UNIVERSITÄTS KLINIKUM FREIBURG

CCCF COMPREHENSIVE CANCER CENTER FREIBURG

dkfz.

German Cancer Consortium

Partner site Freiburg

High Tech and AI to Cure Cancer

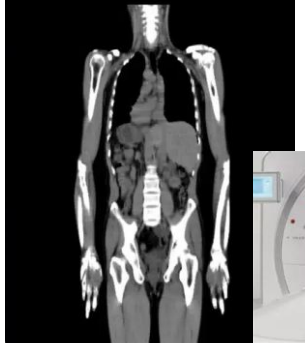
Prof. Dr. med. Dr. h. c. Anca-L. Grosu, FACR

Director and Chair

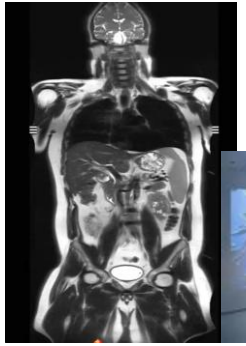
Department of Radiation Oncology

University of Freiburg, Germany







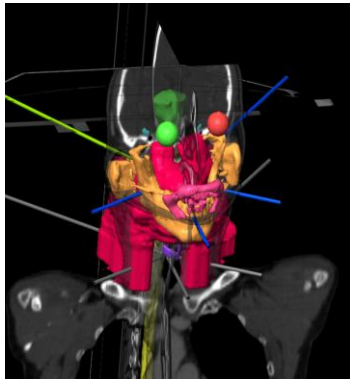


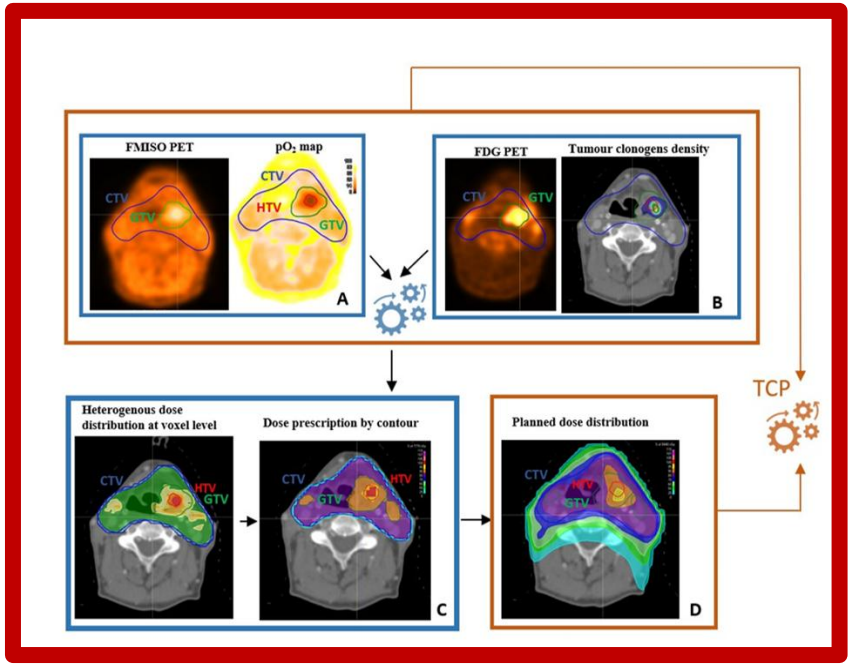



Z: 127,5, B: 255,0
syngo.via
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Schicht: 5 mm
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PET^FDG_GK_404_Lymphom_ (Erwachsener)
Range Parallel MPR_THICK 5.0mm 3.0mm
FA



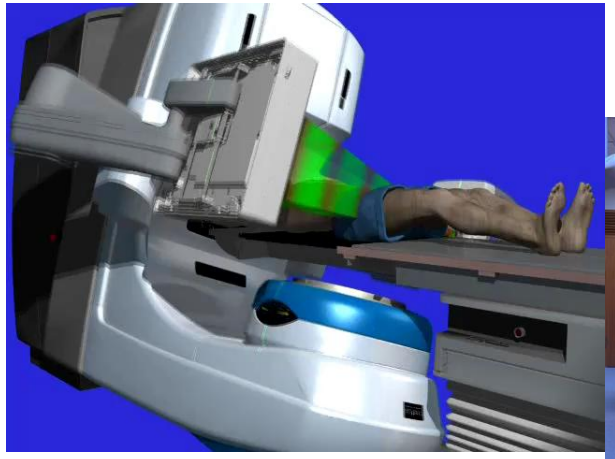





FMISO PET
pO2 map
CTV
GTV
HTV
A
FDG PET
Tumour clonogens density
B
Heterogenous dose distribution at voxel level
Dose prescription by contour
C
Planned dose distribution
D
TCP







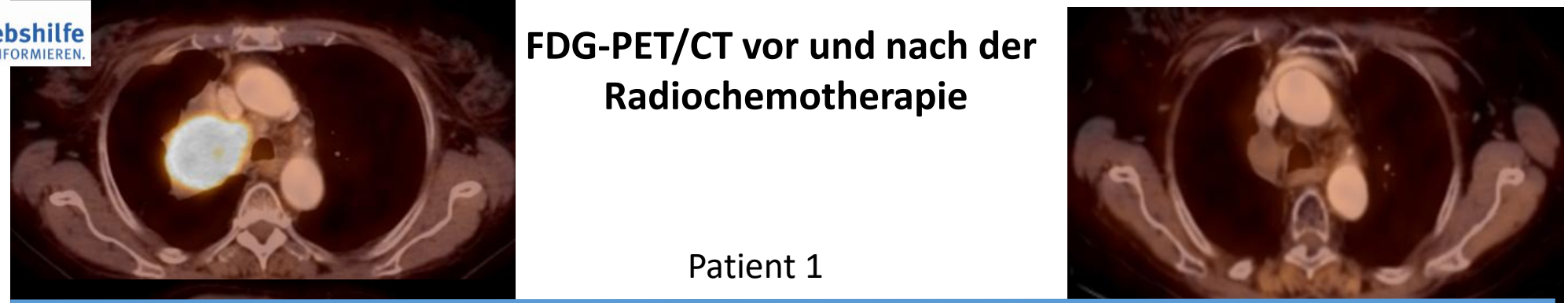



MR-LINAC: OVERVIEW

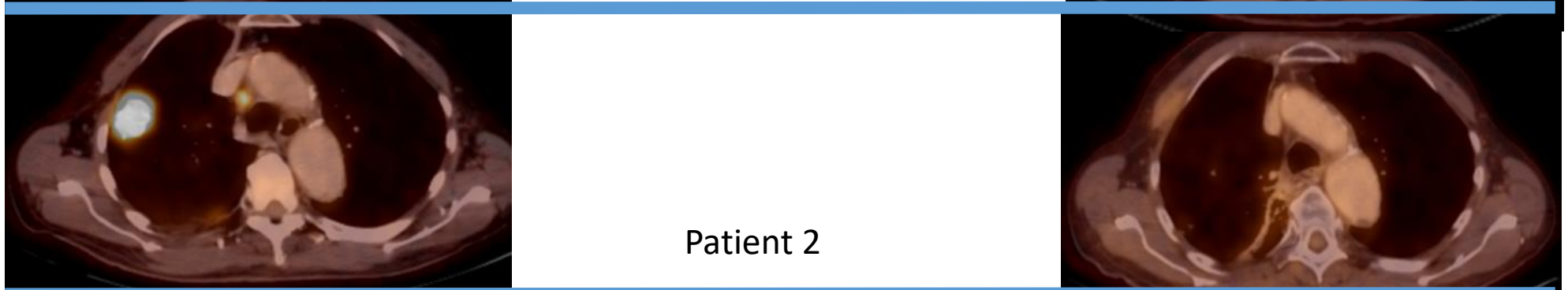


Deutsche Krebshilfe
HELFEN. FORSCHEN. INFORMIEREN.

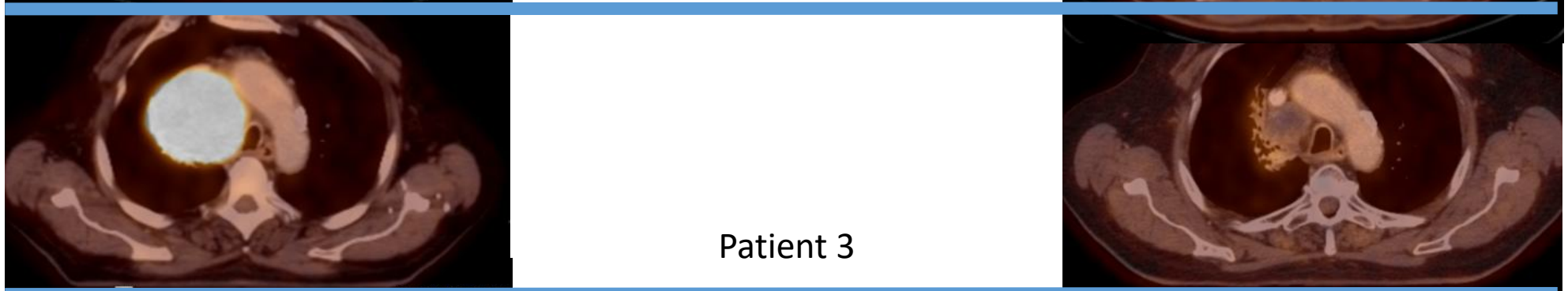
FDG-PET/CT vor und nach der Radiochemotherapie



