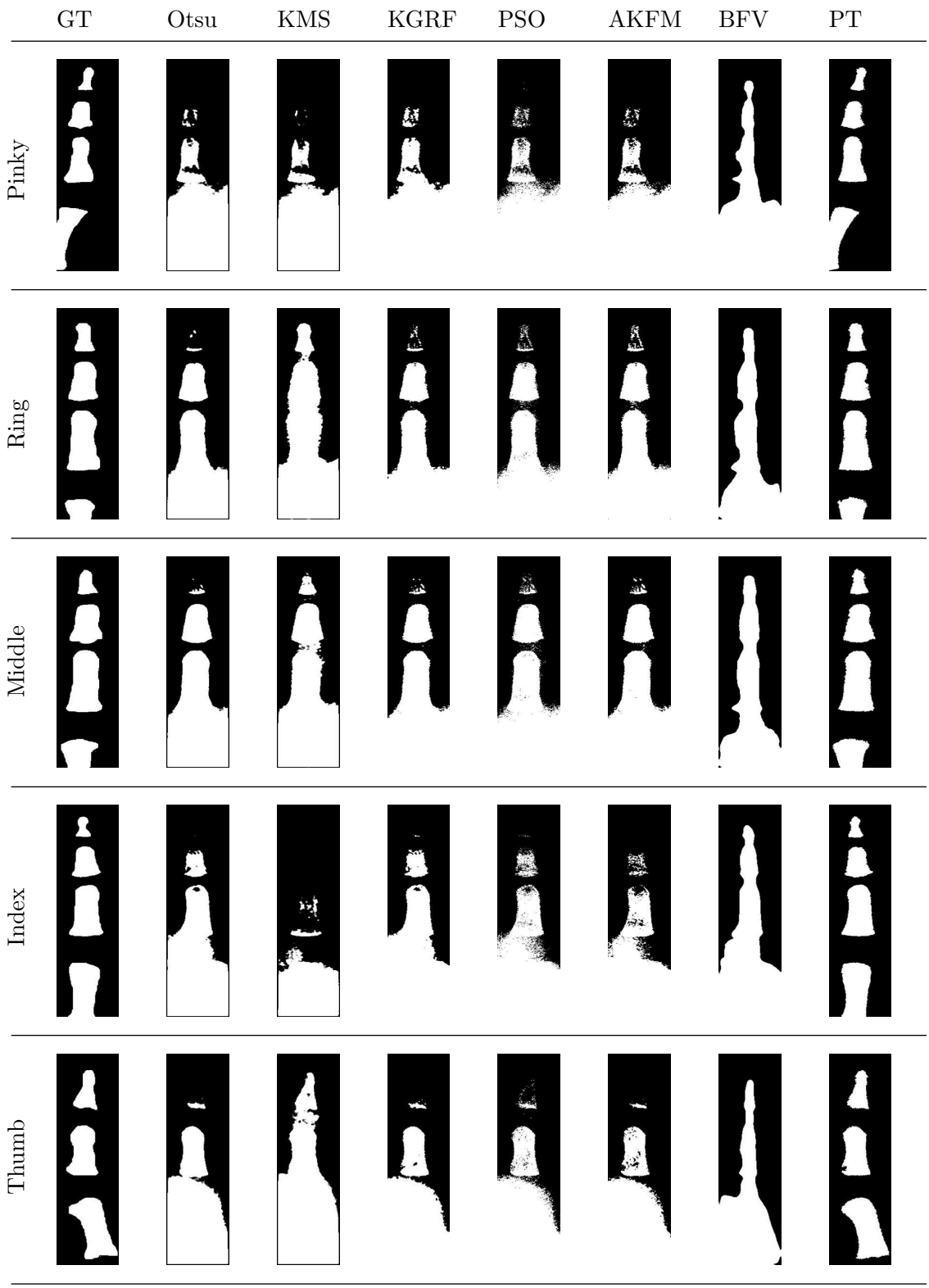

Figure S.5. Segmentation results of different algorithms on hand radiograph taken from person under one year old [5591.jpg].

