

# **Discovery of stable and prognostic CT-based radiomic features independent of contrast administration and dimensionality in oesophageal cancer**

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## **Supplementary Information**

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**Table. List of 2D and 3D radiomic features that showed to be stable when extracted from the mixed, the contrast and the non-contrast group.** GLCM, grey level co-occurrence matrix; GLRLM, grey level run length matrix; GLSZM, grey level size zone matrix; GLDZM, grey level distance zone matrix; NGTDM, neighbourhood grey tone difference matrix; \*, feature computed with merging.

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
GLCM	Joint maximum <sub>2D</sub>	no	yes	yes
	Joint maximum <sub>3D</sub>	no	yes	yes
	Joint maximum <sub>2D</sub> *	no	yes	yes
	Joint maximum <sub>3D</sub> *	no	yes	yes
	Joint average <sub>2D</sub>	no	yes	yes
	Joint average <sub>3D</sub>	no	yes	yes
	Joint average <sub>2D</sub> *	no	yes	yes
	Joint average <sub>3D</sub> *	no	yes	yes
	Joint variance <sub>2D</sub>	yes	yes	yes
	Joint variance <sub>3D</sub>	yes	yes	yes
	Joint variance <sub>2D</sub> *	yes	yes	yes
	Joint variance <sub>3D</sub> *	yes	yes	yes
	Joint entropy <sub>2D</sub>	yes	yes	yes
	Joint entropy <sub>3D</sub>	yes	yes	yes
	Joint entropy <sub>2D</sub> *	yes	yes	yes
	Joint entropy <sub>3D</sub> *	yes	yes	yes
	Difference average <sub>2D</sub>	yes	yes	yes
	Difference average <sub>3D</sub>	yes	yes	yes
	Difference average <sub>2D</sub> *	yes	yes	yes
	Difference average <sub>3D</sub> *	yes	yes	yes
Difference variance <sub>2D</sub>	yes	yes	yes	
Difference variance <sub>3D</sub> *	yes	yes	yes	
Difference entropy <sub>2D</sub>	yes	yes	yes	

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
	Difference entropy <sub>3D</sub>	yes	yes	yes
	Difference entropy <sub>2D</sub> *	yes	yes	yes
	Difference entropy <sub>3D</sub> *	yes	yes	yes
	Sum average <sub>2D</sub>	no	yes	yes
	Sum average <sub>3D</sub>	no	yes	yes
	Sum average <sub>2D</sub> *	no	yes	yes
	Sum average <sub>3D</sub> *	no	yes	yes
	Sum variance <sub>2D</sub>	yes	yes	yes
	Sum variance <sub>3D</sub>	yes	yes	yes
	Sum variance <sub>2D</sub> *	yes	yes	yes
	Sum variance <sub>3D</sub> *	yes	yes	yes
GLCM	Sum entropy <sub>2D</sub>	yes	yes	yes
	Sum entropy <sub>3D</sub>	yes	yes	yes
	Sum entropy <sub>2D</sub> *	yes	yes	yes
	Sum entropy <sub>3D</sub> *	yes	yes	yes
	Angular second moment <sub>2D</sub>	no	yes	yes
	Angular second moment <sub>3D</sub>	no	yes	yes
	Angular second moment <sub>2D</sub> *	no	yes	yes
	Angular second moment <sub>3D</sub> *	no	yes	yes
	Contrast <sub>2D</sub>	yes	yes	yes
	Contrast <sub>3D</sub>	yes	yes	yes
	Contrast <sub>2D</sub> *	yes	yes	yes
	Contrast <sub>3D</sub> *	yes	yes	yes