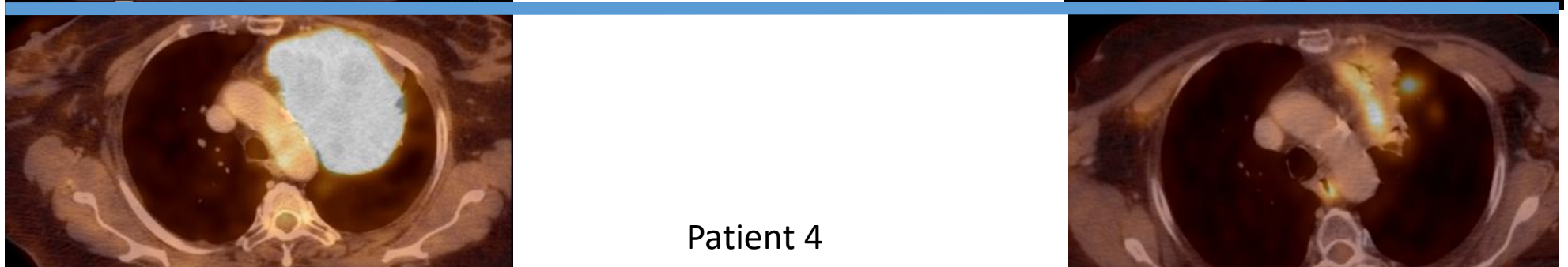
Patient 1



Patient 2

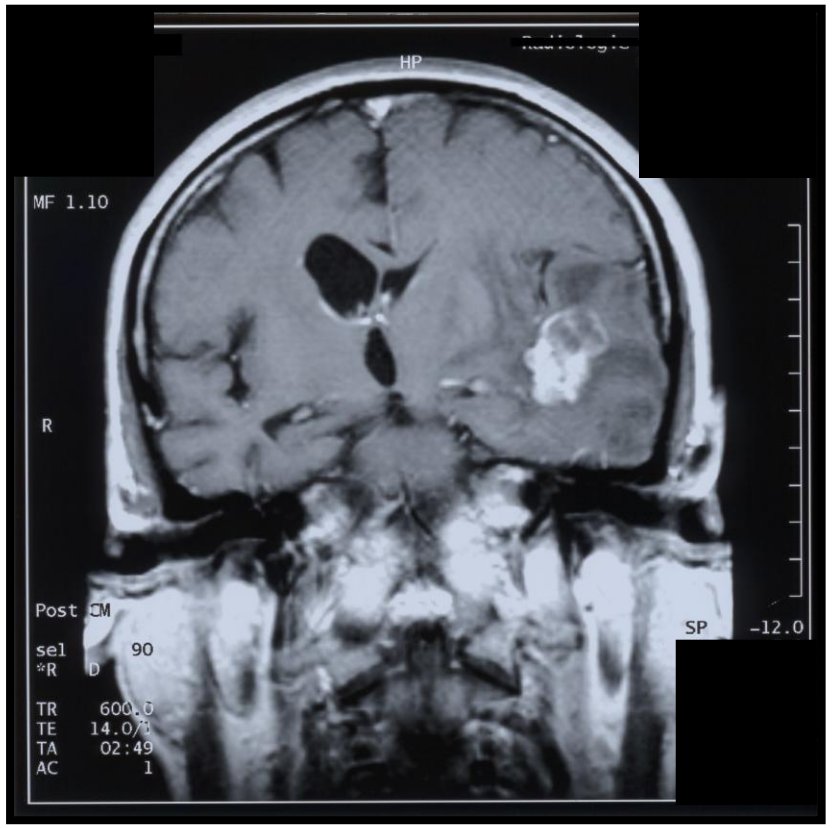


Patient 3

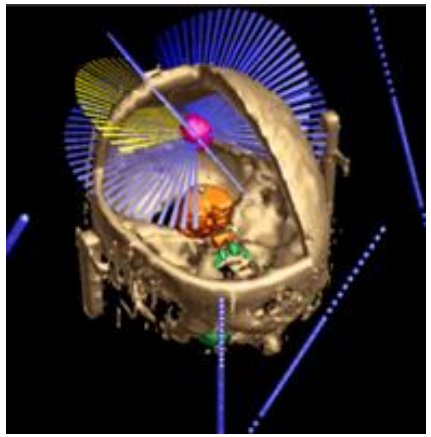


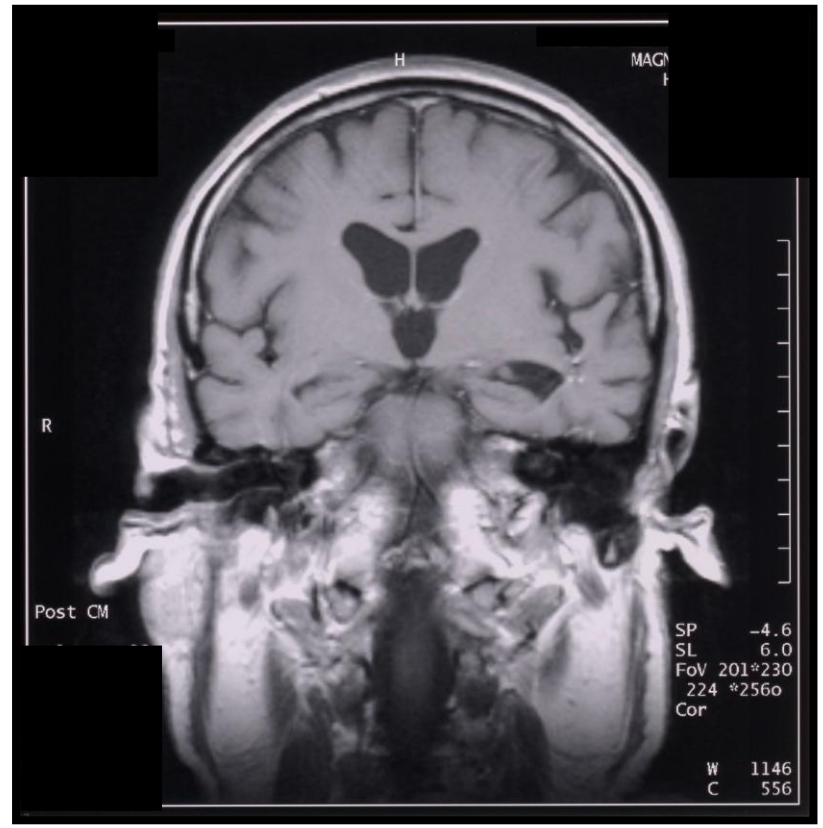
Patient 4

Radiochirurgie (Einzeitbestrahlung) bei Hirnmetastasen



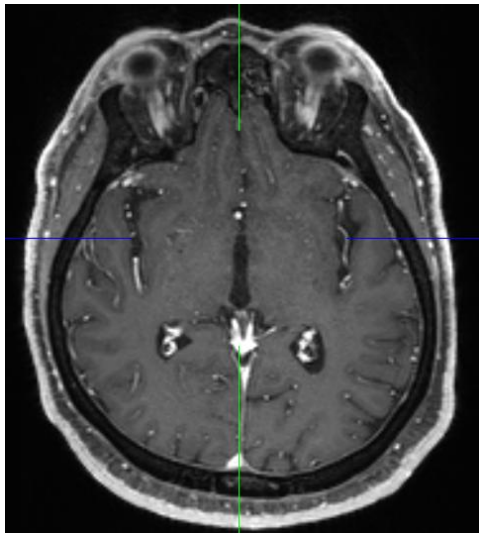




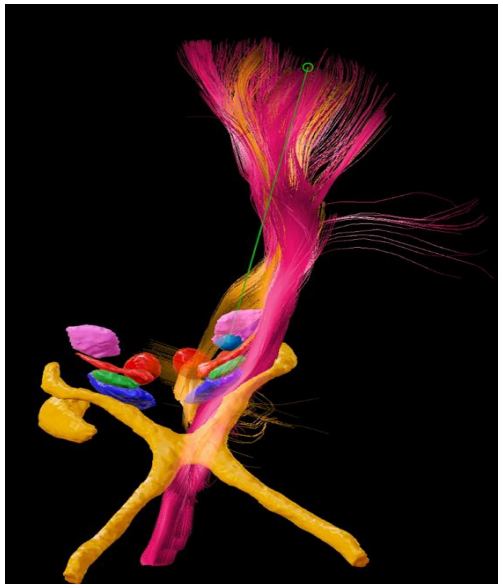


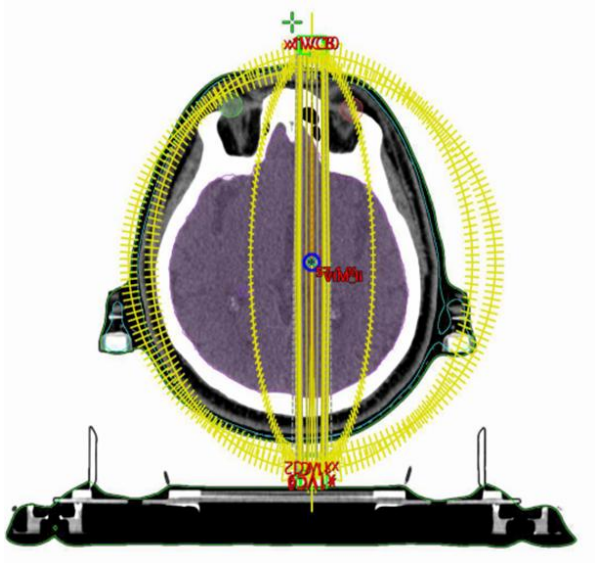
Lokale Tumorkontrolle nach Radiochirurgie von Hirnmetastase: ca. 80-90%