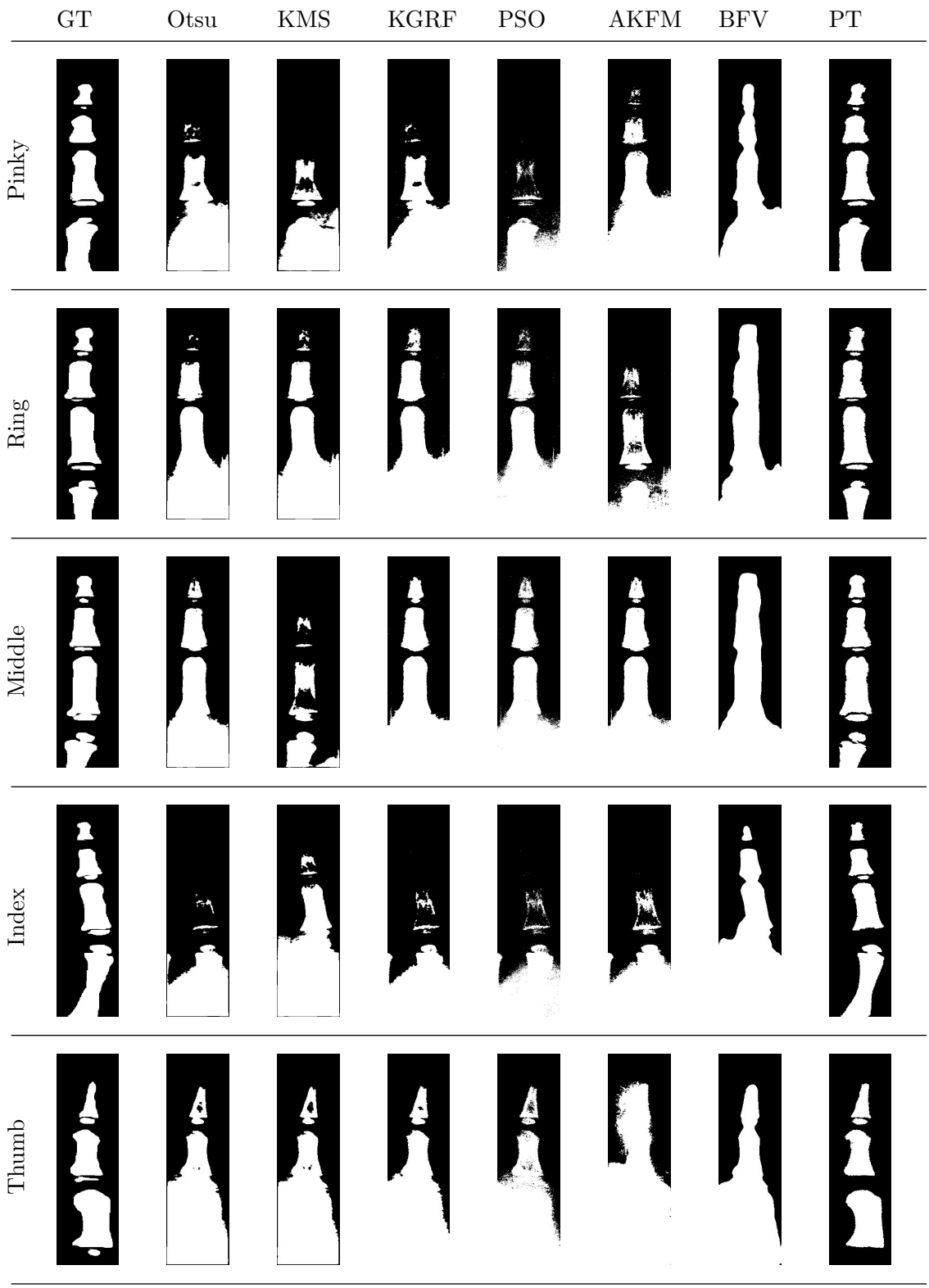

Figure S.6. Segmentation results of different algorithms on hand radiograph taken from 2 year old person [5588.jpg].

