Could textural analysis of MR images reduce overdiagnosis and overtreatment in prostate cancer?

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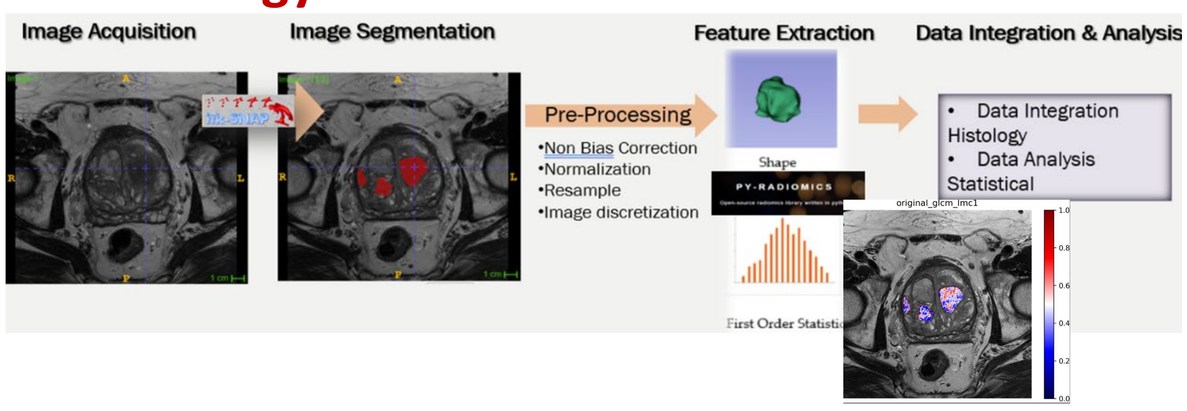
Introduction

- Exclusion of clinically significant prostate cancer is essential to reduce harm from overtreatment.
- An accurate, non-invasive method is therefore required for identifying benign prostatic disease and for the active surveillance of localised prostate cancer (in case of clinically insignificant prostatic cancer).
- This work explores if textural analysis of acquired MR images can serve these goals.