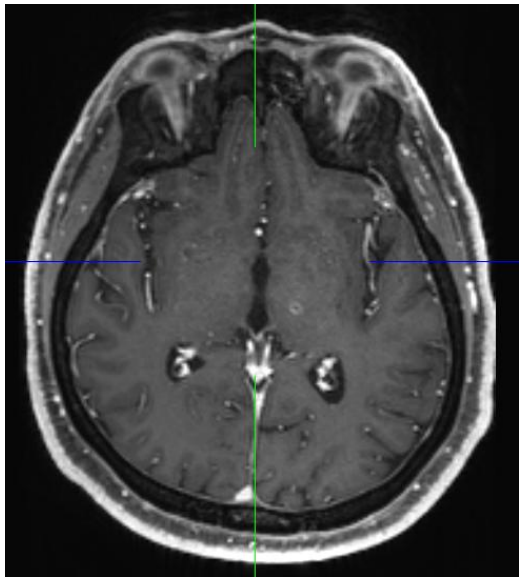
FUNKTIONELLE RADIOCHIRURGIE BEI TREMOR



20.12.2023







18.03.2024

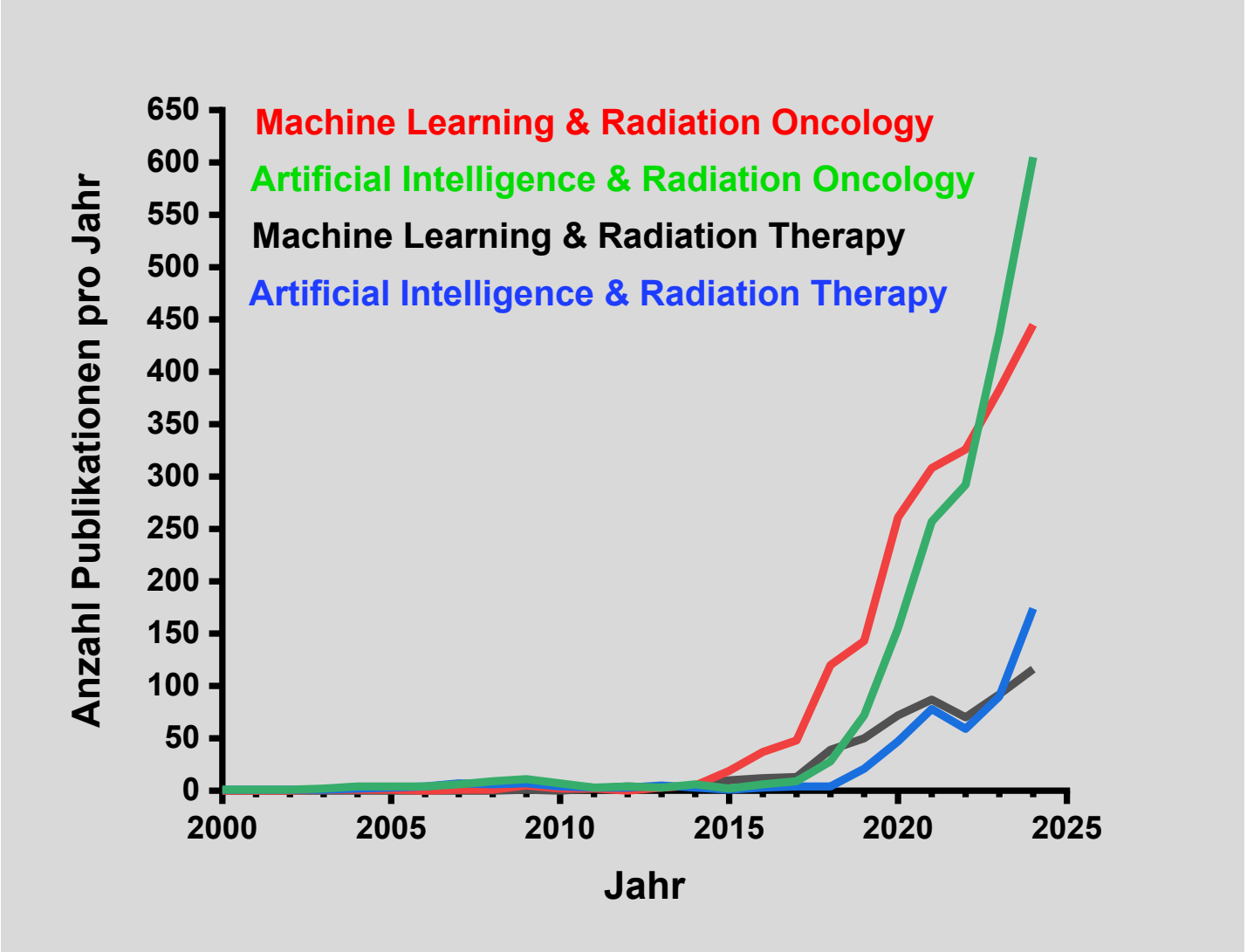






AI / ML in Radiation Therapy / Radiation Oncology

PubMed
31.12.2024



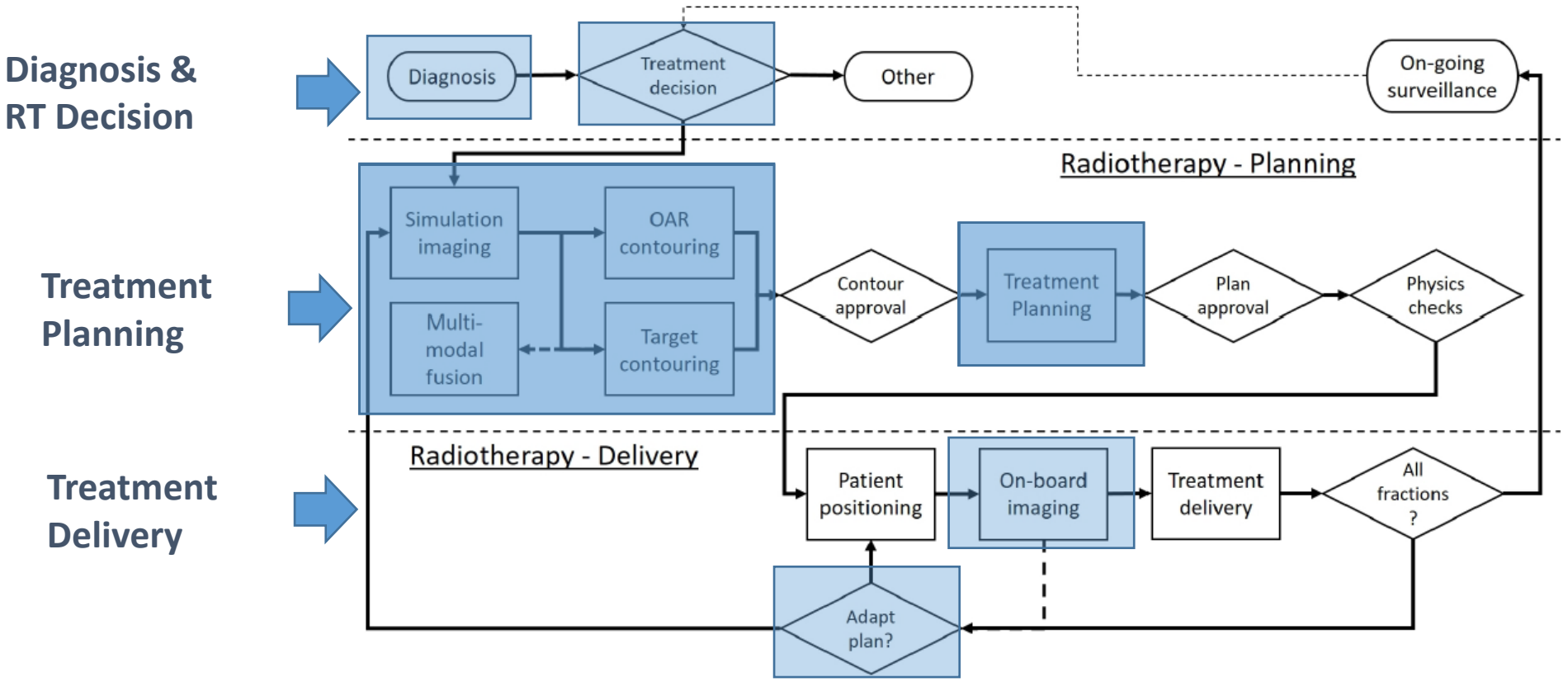
REVIEW ARTICLE https:// doi. org/ 10. 1259/ bjr. 20190001

Applications and limitations of machine learning in radiation oncology

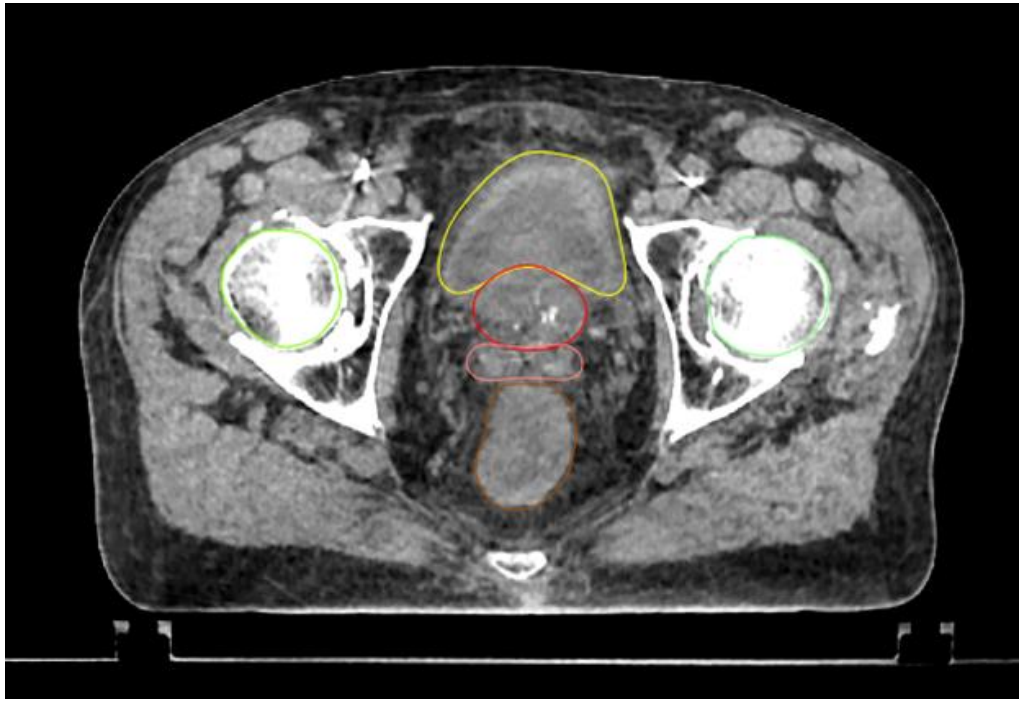
[1,2]DANIEL JARRETT, [1]ELEANOR STRIDE, [3]KATHERINE VALLIS and [2]MARK J. GOODING

[1]Department of Engineering Science, Institute of Biomedical Engineering, University of Oxford, UK
[2]Mirada Medical Ltd, Oxford, UK
[3]Department of Oncology, Oxford Institute for Radiation Oncology, University of Oxford, UK

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Delination of Organs of Risk for Radiation Treatment Planning





Received: 30 August 2024 | Revised: 18 November 2024 | Accepted: 6 December 2024

DOI: 10.1002/acm2.70010

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS

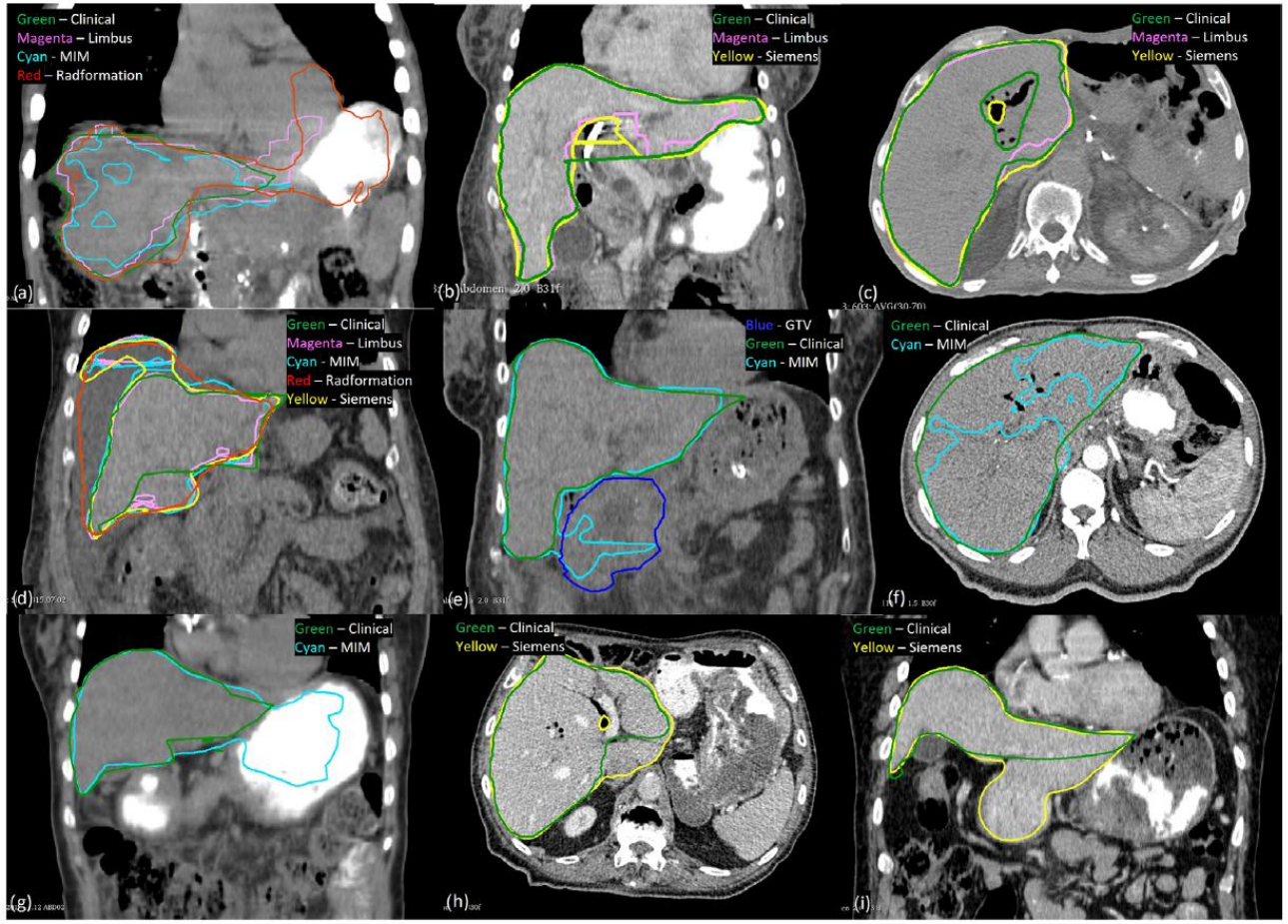
RESEARCH ARTICLE

Evaluation and failure analysis of four commercial deep learning-based autosegmentation software for abdominal organs at risk

Mingdong Fan[1] | Tonghe Wang[2] | Yang Lei[3] | Pretesh R. Patel[1] | Sean Dresser[1] | Beth Bradshaw Ghavidel[1] | Richard L. J. Qiu[1] | Jun Zhou[1] | Kirk Luca[1] | Oluwatosin Kayode[1] | Jeffrey D. Bradley[4] | Xiaofeng Yang[1] | Justin Roper[1]

TABLE 3 Summary of the most prominent auto-segmentation discrepancies for each software.