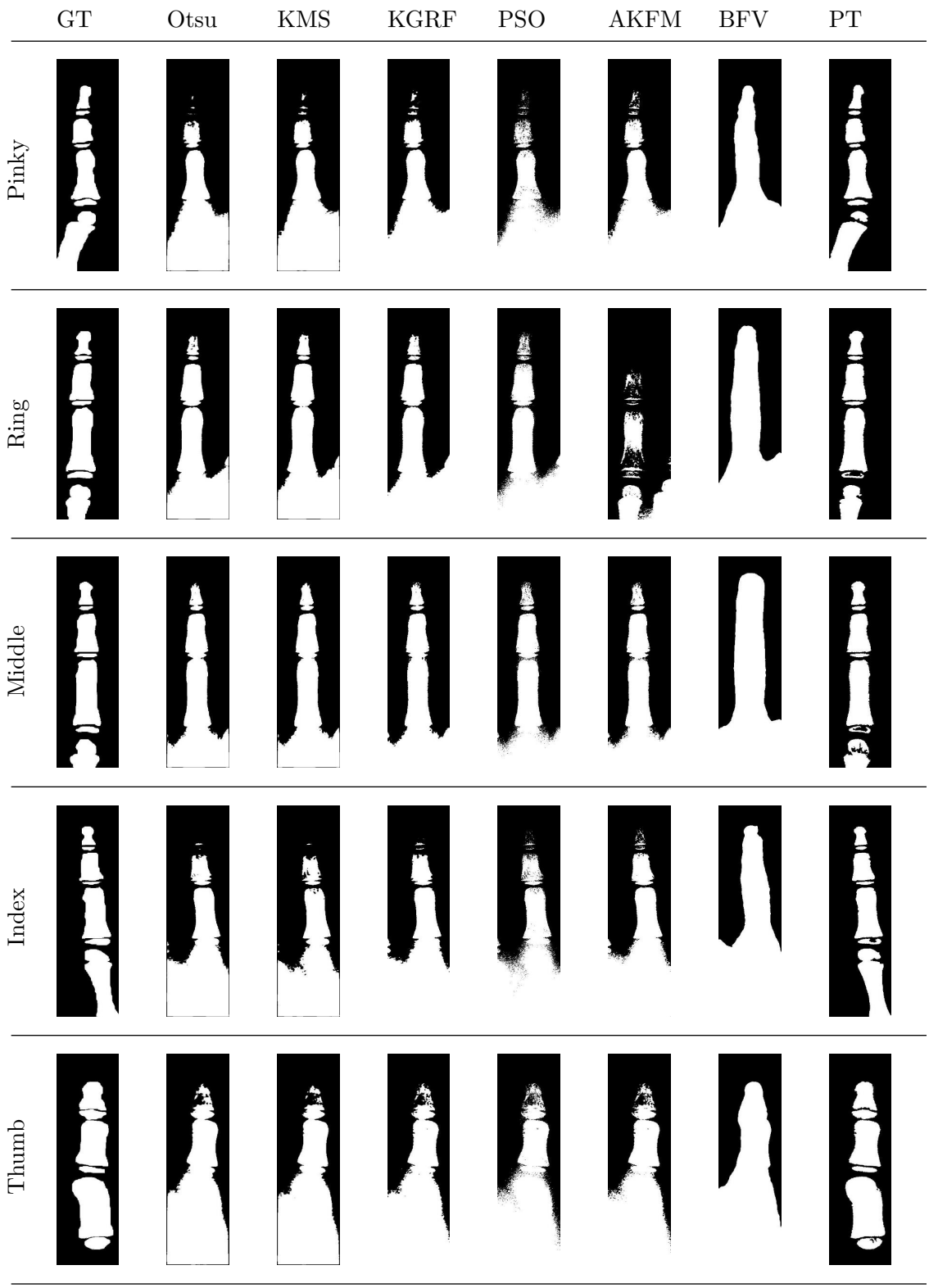

Figure S.7. Segmentation results of different algorithms on hand radiograph taken from 4 year old person [5073.jpg].

