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## RADIOMIC FEATURE RELEVANCE IN THE PREDICTION OF PATHOLOGICAL FEATURES OF PROSTATE CANCER



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#### DICHIARAZIONE Relatore: MARIA GIULIA VINCINI

Come da nuova regolamentazione della Commissione Nazionale per la Formazione Continua del Ministero della Salute, è richiesta la trasparenza delle fonti di finanziamento e dei rapporti con soggetti portatori di interessi commerciali in campo sanitario.

- Posizione di dipendente in aziende con interessi commerciali in campo sanitario (NIENTE DA DICHIARARE)
- · Consulenza ad aziende con interessi commerciali in campo sanitario (NIENTE DA DICHIARARE)
- Fondi per la ricerca da aziende con interessi commerciali in campo sanitario (NIENTE DA DICHIARARE)
- Partecipazione ad Advisory Board (NIENTE DA DICHIARARE)
- •Titolarità di brevetti in compartecipazione ad aziende con interessi commerciali in campo sanitario (NIENTE DA DICHIARARE)
- Partecipazioni azionarie in aziende con interessi commerciali in campo sanitario (NIENTE DA DICHIARARE)
- Altro



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#### Radioterapia di precisione per un'oncologia innovativa e sostenibile

#### Background

Multiple risk classification systems with sub-ottimal prognostic performances → under/over treatment

The lack of a-priori deeper characterization makes difficult to determinate accurately and noninvasively PCa aggressiveness at the time of the first diagnosis in order to guide treatment decision Pre-treatment prostate cancer risk stratification systems by different organizations

Organization	Very Low risk/Low risk unfavorable)		High risk/Very high risk	
D'Amico (22)				
AUA (23)	T1-T2a and GS $\leq 6$ and PSA $\leq 10$	T2b and/or GS =7 and/or PSA >10–20 not low-risk	≥T2c or PSA >20 or GS 8–10	
EAU (24)				
GUROC* (25)	T1-T2a and GS ≤6 and PSA	T1-T2 and/or Gleason ≤7	≥T3a or PSA >20 or GS 8–10	
NICE (26)	≤10	risk		
CAPSURE*	T1-T2a and GS ≤6 and PSA	T2b and/or GS =7 and/or	T3-4 or PSA >20 or GS 8–10	
(27)	≤10	PSA >10–20 not low-risk		
NCCN (28)	T1-T2a and GS 2–6 and PSA ≤10 not very low-risk AND very-low risk category: T1c and GS ≤6 and PSA <10 and Fewer than 3 biopsy cores positive and ≤50% cancer in each core	T2b or T2c and/or GS =7 and/or PSA >10–20 not low-risk	T3a or PSA >20 or GS 8–10 not very high risk AND very high-risk category: T3b-4	
ESMO (29)	T1-T2a and GS ≤6 and PSA <10	Not high risk and not low risk	T3-4 or PSA >20 or GS 8–10	



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#### Aims

#### Primary endpoint:

 Non-invasive prediction of PCa pathological characteristics with mathematical models integrating radiological, clinical and radiomics features



#### Secondary endpoints: focus on radiomic features

- Investigate radiomic contribution
- Investigate leading features
- Exploring model behaviour across patients subgroups





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#### **Patients**

"A total of **949 prostate cancer** (PCa) patients who had undergone multiparametric magnetic resonance imaging (mp-MRI) and radical prostatectomy at the IEO (European Institute of Oncology IRCSS, Milan, Italy) between 2015 and 2018 were retrospectively included."

#### **Inclusion criteria:**

- ✓ Age ≥ 18 years
- histological proven diagnosis of Prostate Cancer
- multiparametric magnetic resonance (mp-MRI) performed c/o IEO
- ✓ radical prostatectomy performed c/o IEO
- availability of pre- and post-surgery clinical and radiological data
- ✓ written consent to the anonymous use of clinical data for educational and scientific purposes

**Exclusion criteria:** any hormone therapy prior to surgery.







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#### **Methods**

#### Input Output M1. Clinical features Clinical variables: Age, - pT Comorbidities, risk class, pN PSA, cT, cN, GS pre-op, - Residual ISUP pre-op M2. Clinical + radiological surgical margin - Post-op GS **Radiomic features** Post-op ISUP M3. Clinical + radiomics **Biochemical** Radiological Open Access variables (mpMRI): progression Check for - Clinical pirads, EPE, ADC, M4. Clinical + radiological volume + radiomics progression