OAR	Limbus	MIM	Radformation	Siemens
Liver	Biliary stent/drain & resulting pneumobilia	• Fragmented Contours • Included stomach (all occurred with barium contrast but not the only factor)	Significant over-extension into heart and stomach even with barium contrast	• Biliary stent/drain & resulting pneumobilia • Inclusion of kidney, IVC, duodenum, and gallbladder
Stomach	Significant portion of stomach unsegmented due to barium contrast		Significant portion of stomach unsegmented due to barium contrast	
Kidneys	• Guideline difference (renal pelvis excluded) • Broken contours	Severely fragmented contours caused by IV contrast	Benefit: Followed RTOG contouring guidelines more consistently than manual contour	Benefit: Followed RTOG contouring guidelines more consistently than manual contour



Strahlentherapie und Onkologie
https://doi.org/10.1007/s00066-025-02403-1

ORIGINAL ARTICLE

Contouring in transition: perceptions of AI-based autocontouring by radiation oncologists and medical physicists in German-speaking countries

Samuel M. Vorbach[1,9] · Florian Putz[2,9] · Ute Ganswindt[1] · Stefan Janssen[3,9] · Maximilian Grohmann[4,9] · Stefan Knippen[5,9] · Felix Heinemann[6,9] · Rami A. El Shafie[7,9] · Jan C. Peeken[8,9,10,11]

Received: 18 November 2024 / Accepted: 31 March 2025
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Table 1 Characteristics of the participants

Characteristic	Participants
Profession	
Resident	28 (17.2%)
Radiation oncology specialist	118 (72.4%)
Physicist	17 (10.4%)

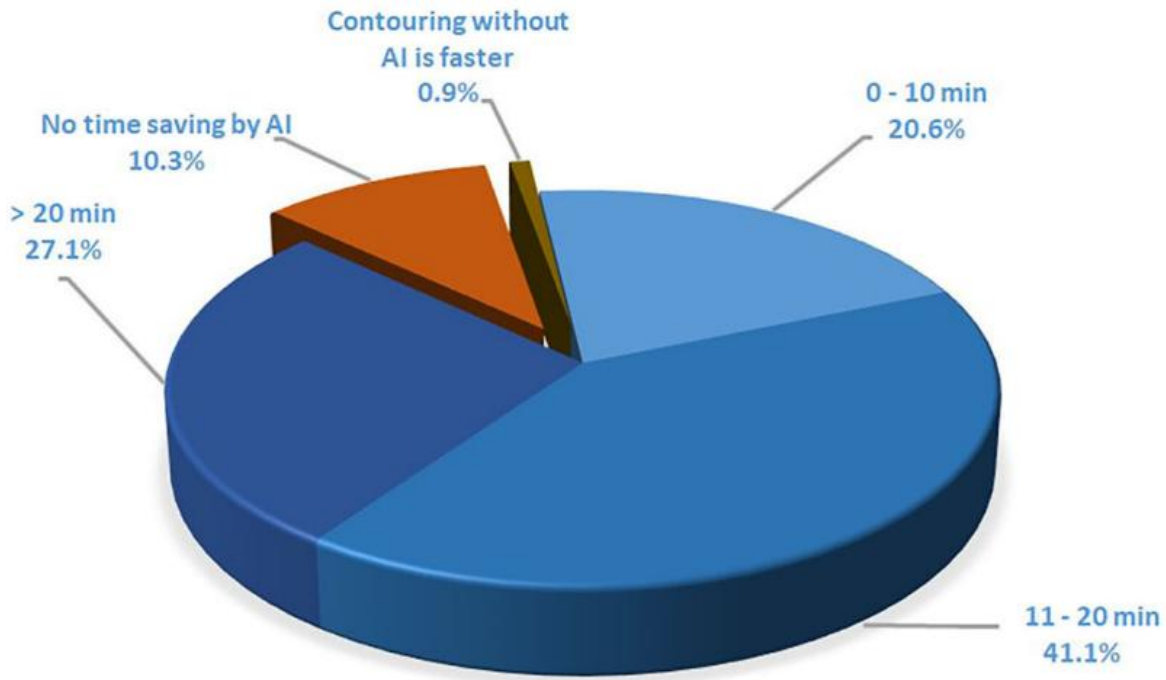


Fig. 1 Estimation of time savings per organ at risk contouring with artificial intelligence(*AI*)-based autocontouring software

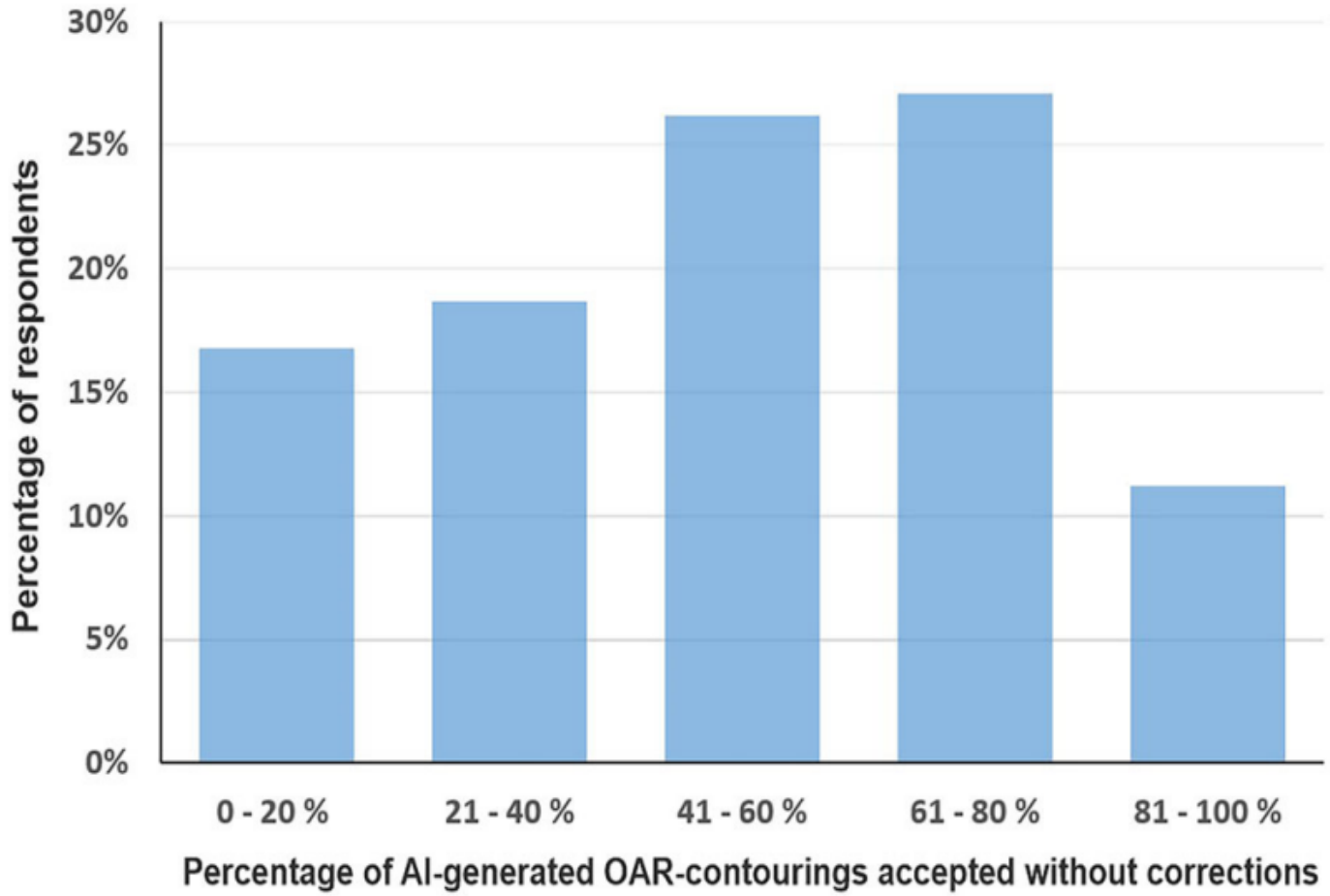
Strahlentherapie und Onkologie
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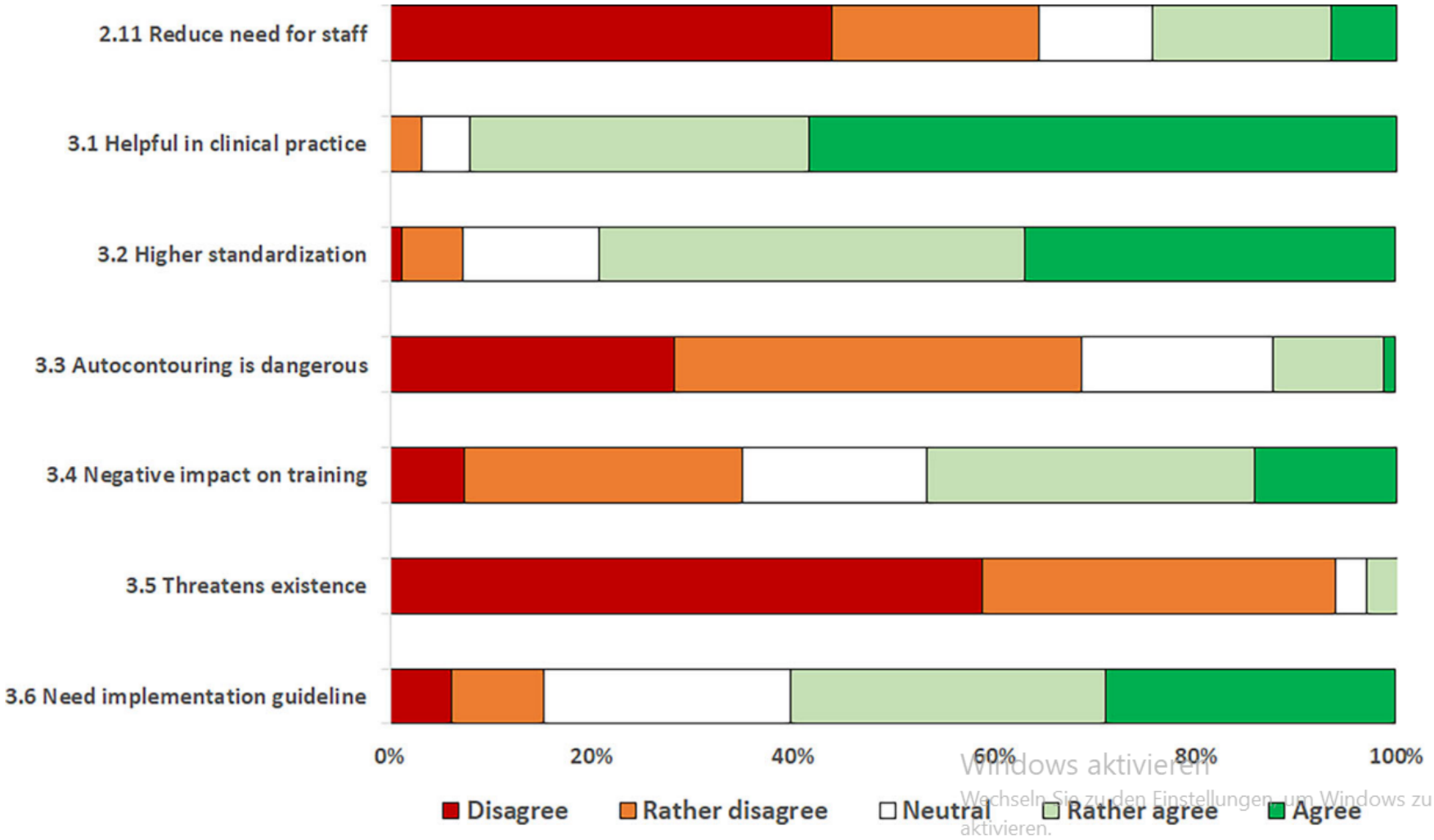
Strahlentherapie und Onkologie
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ORIGINAL ARTICLE

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Windows aktivieren
Wechseln Sie zu den Einstellungen, um Windows zu aktivieren.