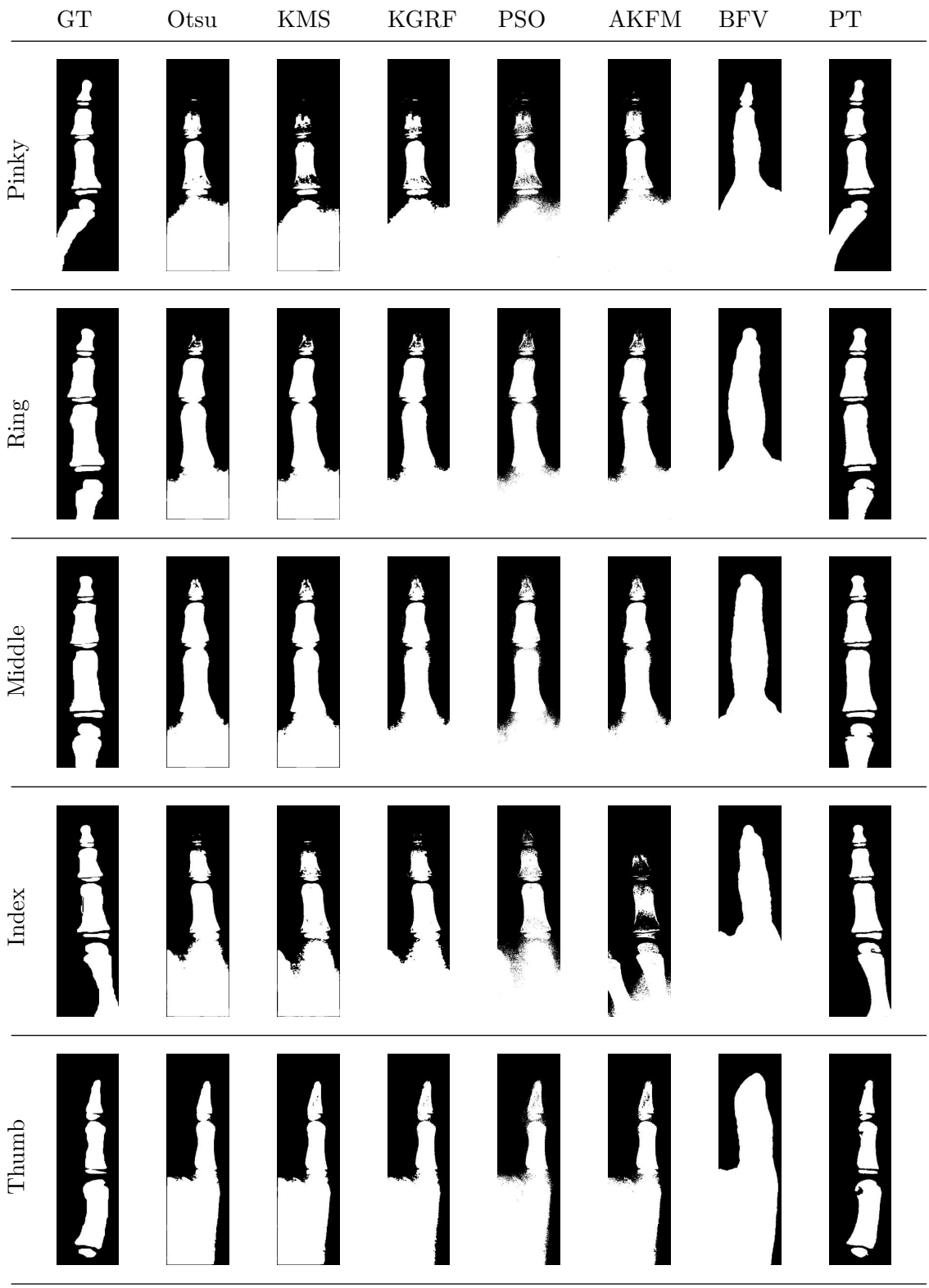

Figure S.8. Segmentation results of different algorithms on hand radiograph taken from 6 year old person [5056.jpg].