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
	Dissimilarity <sub>2D</sub>	yes	yes	yes
	Dissimilarity <sub>3D</sub>	yes	yes	yes
	Dissimilarity <sub>2D</sub> *	yes	yes	yes
	Dissimilarity <sub>3D</sub> *	yes	yes	yes
	Inverse difference <sub>2D</sub>	no	yes	yes
	Inverse difference <sub>3D</sub>	no	yes	yes
	Inverse difference <sub>2D</sub> *	no	yes	yes
	Inverse difference <sub>3D</sub> *	no	yes	yes
	Inverse difference norm <sub>2D</sub>	yes	yes	yes
	Inverse difference norm <sub>3D</sub>	yes	yes	yes
	Inverse difference norm <sub>2D</sub> *	yes	yes	yes
GLCM	Inverse difference norm <sub>3D</sub> *	yes	yes	yes
	Inverse diff moment <sub>2D</sub>	no	yes	yes
	Inverse diff moment <sub>3D</sub>	no	yes	yes
	Inverse diff moment <sub>2D</sub> *	no	yes	yes
	Inverse diff moment <sub>3D</sub> *	no	yes	yes
	Inverse diff moment norm <sub>2D</sub>	yes	yes	yes
	Inverse diff moment norm <sub>3D</sub>	yes	yes	yes
	Inverse diff moment norm <sub>2D</sub> *	yes	yes	yes
	Inverse diff moment norm <sub>3D</sub> *	yes	yes	yes
	Inverse invariance <sub>2D</sub>	yes	yes	yes
	Inverse invariance <sub>3D</sub>	yes	yes	yes
	Inverse variance <sub>2D</sub> *	yes	yes	yes

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
GLCM	Inverse variance <sub>3D</sub> *	yes	yes	yes
	Autocorrelation <sub>2D</sub>	no	yes	yes
	Autocorrelation <sub>3D</sub>	no	yes	yes
	Autocorrelation <sub>2D</sub> *	no	yes	yes
	Autocorrelation <sub>3D</sub> *	no	yes	yes
	Correlation <sub>2D</sub>	yes	yes	yes
	Correlation <sub>3D</sub>	yes	yes	yes
	Correlation <sub>2D</sub> *	yes	yes	yes
	Correlation <sub>3D</sub> *	yes	yes	yes
	Cluster tendency <sub>2D</sub>	yes	yes	yes
	Cluster tendency <sub>3D</sub>	yes	yes	yes
	Cluster tendency <sub>2D</sub> *	yes	yes	yes
	Cluster tendency <sub>3D</sub> *	yes	yes	yes
	Cluster shade <sub>2D</sub>	yes	yes	yes
	Cluster shade <sub>3D</sub>	yes	yes	yes
	Cluster shade <sub>2D</sub> *	yes	yes	yes
	Cluster shade <sub>3D</sub> *	yes	yes	yes
	Cluster prominence <sub>2D</sub>	yes	yes	yes
	Cluster prominence <sub>3D</sub>	yes	yes	yes
	Cluster prominence <sub>2D</sub> *	yes	yes	yes
Cluster prominence <sub>3D</sub> *	yes	yes	yes	
Info correlation 1 <sub>2D</sub>	yes	yes	yes	
Info correlation 1 <sub>3D</sub>	yes	yes	yes	

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
GLCM	Info correlation $1_{2D}^*$	yes	yes	yes
	Info correlation $1_{3D}^*$	yes	yes	yes
	Info correlation $2_{2D}$	yes	yes	yes
	Info correlation $2_{3D}$	yes	yes	yes
	Info correlation $2_{2D}^*$	yes	yes	yes
	Info correlation $2_{3D}^*$	yes	yes	yes
GLRL	Short run emp $_{2D}$	no	yes	yes
	Short run emp $_{3D}$	no	yes	yes
	Short run emp $_{2D}^*$	no	yes	yes
	Short run emp $_{3D}^*$	no	yes	yes
	Long run emp $_{2D}$	no	yes	yes
	Long run emp $_{3D}$	no	yes	yes
	Long run emp $_{2D}^*$	no	yes	yes
	Long run emp $_{3D}^*$	no	yes	yes
	Low GL run emp $_{2D}$	no	yes	yes
	Low GL run emp $_{3D}$	no	yes	yes
	Low GL run emp $_{2D}^*$	yes	yes	yes
	Low GL run emp $_{3D}^*$	no	yes	yes
	High GL run emp $_{2D}$	no	yes	yes
	High GL run emp $_{3D}$	no	yes	yes
	High GL run emp $_{2D}^*$	no	yes	yes
High GL run emp $_{3D}^*$	no	yes	yes	
Short run low GL emp $_{2D}$	yes	yes	yes	