Conclusion Artificial intelligence-based autocontouring software shows promise for integration into radiation oncology workflows, with respondents recognizing its potential for time saving and standardization. However, successful implementation will require ongoing education and curriculum adaptation to ensure AI enhances, rather than replaces, clinical expertise.

AI in Ocology /Radiation Oncology

Example: Radiation Therapy in Prostate Cancer

Horizon 2020 ERA PerMed

Deutsche Forschungsgemeinschaft

Grosu, Zamboglou, Spohn, Schilling

KTS Klaus Tschira Stiftung

DKTK

Imaging and AI for Radiation Therapy in Primary Prostate Cancer

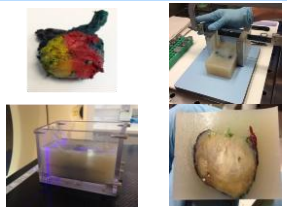
PersoProCaRisk

HORIZON 2020 Freiburg, Paris, Toronto 2018,
PI A.L. Grosu

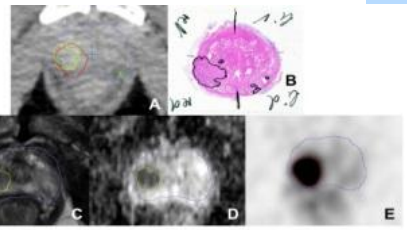
Integrative Personalized Risk and Therapy Stratification of Localized Prostate Cancer

Personalized stratification of localized PCa

Paris
- Data management
- Biostatistics
- Clinical correlation



Toronto
- Semen plasma cohort
- Genomics
- Targeted proteomics



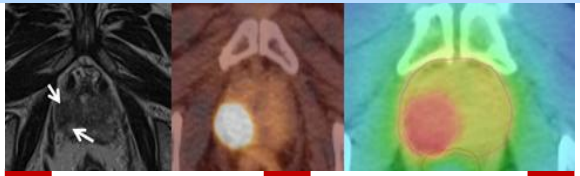
Freiburg
- Treatment cohort radiomics
- Immunohistochemistry
- Explorative proteomics

PersoRad

HORIZON 2020 Freiburg, Vienna, Milan, Athens 2019
PI A.L. Grosu

Implementation of mobile health tools and artificial intelligence for personalized radiation treatment planning and monitoring in prostate cancer

RTx based on bio-imaging/bio-markers/patients empowerment



Tissue probes
- Ex-vivo RT and measurement of residual yH2AX foci
- Genomic analyses

Artificial intelligence
- Automatic tumor segmentation
- Feature extraction

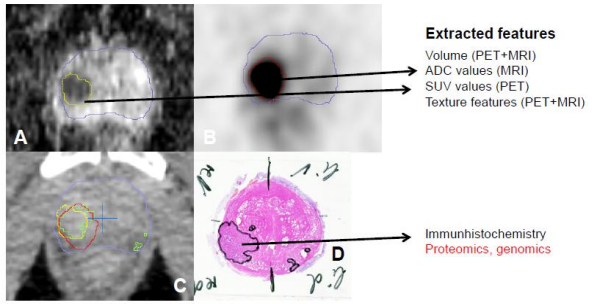
Digital health tools
- Patient's preferences
- Individualized follow-up

Data integration

(Radio)biological modelling

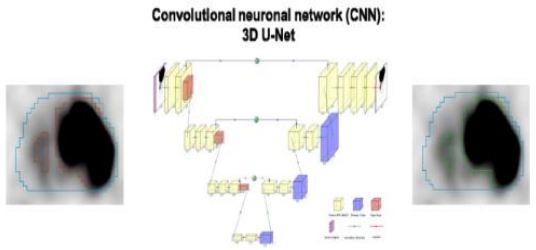
PSMA-PET and mpMRI for Radiation Therapy in Primary Prostate Cancer

Morphology → Biology → Treatment



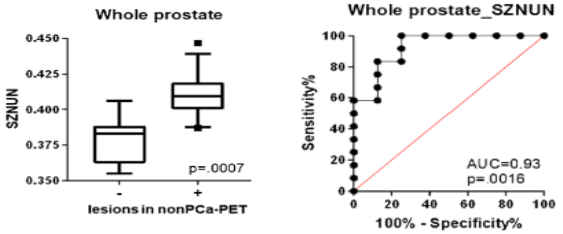
In a slice by slice analysis with histopathology **PSMA-PET and mpMRI showed high sensitivity and specificity in detection of primary PCa**.

Grosu…Krause EJNMMI 2014
Zamboglou…Grosu EJNMMI 2016
Zamboglou…Grosu Theranostics 2016
Zamboglou…Grosu Theranostics 2017
Bettermann…Grosu Radiother Oncol 2019



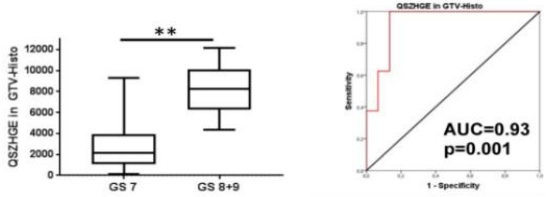
The application of **CNN for automated contouring of GTV in PSMA-PET** resulted in a high concordance with expert contours and in high sensitivities and specificities in comparison to the histology as reference.

Rajan…Grosu R Artif Intel 2023
Holzschuh. Zamboglou Radiother Oncol 2023
Kostyszyn..Grosu..Zamboglou JNM 2021
Spohn … Grosu ..Zamboglou Tharanostics 2021
Spohn..Grosu..Zamboglou EJNMMI 2020



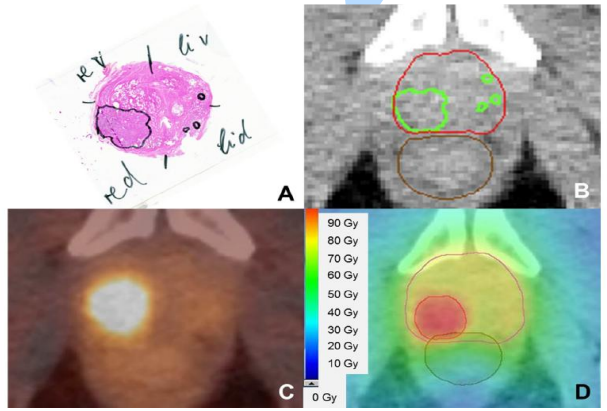
Uncovering the invisible-prevalence, characterisitcs and **radiomics-features**-based detection of visually undetectable intraprostatic tumor lesions in PSMA-PET in primary PCa.

Zamboglou…Grosu EJNMMI 2021



Radiomic features derived from PSMA PET discriminated between PCa and non-Pca tissue and between GI sc 7 and GI sc 8=/>.

Zamboglou…Grosu Theranostics 2019



IMRT dose painting using PSMA PET/mpMRI is technically feasible (planning study based on histopathology reference) and resulted in significantly higher **TCPs without higher NTCPs**

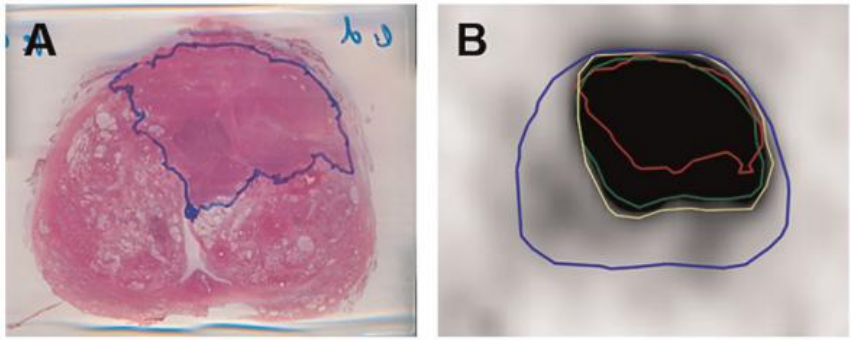
Influence of **radioresistance and intrafractional movement** on the **TCP** in IMRT PCa using SIB PSMA-PET delineated GTV

Zamboglou…Grosu IJROBP 2022
Spohn…Zamboglou JROBP 2022
Spohn….Zamboglou Front Oncol 2021
Shapazidis….Baltas Radiat Oncol 2020
Zamboglou…Grosu Radiat Oncol 2018
Thomann…Baltas Radiother Oncol 2018
Zamboglou….Baltas Radiother Oncol 2017