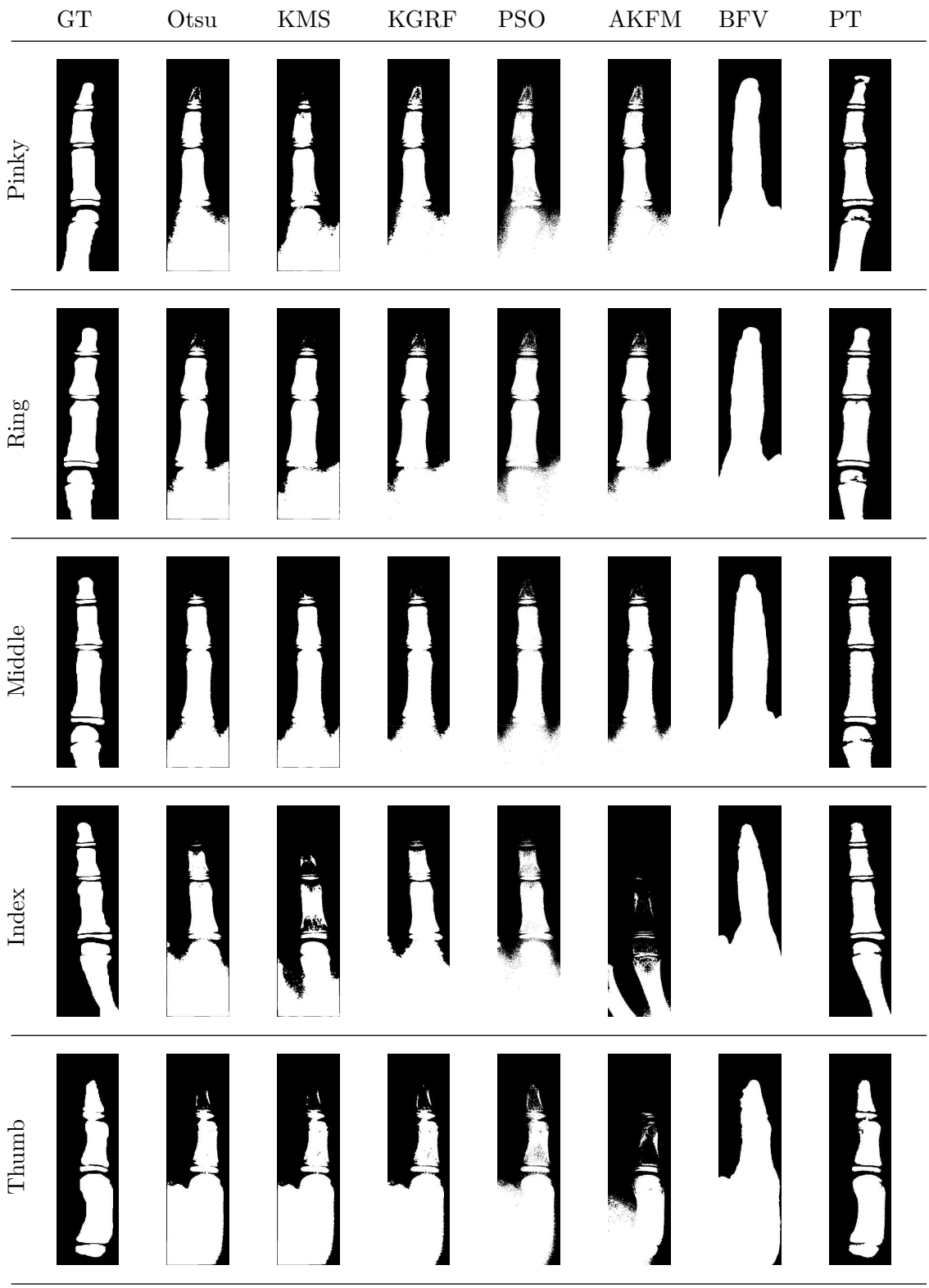

Figure S.9. Segmentation results of different algorithms on hand radiograph taken from 8 year old person [3806.jpg].