#### **Radiomic features extraction:**

- All images acquired at IEO
- Extraction from T2 weighted
- Whole prostate segmented with an internally-developed learning autosegmentation tool

#### ORIGINAL ARTICLE

# Quality assurance for automatically generated contours with additional deep learning

Lars Johannes Isaksson<sup>11</sup> <sup>(6)</sup>, Paul Summers<sup>2</sup>, Abhir Bhalerao<sup>3</sup>, Sara Gandini<sup>4</sup>, Sara Raimondi<sup>4</sup>, Matteo Pepa<sup>1</sup>, Mattia Zaffaroni<sup>1</sup>, Giulia Corrao<sup>1,5</sup>, Giovanni Carlo Mazzola<sup>1,5</sup>, Marco Rotondi<sup>1,5</sup>, Giuliana Lo Presti<sup>4</sup>, Zaharudin Haron<sup>6</sup>, Sara Alessi<sup>2</sup>, Paola Pricolo<sup>2</sup>, Francesco Alessandro Mistretta<sup>7</sup>, Stefano Luzzago<sup>7</sup>, Federica Cattani<sup>8</sup>, Gennaro Musi<sup>5,2</sup>, Ottavio De Cobelli<sup>5,7</sup>, Marta Cremonesi<sup>9</sup>, Roberto Orecchia<sup>10</sup>, Giulia Marvaso<sup>1,5</sup>, Giuseppe Petralia<sup>5,11</sup> and Barbara Alicja Jereczek-Fossa<sup>1,5</sup>





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#### **Results – Models performance**



radiological variables improve the performance by a **substantial margin** (blue vs. orange).

The radiomic variables appear to improve the performance by a small margin (blue vs. green and orange vs. red),

#### Mean AUC 0.78

→ Inclusion of radiomics seems to give a **boost** in models performance, although small

BOLOGNA, 25-27 NOVEMBRE

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# **Results -** Do the radiomic features actually influence the decisions of the model? On what variables does the model base its decisions?



Post-op ISUP Group

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## **Results** – **On what** variables does the model base its decisions?

features

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EPE + EPE + 24 EPE + 23 PIRADS + 6 PIRADS + 10 PIRADS + 8 Risk class 6 Initial PSA 9 Risk class Initial PSA Risk class 9 ADC+ Initial ISUP Group ADC+ Initial ISUP Group 5 Cumulative: 31.8 % Cumulative: 59.3 % Cumulative: 48.8 % **Biochemical progression** Clinical progression Surgical margin PIRADS + PIRADS + 12 EPE + 14 21 15 Risk class Initial PSA 12 Risk class 14 EPE + 14 Risk class 12 ADC+ 13 EPE + PIRADS + Clinical T 10 Initial ISUP Group 5 Initial ISUP Group Initial ISUP Group 8 Cumulative: 54.9 % Cumulative: 56.2 % Cumulative: 60.3 % Delta T Delta ISUP Delta N Clinical T 83 EPE + Initial ISUP Group 35 MODEL 4. EPE + EPE + 6 ADC+ 8 Risk class 2 PIRADS + Risk class **TOP 5 used** Initial PSA 2 Initial PSA PIRADS + 1 Risk class age Clinical T 4 Cumulative: 90.5 % Cumulative: 47.5 % Cumulative: 61.4 % RAO Avenutationer Radiotragia e Oreologia FAB BOLOGNA, 25-27 NOVEMBRE Associazione Italiana Radioterapia e Oncologia clinica PALAZZO DEI CONGRESSI RAO) Società Italiana di Radiobiologia

Pathological T

Pathological N

# All

Post-op ISUP Group

EPE +

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## **Results** – On v vari doe mod its d