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
	Short run low GL emp <sub>3D</sub>	yes	yes	yes
	Short run low GL emp <sub>2D</sub> *	yes	yes	yes
	Short run low GL emp <sub>3D</sub> *	yes	yes	yes
	Short run high GL emp <sub>2D</sub>	no	yes	yes
	Short run high GL emp <sub>3D</sub>	no	yes	no
	Short run high GL emp <sub>2D</sub> *	no	yes	no
	Short run high GL emp <sub>3D</sub> *	no	yes	no
	Long run low GL emp <sub>2D</sub>	no	yes	yes
	Long run low GL emp <sub>3D</sub>	no	yes	yes
	Long run low GL emp <sub>2D</sub> *	no	yes	yes
	Long run low GL emp <sub>3D</sub> *	no	yes	yes
GLRL	Long run high GL emp <sub>2D</sub>	yes	yes	yes
	Long run high GL emp <sub>3D</sub>	yes	yes	yes
	Long run high GL emp <sub>2D</sub> *	yes	yes	yes
	Long run high GL emp <sub>3D</sub> *	yes	yes	yes
	GL non uniformity <sub>2D</sub>	yes	yes	yes
	GL non uniformity <sub>3D</sub>	yes	yes	yes
	GL non uniformity <sub>2D</sub> *	yes	yes	yes
	GL non uniformity <sub>3D</sub> *	yes	yes	yes
	GL non uniformity norm <sub>2D</sub>	yes	yes	yes
	GL non uniformity norm <sub>3D</sub>	yes	yes	yes
	GL non uniformity norm <sub>2D</sub> *	yes	yes	yes
	GL non uniformity norm <sub>2D</sub> *	yes	yes	yes

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
	RL non uniformity <sub>2D</sub>	yes	yes	yes
	RL non uniformity <sub>3D</sub>	yes	yes	yes
	RL non uniformity <sub>2D</sub> *	yes	yes	yes
	RL non uniformity <sub>3D</sub> *	yes	yes	yes
	RL non uniformity norm <sub>2D</sub>	no	yes	yes
	RL non uniformity norm <sub>3D</sub>	no	yes	yes
	RL non uniformity norm <sub>2D</sub> *	no	yes	yes
	RL non uniformity norm <sub>3D</sub> *	no	yes	yes
	Run percentage <sub>2D</sub>	no	yes	yes
	Run percentage <sub>3D</sub>	no	yes	yes
	Run percentage <sub>2D</sub> *	no	yes	yes
GLRL	Run percentage <sub>3D</sub> *	no	yes	yes
	GL variance <sub>2D</sub>	yes	yes	yes
	GL variance <sub>3D</sub>	yes	yes	yes
	GL variance <sub>2D</sub> *	yes	yes	yes
	GL variance <sub>3D</sub> *	yes	yes	yes
	RL variance <sub>2D</sub>	no	yes	yes
	RL variance <sub>3D</sub>	no	yes	yes
	RL variance <sub>2D</sub> *	no	yes	yes
	RL variance <sub>3D</sub> *	no	yes	yes
	Run entropy <sub>2D</sub>	yes	yes	yes
	Run entropy <sub>3D</sub>	yes	yes	yes
	Run entropy <sub>2D</sub> *	yes	yes	yes



Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
GLRL	Run entropy <sub>3D</sub> *	yes	yes	yes
	Small zone emphasis <sub>2D</sub>	yes	yes	yes
	Small zone emphasis <sub>3D</sub>	no	yes	yes
	Large zone emphasis <sub>2D</sub>	no	yes	yes
	Large zone emphasis <sub>3D</sub>	no	yes	yes
	Low GL zone emphasis <sub>2D</sub>	yes	yes	yes
	Low GL zone emphasis <sub>3D</sub>	yes	yes	yes
	High GL zone emphasis <sub>2D</sub>	no	yes	yes
	High GL zone emphasis <sub>3D</sub>	no	yes	no
	Small zone low GL emphasis <sub>2D</sub>	yes	yes	yes
	Small zone low GL emphasis <sub>3D</sub>	yes	yes	yes
GLSZM	Small zone high GL emphasis <sub>2D</sub>	no	yes	yes
	Small zone high GL emphasis <sub>3D</sub>	no	yes	yes
	Large zone low GL emphasis <sub>2D</sub>	no	yes	yes
	Large zone low GL emphasis <sub>3D</sub>	no	yes	yes
	Large zone high GL emphasis <sub>2D</sub>	yes	yes	yes
	Large zone high GL emphasis <sub>3D</sub>	yes	yes	yes
	GL non uniformity <sub>2D</sub>	yes	yes	yes
	GL non uniformity <sub>3D</sub>	yes	no	yes
	GL non uniformity norm <sub>2D</sub>	yes	yes	yes
	GL non uniformity norm <sub>3D</sub>	yes	yes	yes
	Zone size non uniformity <sub>2D</sub>	yes	yes	yes
	Zone size non uniformity <sub>3D</sub>	yes	yes	yes