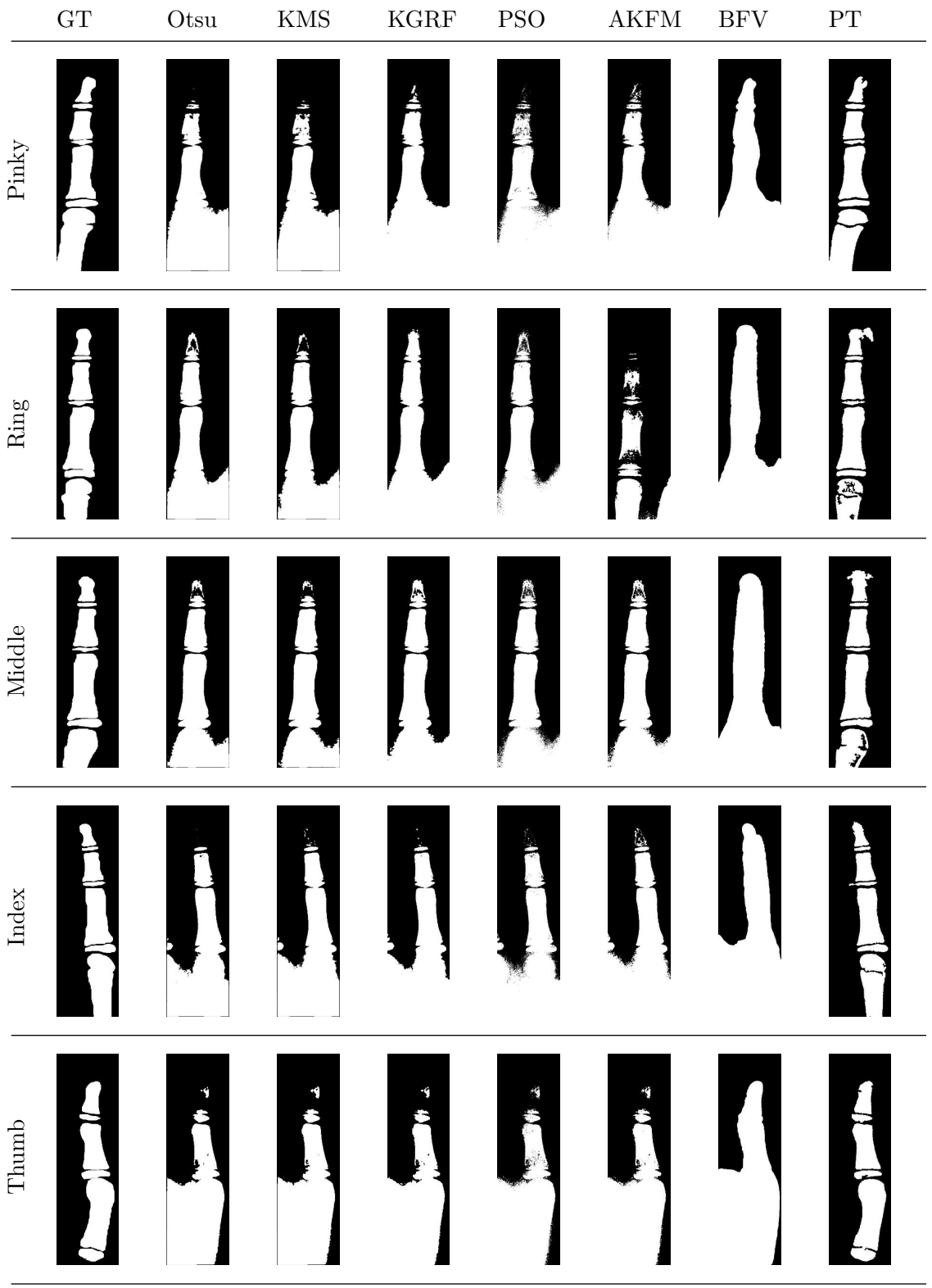

Figure S.10. Segmentation results of different algorithms on hand radiograph taken from 11 year old person [5387.jpg].