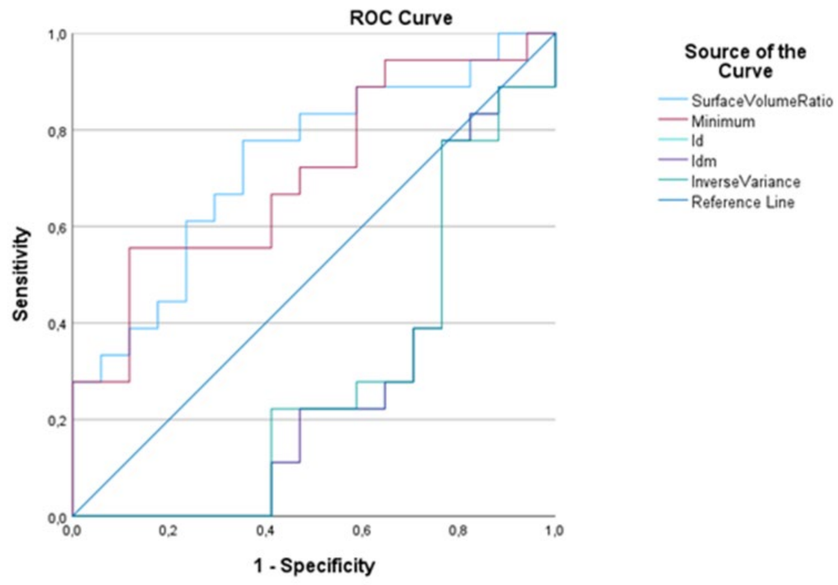
Methodology



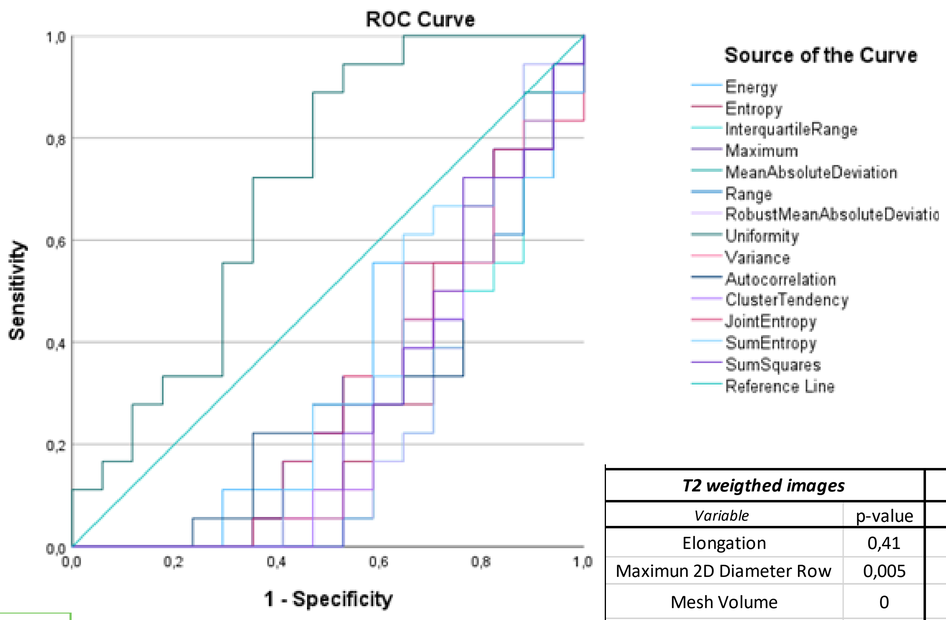
- **Study group:** Following ethical approval, 89 subjects with increased prostate specific antigen (PSA) and prostatic hyperplasia (n=54) or neoplasia (n=35) were enrolled.
- **MR scanning:** Subjects were scanned at 3.0T (Achieva TX Philips) using a multiparametric protocol according to the Prostate Imaging Reporting and Data System (PIRADSv2).
- **Histopathology:** All subjects underwent transrectal ultrasound guided biopsy following MRI, whilst the Gleason score (GS) and the International Society of Urological Pathology (ISUP) grade group were recorded.
- **Segmentation:** T2-weighted (T2w) and diffusion-weighted (DW) images were reviewed by an experienced radiologist and the dominant visible lesion was segmented (ITK-snap).
- **Feature extraction:** First-order, shape and gray-level co-occurrence matrix (GLCM) features (n=54) of segmented regions were extracted (Pyradiomics v3.1.0) for both T2w & DW images, following bias field correction, voxel rescaling to 1x1x1mm^3, as well as image normalization and discretization.
- **Linear Regression:** Extracted features were correlated to Gleason score (SPSS).
- **Intercomparison:** The independent samples t-test (SPSS) was used to intercompare features between low (<6) & high (≥6) GS and low (1) & high (>1) ISUP grade categories.
- **AU-ROC:** The area under the receiver operating characteristic (AU-ROC) curve was used to quantify the discriminative power of statistically significant features for patient stratification (GS<6 *vs* GS≥6) and ISUP grade categorization (1 *vs* >1).

Results & Discussion

- Surface Volume Ratio, 10Percentile & Imc1 derived from T2w and Range, Sphericity, Difference Variance & Skewness extracted from DW images revealed a significant correlation (p<0,01) with GS.
- Regression analysis in 35 cancer cases with GS≥6 showed significant linear correlations (p<0,01) between GS and T2w-extracted Surface Volume Ratio & lmc1 and DW-extracted Interquartile Range.
- 5 T2w-extracted features could discriminate between low (1) and high (>1) ISUP scores, with corresponding ROC curves shown below:



- 14 DW-extracted features could discriminate between low and high ISUP scores (i.e., clinically insignificant *vs* significant cancer), with corresponding ROC curves presented below:



- The nearby table presents the T2w- and DW-extracted features that proved competent discriminators between normal (<6) and abnormal (≥6) GS.

T2 weigthed images		*DWI images*	
Variable	p-value	*Variable*	p-value
Elongation	0,41	Flatness	0,012
Maximun 2D Diameter Row	0,005	LeastAxisLength	0,041
Mesh Volume	0	Maximum2DDiameterRow	0,006
Surface Area	0,009	MeshVolume	0,000
Surface Volume Ratio	0	MinorAxisLength	0,002
Voxel Volume	0	SurfaceArea	0,002
10% Percentile	0,025	SurfaceVolumeRatio	0,001
Energy	0,009	VoxelVolume	0,000
Kurtosis	0,03	90Percentile	0,029
Mean	0,036	Energy	0,000
Median	0,033	Entropy	0,003
Minimun	0,046	InterquartileRange	0,004
RootMeanSquared	0,039	Maximum	0,001
Skewness	0,025	MeanAbsoluteDeviation	0,002
Total Energy	0,009	Range	0,000
Idm	0,03	RobustMeanAbsoluteDeviation	0,003
Idmn	0,024	TotalEnergy	0,000
Id	0,035	Uniformity	0,020
Idn	0,013	Variance	0,003
Inverse Variance	0,024	Autocorrelation	0,005
		JointAverage	0,006
		ClusterProminence	0,032
		ClusterTendency	0,004
		Correlation	0,004
		DifferenceEntropy	0,043
		DifferenceVariance	0,042
		JointEntropy	0,004
		Idmn	0,005
		Idn	0,002
		SumEntropy	0,003
		SumSquares	0,004

Conclusions

- Obtained results suggest that radiomic features could differentiate normal (GS<6) *vs* abnormal (≥6) prostatic tissue and low (1) *vs* high (>1) ISUP score in cancerous tissue, although powerful features seem to differ in the two scenarios.
- T2w- and DW-extracted features with discriminative power are different and, thus, an approach similar to that of PI-RADS (DW domination for peripheral zone lesions and T2w domination for transition zone lesions) may have to be adopted.
- Textural analysis could potentially serve the goal of overdiagnosis and overtreatment reduction in prostate ca, although different features may have to be employed for patient stratification, disease burden assessment, lesion monitoring and treatment outcome evaluation.

Limitations

- Standardization of methodology and extending the study to a large sample size with longitudinal MRI scans are warranted.

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