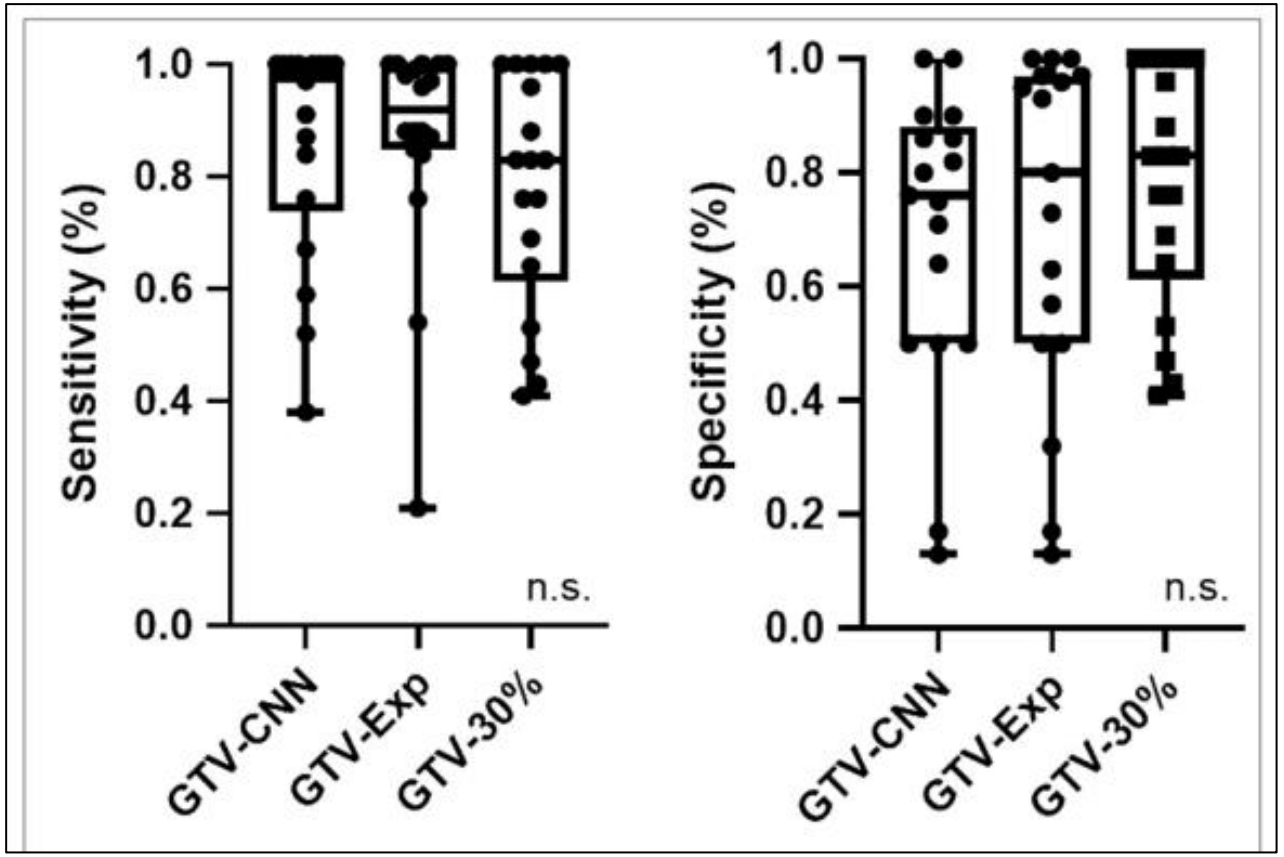
Intraprostatic Tumor Segmentation on PSMA PET Images in Patients with Primary Prostate Cancer with a Convolutional Neural Network

Dejan Kostyszyn[*1,2], Tobias Fechter[*1,3,4], Nico Bartl[3,4], Anca L. Grosu[3,4], Christian Gratzke[5], August Sigle[5], Michael Mix[6], Juri Ruf[6], Thomas F. Fassbender[6], Selina Kiefer[7], Alisa S. Bettermann[4], Nils H. Nicolay[3,4], Simon Spohn[3,4], Maria U. Kramer[4], Peter Bronsert[3,7], Hongqian Guo[8], Xuefeng Qiu[8], Feng Wang[9], Christoph Henkenberens[10], Rudolf A. Werner[11], Dimos Baltas[1,3], Philipp T. Meyer[6], Thorsten Derlin[11], Mengxia Chen[†8], and Constantinos Zamboglou[†3,4]

J Nucl Med 2021; 62:823–828
DOI: 10.2967/jnumed.120.254623



Validation – ground truth: Histology



The application of a **CNN for automated contouring** of intraprostatic GTV in **68Ga-PSMA PET** images resulted in a high concordance with expert contours and in high sensitivities and specificities in comparison with histology as a reference.

Radiotherapy and Oncology 188 (2023) 109774

Contents lists available at ScienceDirect

Radiotherapy and Oncology

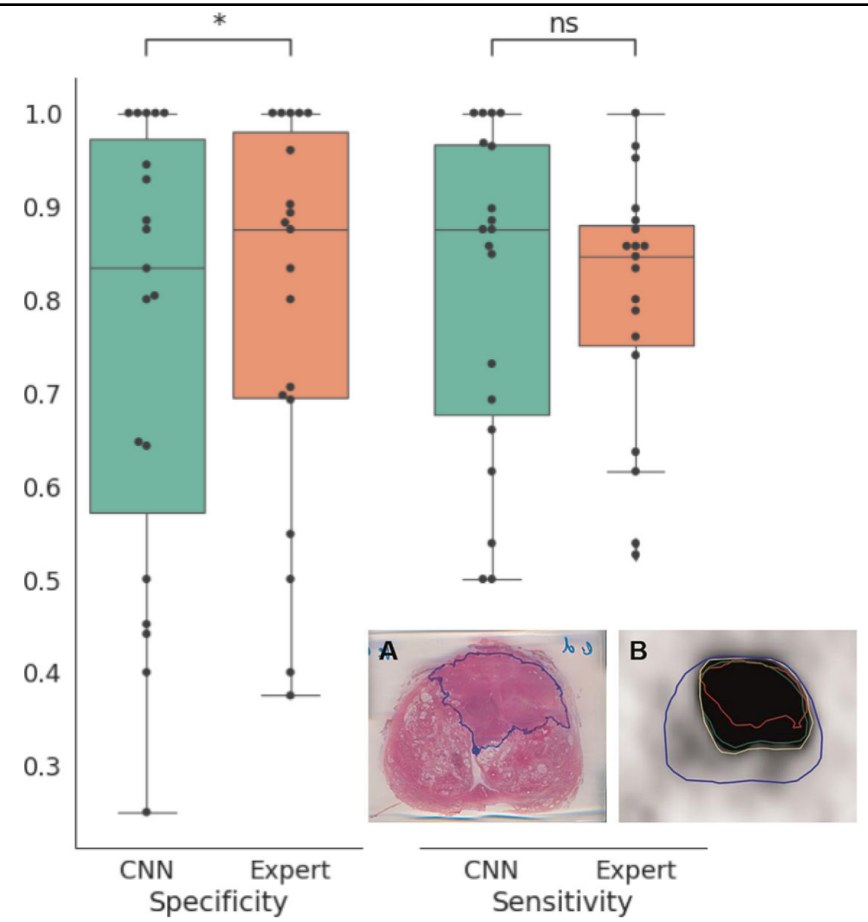
journal homepage: www.thegreenjournal.com

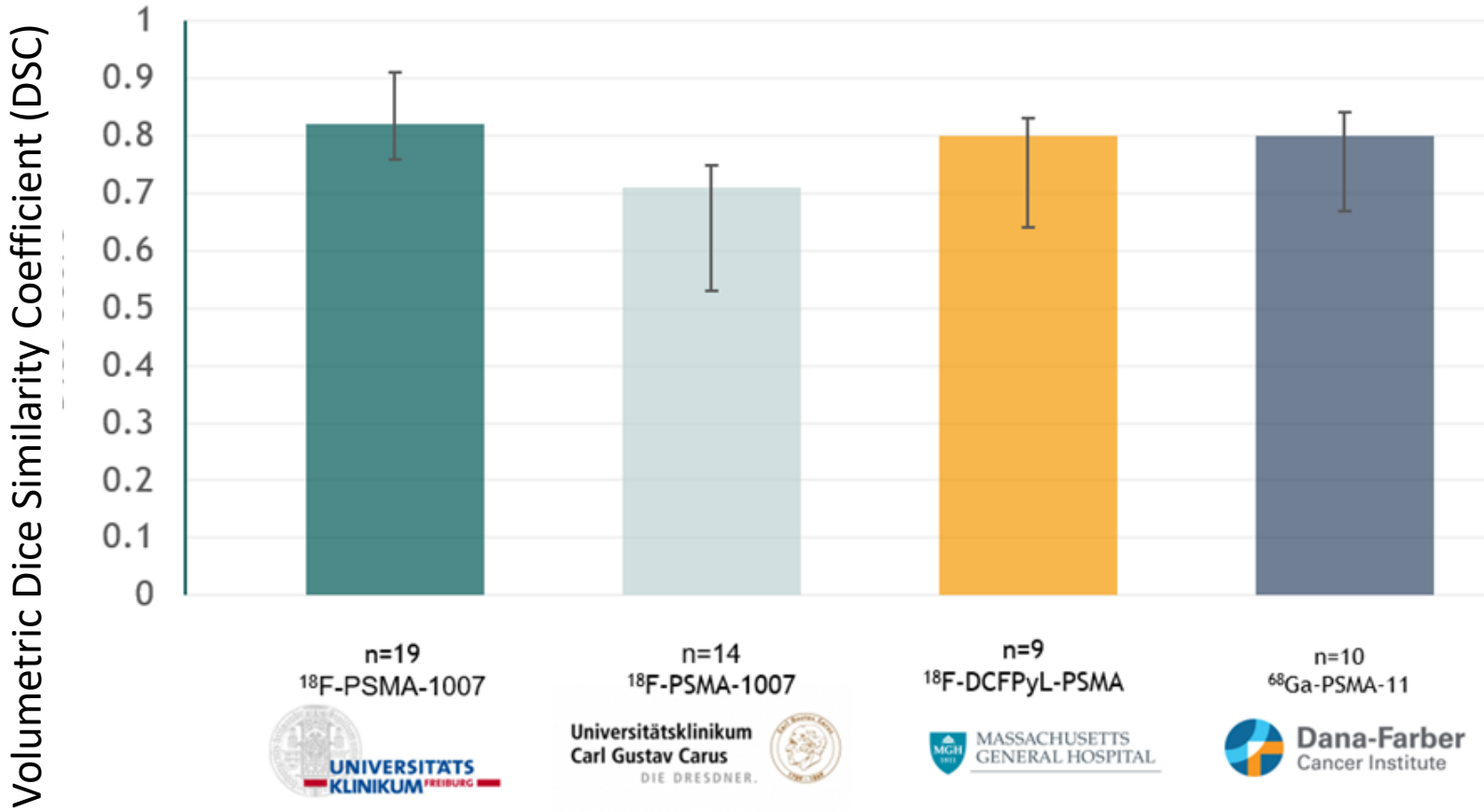
Original Article

Deep learning based automated delineation of the intraprostatic gross tumour volume in PSMA-PET for patients with primary prostate cancer

Julius C. Holzschuh [a,b,c,*], Michael Mix [d], Juri Ruf [d], Tobias Hölscher [f], Jörg Kotzerke [g], Alexis Vrachimis [h], Paul Doolan [s], Harun Ilhan [i], Ioana M. Marinescu [a,b], Simon K.B. Spohn [a,b,j], Tobias Fechter [a,b,e], Dejan Kuhn [a,b,e], Peter Bronsert [k], Christian Gratzke [l], Radu Grosu [m,t], Sophia C. Kamran [n], Pedram Heidari [o], Thomas S.C. Ng [o,p,q], Arda Könik [p,q], Anca-Ligia Grosu [a,b], Constantinos Zamboglou [a,r]

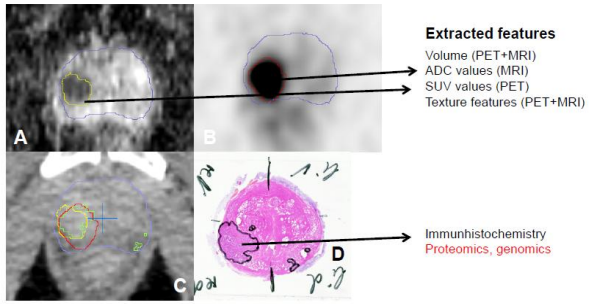
The CNN was trained and tested on **internal and external datasets** as well as **histopathology reference**, achieving a fast GTV segmentation for three PSMA-PET tracers: **18F, 68Ga, 18F-DCFPyL** in different institution, with high diagnostic accuracy comparable to manual experts.