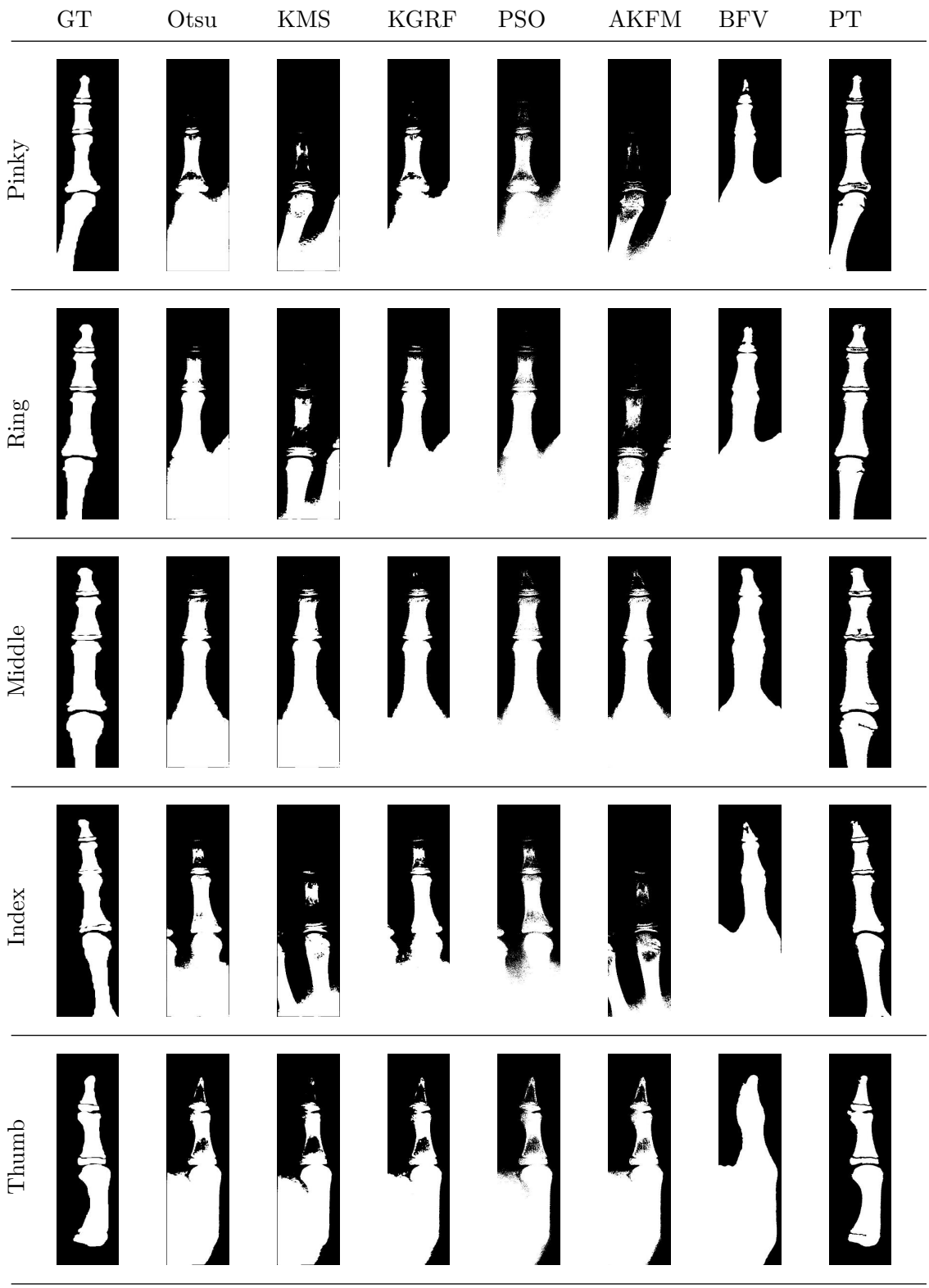

Figure S.11. Segmentation results of different algorithms on hand radiograph taken from 13 year old person [4502.jpg].

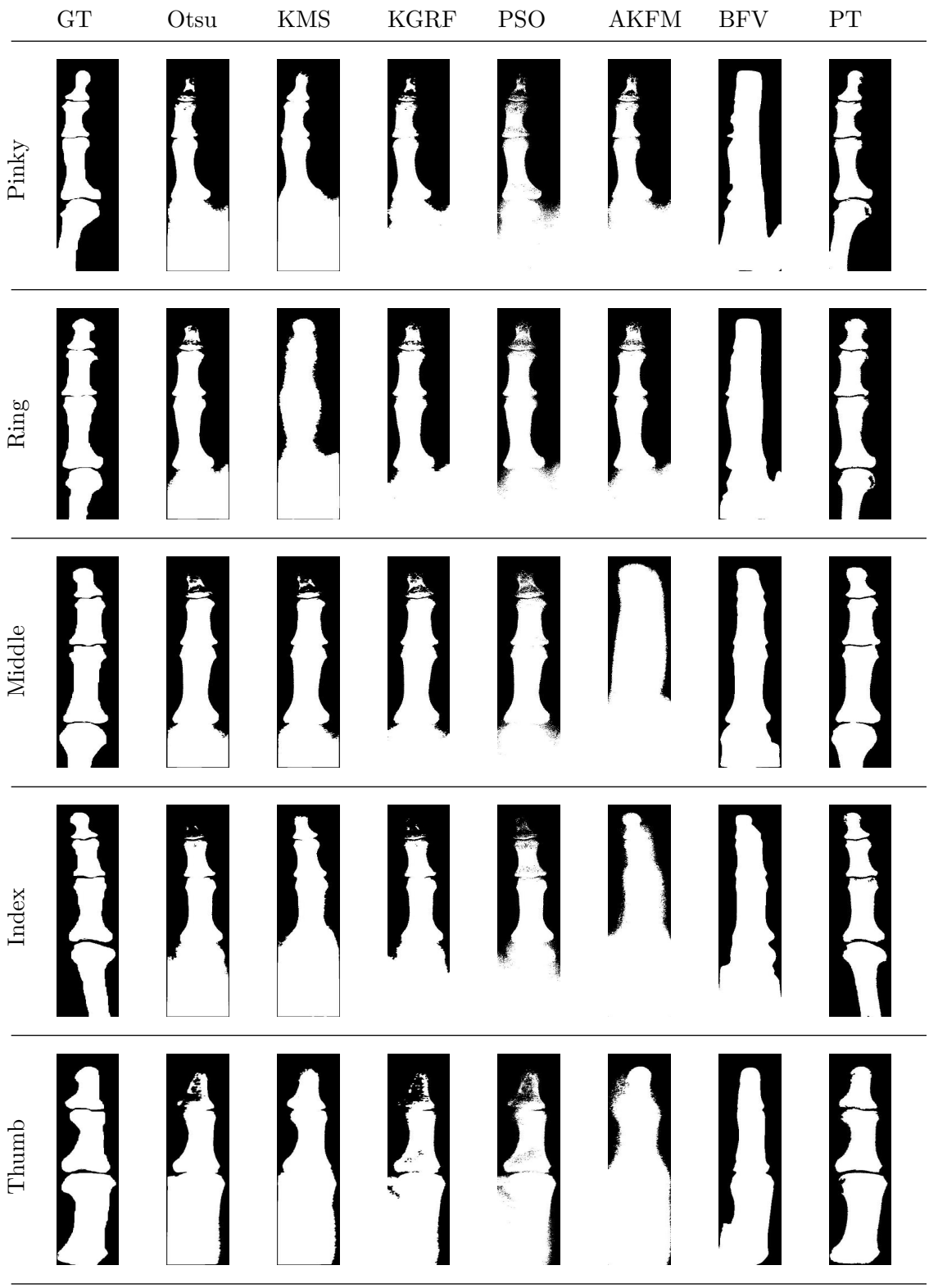

Figure S.12. Segmentation results of different algorithms on hand radiograph taken from 15 year old person [4116.jpg].