n what	PIRADS +	6	PIRADS +	10	PIRADS +	8	
	Risk class	6	Initial PSA	9	Risk class	7	
viables	Initial PSA	5	Risk class	9	ADC+	6	
irlaptes	Initial ISUP Group	5	ADC+	7	Initial ISUP Group	5	
		Cumulative: 31.8 %		Cumulative: 59.3 %		Cumulative: 48.8 %	
bes the		Surgical margin		Biochemical progressio	n	Clinical progression	
adal baca	PIRADS +		12 EPE +		14 PIRADS +		21
uuel base	Initial PSA		12 Risk class		14 Risk class	15	
	Risk class		12 ADC+	1	3 EPE +	14	
s decisions?	EPE +	10	PIRADS +	8	Clinical T	6	
	Initial ISUP Group	9	Initial ISUP Group	8	Initial ISUP Group	5	
		Cumulative: 54.9 %		Cumulative: 56.2 %		Cumulative: 60.3 %	
		Delta ISUP		Delta T		Delta N	
	Initial ISUP Group		30 Clinical T	8	B3 EPE +		35
MODEL 4.	EPE +	6	EPE +	2	ADC+	8	
	PIRADS +	4	Risk class	2	Risk class	7	
IOP 5 used	Initial PSA	4	Initial PSA	2	PIRADS +	7	
features	Risk class	4	age	1	Clinical T	4	
		Cumulative: 47.5 %		Cumulative: 90.5 %		Cumulative: 61.4 %	
IEO	Association Association	zione Italiana	RAB	Nonsone Receiption Provide State Characteristic	BOLO	GNA. 25-27 NOVEMBR	RE
lstituto Europeo di Oncologia	Radiote	rapia e Oncologia clinica Socie	età Italiana di Radiobiologia	RAD		PALAZZO DEI CONGRES	SSI

EPE +

Pathological T

24

Pathological N

23

EPE +





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# **Results** – Does radiomics play a specific role for low/high-risk patients?

MODEL 4. SHAP value distribution for different class-risk group

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#### **Results** – Is there a performance difference between the low-risk and high-risk patients?

MODEL 4. **MAE** values distribution for different class-risk group





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# **Results** – Is there a performance difference between the low-risk and high-risk patients?

MODEL 4. MAE values distribution for different class-risk group



![](_page_13_Figure_7.jpeg)

![](_page_13_Figure_8.jpeg)

ow Favorable Unfavorable High Risk class

![](_page_13_Picture_10.jpeg)

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![](_page_13_Picture_13.jpeg)

![](_page_14_Picture_0.jpeg)

![](_page_14_Picture_2.jpeg)

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#### **Results – Model 4** Comparison with clinical workflow

Clinical workflow	≤ 3 predicted	≥4 predicted	Model 4	≤ 3 predicted	≥ 4 predicted
≤3 true	877	0	ISUP $\leq$ 3 true	841	36
≥4 true	67	1	$ISUP \ge 4 true$	46	22

#### Confusion matrices for ISUP prediction

Clinical workflow	≤ 2 predicted	≥ 3 predicted	Model 4	≤ 2 predicted	≥ 3 predicted
≤ <b>2</b> true	568	14	cT ≤ 2 true	463	119
≥3 true	319	48	cT≥3 true	141	226

#### Confusion matrices for **pathological T (pT)** prediction

Clinical workflow	0 predicted	1 predicted	Model 4	0 predicted	1 predicted
0 true	493	2	cN = 0 true	408	87
1 true	76	0	cN = 1 true	36	40

Confusion matrices for **pathological N (pN)** prediction

![](_page_14_Picture_11.jpeg)

![](_page_14_Picture_12.jpeg)

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![](_page_14_Picture_14.jpeg)

![](_page_15_Picture_0.jpeg)

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#### Take home messages

- **mp-MRI variables** are fundamental for model performances (PI-RADS and EPE)
- Models can provide clinicians with pathological information prior to surgery, helping identify the correct stage of the disease and guiding the clinical course (tailored treatment)
- $\rightarrow$  potential benefit of mathematical models for pathological features prediction in Pca

#### WHAT ABOUT RADIOMICS?

- Radiomics features bring a measurable boost in model performance, although small
- → explore the use of additional mp-MRI sequences for radiomic features extraction

The possibility shown by these models to improve risk stratification and drive treatmentdecision process is promising and warrant further efforts

![](_page_15_Picture_11.jpeg)

![](_page_15_Picture_12.jpeg)

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![](_page_15_Picture_14.jpeg)

![](_page_16_Picture_0.jpeg)

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*Thank you for your kind attention* 

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Vincini, G. Corrao, G.C. Mazzola, M. Rotondi, S. Raimondi, S. Gandini,
S. Volpe, Z. Haron, S. Alessi, P. Pricolo, F.A. Mistretta, S. Luzzago, F.
Cattani, G. Musi, O. De Cobelli, M. Cremonesi, R. Orecchia, D. La Torre,
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![](_page_16_Picture_6.jpeg)

![](_page_16_Picture_7.jpeg)

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