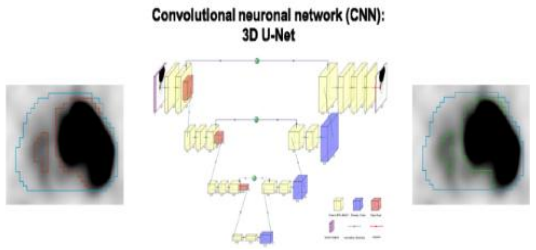
PSMA-PET and mpMRI for Radiation Therapy in Primary Prostate Cancer

Morphology → Biology → Treatment



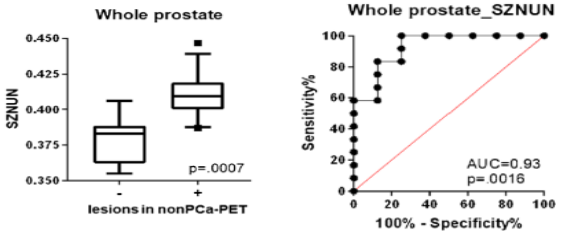
In a slice by slice analysis with histopathology **PSMA-PET and mpMRI showed high sensitivity and specificity in detection of primary PCa**.

Grosu…Krause EJNMMI 2014
Zamboglou…Grosu EJNMMI 2016
Zamboglou…Grosu Theranostics 2016
Zamboglou…Grosu Theranostics 2017
Bettermann…Grosu Radiother Oncol 2019



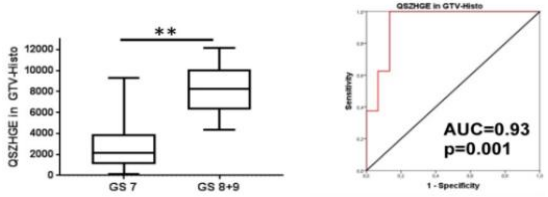
The application of **CNN for automated contouring of GTV in PSMA-PET** resulted in a high concordance with expert contours and in high sensitivities and specificities in comparison to the histology as reference.

Rajan…Grosu R Artif Intel 2023
Holzschuh. Zamboglou Radiother Oncol 2023
Kostyszyn..Grosu..Zamboglou JNM 2021
Spohn … Grosu ..Zamboglou Tharanostics 2021
Spohn..Grosu..Zamboglou EJNMMI 2020



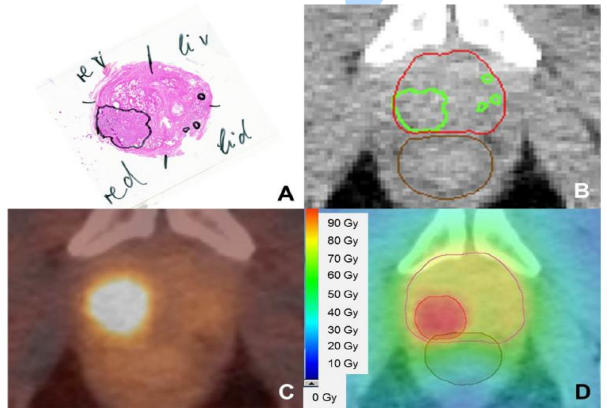
Uncovering the invisible-prevalence, characterisitcs and **radiomics-features**-based detection of visually undetectable intraprostatic tumor lesions in PSMA-PET in primary PCa.

Zamboglou…Grosu EJNMMI 2021



Radiomic features derived from PSMA PET discriminated between PCa and non-Pca tissue and between GI sc 7 and GI sc 8=/>.

Zamboglou…Grosu Theranostics 2019



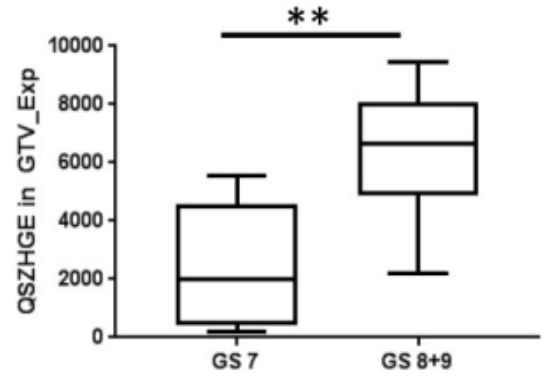
IMRT dose painting using PSMA PET/mpMRI is technically feasible (planning study based on histopathology reference) and resulted in significantly higher **TCPs without higher NTCPs**

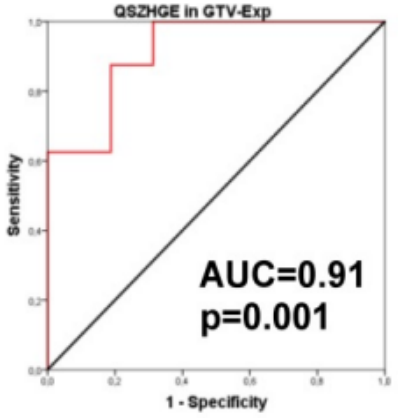
Influence of **radioresistance and intrafractional movement** on the **TCP** in IMRT PCa using SIB PSMA-PET delineated GTV

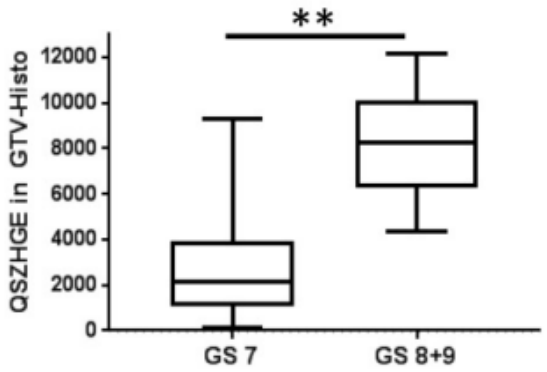
Zamboglou…Grosu IJROBP 2022
Spohn…Zamboglou JROBP 2022
Spohn….Zamboglou Front Oncol 2021
Shapazidis….Baltas Radiat Oncol 2020
Zamboglou…Grosu Radiat Oncol 2018
Thomann…Baltas Radiother Oncol 2018
Zamboglou….Baltas Radiother Oncol 2017

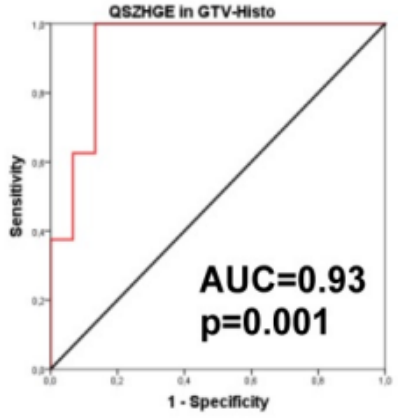
Prostate Cancer: Tumor Malignancy Grade (Gleason Score) after Imaging Processing with AI

Prospective study

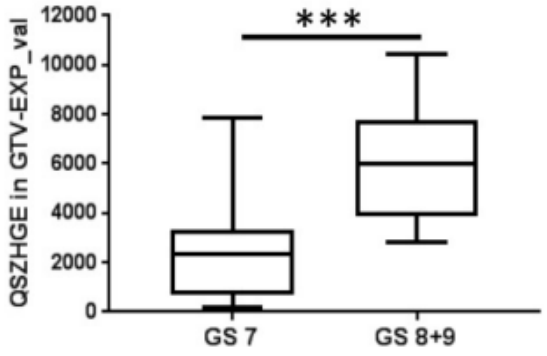








Validation cohort



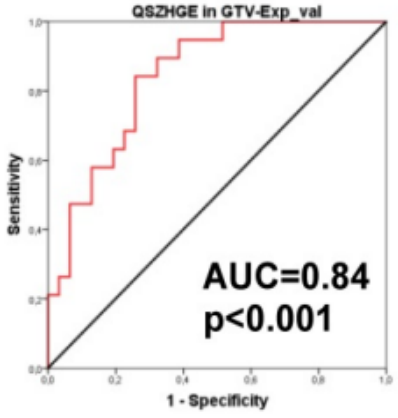


Table 1a. Differentiation between GS 7 and GS > 7 PCa (pooled cohorts)

	Univariate analysis			Multivariate analysis		
Parameter	OR	95% CI	p-value	OR	95% CI	p-value
PSA (<20 vs ≥ 20 ng/ml)	2.87	(1.077.95)	0.04	0.89	(0.21-3.42)	0.87
cT stage (cT2 vs cT3)	4.6	(1.73-12.96)	<0.01	3.65	(1-15.1)	0.05
QSZHGE (metric)	23.56	(6.34-119.5)	<0.01	21.11	(5.12-124.79)	<0.01

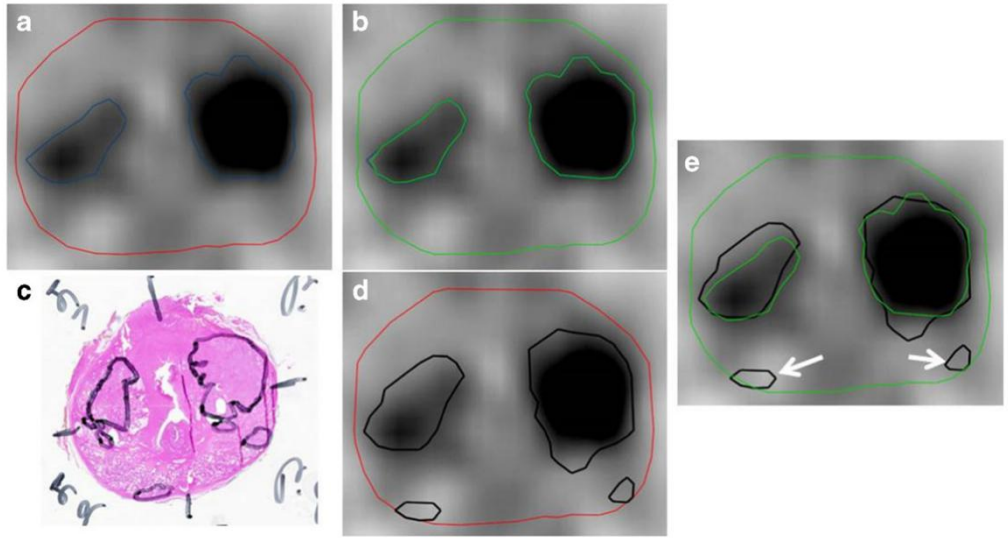
European Journal of Nuclear Medicine and Molecular Imaging
https://doi.org/10.1007/s00259-020-05111-3

ORIGINAL ARTICLE

Uncovering the invisible—prevalence, characteristics, and radiomics feature–based detection of visually undetectable intraprostatic tumor lesions in ^{68}GaPSMA-11 PET images of patients with primary prostate cancer

Constantinos Zamboglou[1,2] · Alisa S. Bettermann[1] · Christian Gratzke[3] · Michael Mix[4] · Juri Ruf[4] · Selina Kiefer[5] · Cordula A. Jilg[3] · Matthias Benndorf[6] · Simon Spohn[1,2] · Thomas F. Fassbender[4] · Peter Bronsert[2,5] · Mengxia Chen[7] · Hongqian Guo[7] · Feng Wang[8] · Xuefeng Qiu[7] · Anca-Ligia Grosu[1,2]