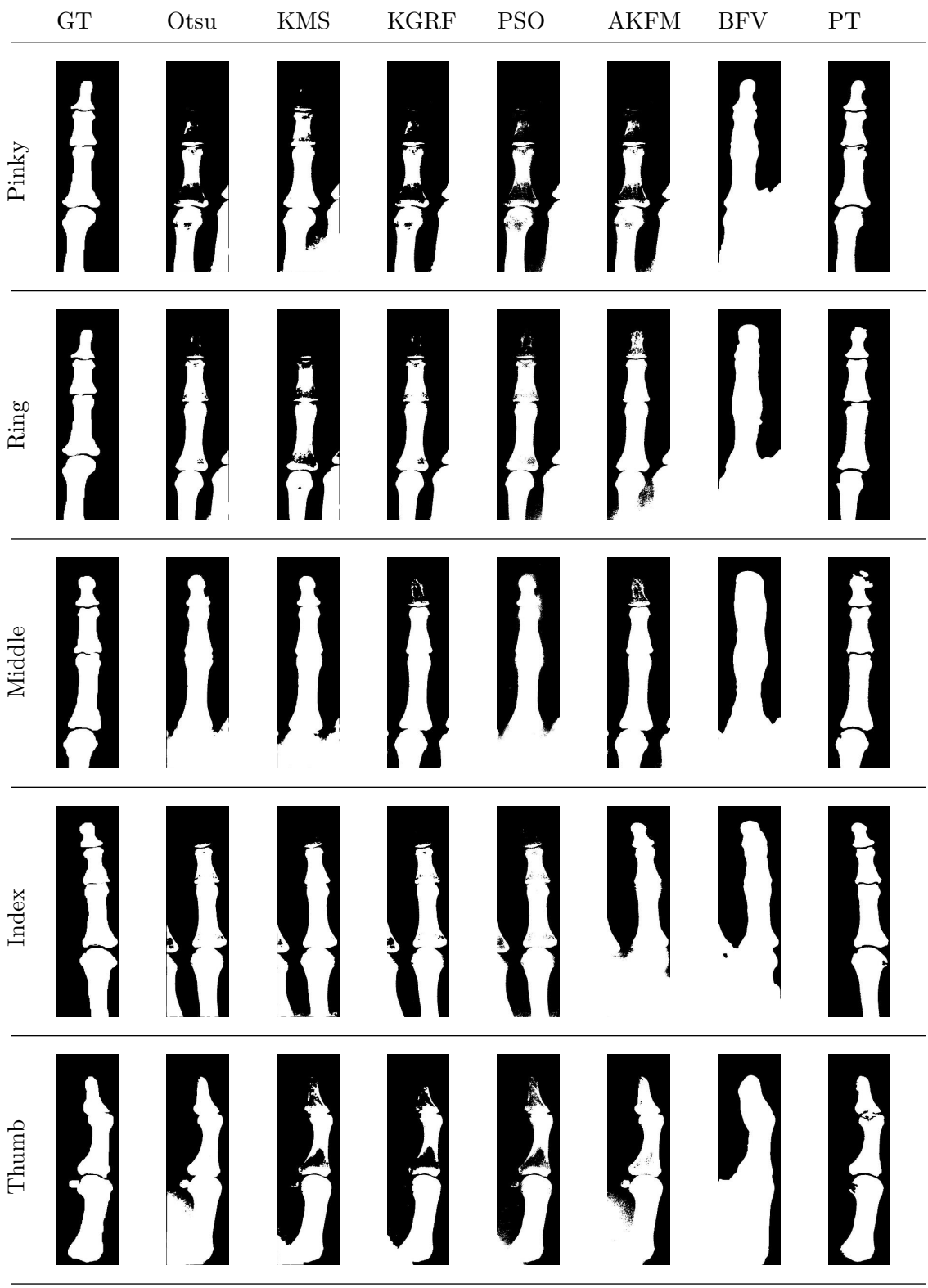

Figure S.13. Segmentation results of different algorithms on hand radiograph taken from 17 year old person [5581.jpg].