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
GLSZM	Size zone non uniformity norm <sub>2D</sub>	yes	yes	yes
	Size zone non uniformity norm <sub>3D</sub>	no	yes	yes
	Zone percentage <sub>2D</sub>	no	yes	yes
	Zone percentage <sub>3D</sub>	yes	yes	yes
	GL variance <sub>2D</sub>	yes	yes	yes
	GL variance <sub>3D</sub>	yes	yes	yes
	Zone size variance <sub>2D</sub>	no	yes	yes
	Zone size variance <sub>3D</sub>	no	yes	yes
	Zone size entropy <sub>2D</sub>	yes	yes	yes
	Zone size entropy <sub>3D</sub>	yes	yes	yes
GLDZM	Small distance emphasis <sub>2D</sub>	yes	yes	yes
	Small distance emphasis <sub>3D</sub>	yes	yes	yes
	Large distance emphasis <sub>2D</sub>	yes	yes	yes
	Large distance emphasis <sub>3D</sub>	yes	yes	yes
	Low grey level zone emphasis <sub>2D</sub>	yes	yes	yes
	Low grey level zone emphasis <sub>3D</sub>	yes	yes	yes
	High grey level zone emphasis <sub>2D</sub>	no	yes	yes
	High grey level zone emphasis <sub>3D</sub>	no	yes	no
	Small distance low grey L Emphasis <sub>2D</sub>	yes	yes	yes
	Small distance low grey L Emphasis <sub>3D</sub>	yes	yes	yes
	Small distance high grey L Emphasis <sub>2D</sub>	yes	yes	yes
	Small distance high grey L Emphasis <sub>3D</sub>	no	yes	no
Large distance low grey L Emphasis <sub>2D</sub>	yes	yes	yes	

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
	Large distance low grey L Emphasis <sub>3D</sub>	yes	yes	yes
	Large distance high grey L Emphasis <sub>2D</sub>	yes	yes	yes
	Large distance high grey L Emphasis <sub>3D</sub>	yes	yes	yes
	Grey level non uniformity <sub>2D</sub>	yes	yes	yes
	Grey level non uniformity <sub>3D</sub>	yes	no	yes
	Grey level non uniformity norm <sub>2D</sub>	yes	yes	yes
	Grey level non uniformity norm <sub>3D</sub>	yes	yes	yes
	Zone distance non uniformity <sub>2D</sub>	yes	yes	yes
	Zone distance non uniformity <sub>3D</sub>	yes	no	yes
GLDZM	Zone distance non uniformity norm <sub>2D</sub>	yes	yes	yes
	Zone distance non uniformity norm <sub>3D</sub>	yes	yes	yes
	Zone percentage <sub>2D</sub>	no	yes	yes
	Zone percentage <sub>3D</sub>	yes	yes	yes
	Grey level variance <sub>2D</sub>	yes	yes	yes
	Grey level variance <sub>3D</sub>	yes	yes	yes
	Zone distance variance <sub>2D</sub>	yes	yes	yes
	Zone distance variance <sub>3D</sub>	yes	yes	yes
	Zone distance entropy <sub>2D</sub>	yes	yes	yes
	Zone distance entropy <sub>3D</sub>	yes	yes	yes
	Coarseness <sub>2D</sub>	yes	yes	yes
	Coarseness <sub>3D</sub>	yes	yes	yes
NGTDM	Contrast <sub>2D</sub>	yes	yes	yes
	Contrast <sub>3D</sub>	yes	yes	yes

Table 4. (continued)

Texture type	Feature	Mixed group	Contrast group	Non-contrast group
NGTDM	Busyness <sub>2D</sub>	yes	yes	yes
	Busyness <sub>3D</sub>	no	yes	yes
	Complexity <sub>2D</sub>	yes	yes	yes
	Complexity <sub>3D</sub>	yes	yes	yes
	Strength <sub>2D</sub>	yes	yes	yes
	Strength <sub>3D</sub>	no	yes	yes