Received: 31 July 2020 / Accepted: 8 November 2020



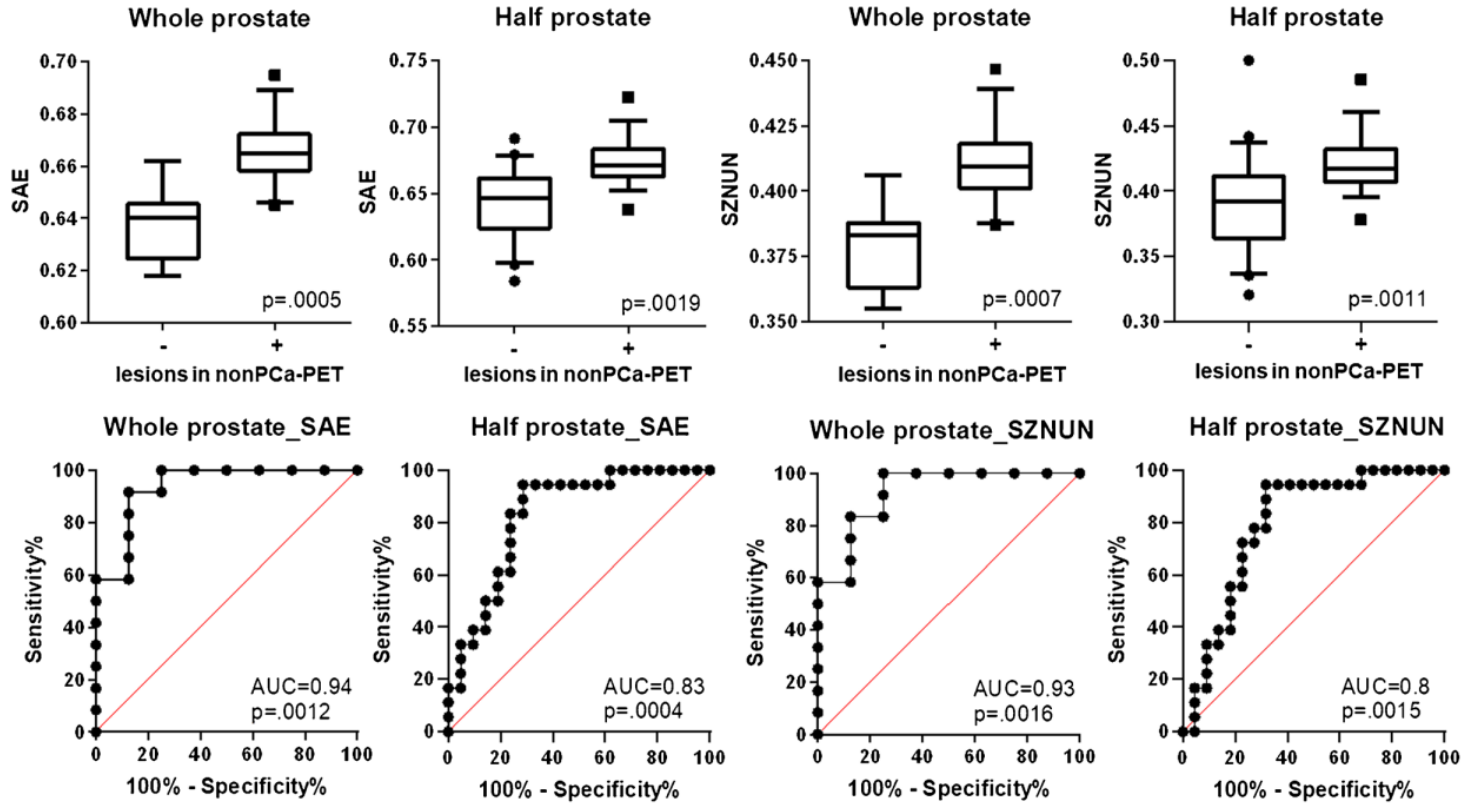


Image-guided focal dose escalation in patients with primary prostate cancer (*intermediate and high risk*) treated with primary external beam hypofractionated stereotactic radiation therapy

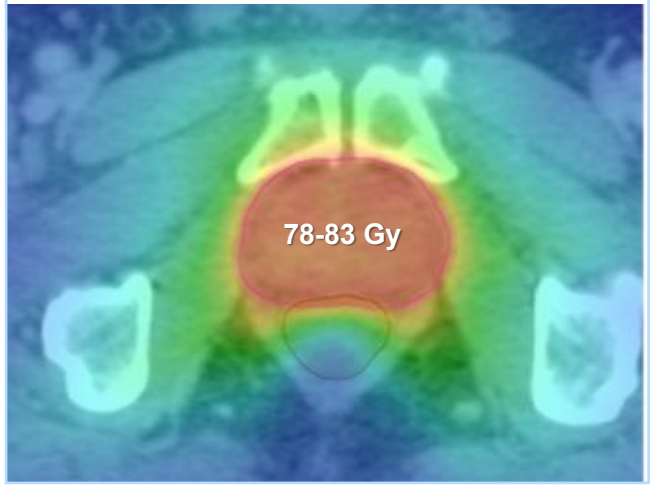
(HypoFocal-SBRT) – International (24 centers), prospective, randomized phase III trial

374 Patients

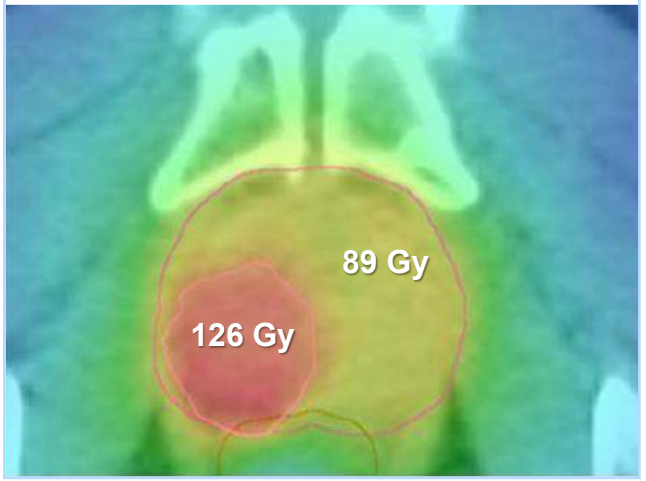
NATIONALE DEKADE GEGEN KREBS

Control Arm:
homogeneous RTx of the prostate
60-62 Gy in 20 days
(EQD2 80 Gy*)

*alpha/beta = 1.2



Experimental Arm:
SBRT and focused dose escalation based on PET/mpMRI
35/40-42 Gy in 5 days
(EQD2 89/115-126 Gy*)



Advancing Radioproteomics: Integration of Prostate-specific Membrane Antigen Positron Emission Tomography/Computed Tomography and Multiparametric Magnetic Resonance Imaging with Localized Proteomic Profiling in Prostate Cancer *(European Urology 2025)*



M Fahrner, C Zamboglou, SKB Spohn, B Oerther, T Fechter, MT Freitag, C Gratzke, P Bronsert, O Schilling, AL Grosu

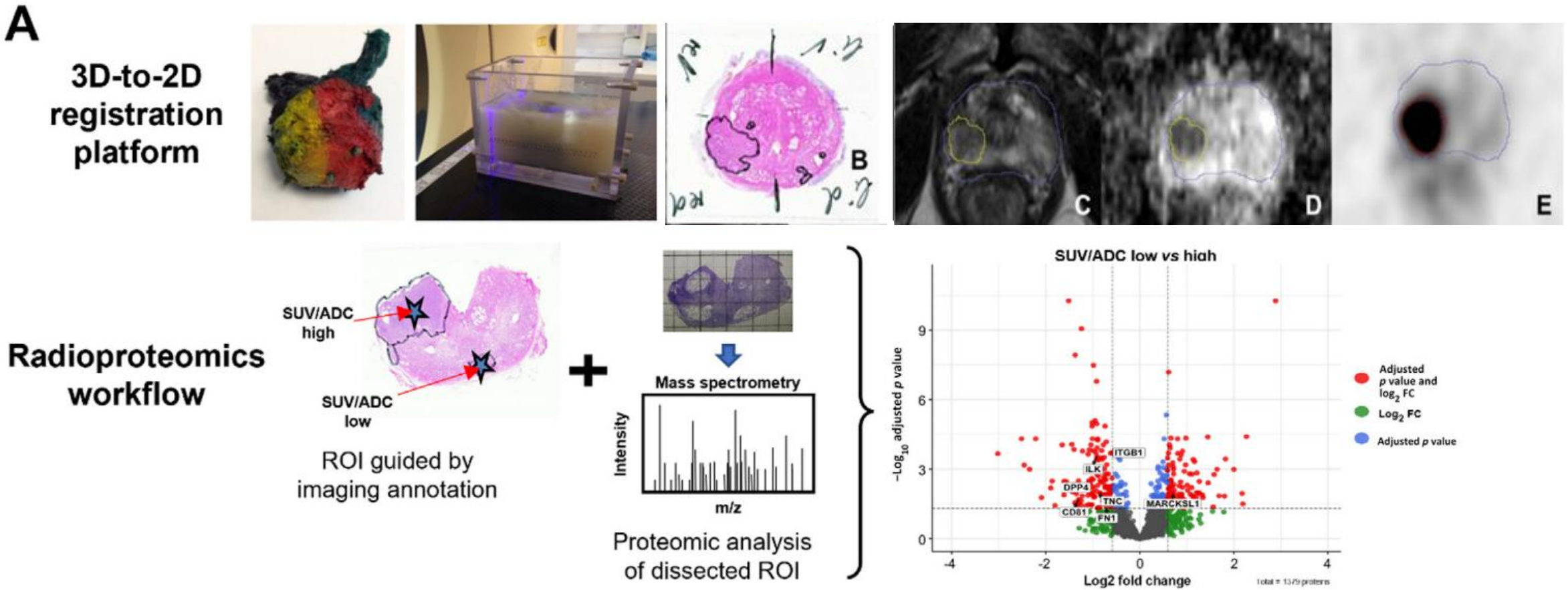
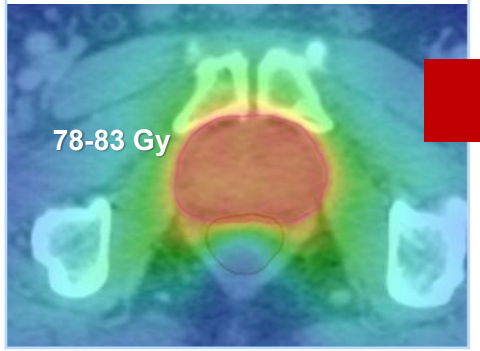


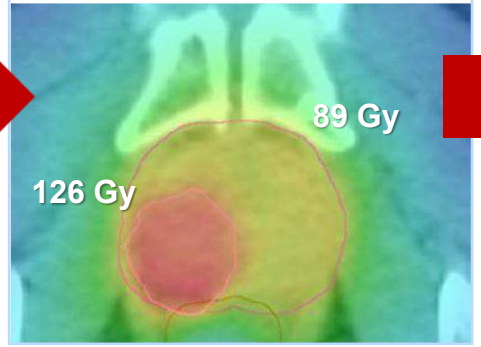
Image-guided focal dose escalation in patients with *intermediate and high-risk* prostate cancer treated with primary external beam hypofractionated stereotactic radiation therapy (HypoFocal-SBRT)

300/374 Patients – 24 centers in EU

Control Arm:
homogeneous RTx of the prostate
60-62 Gy in 20 days
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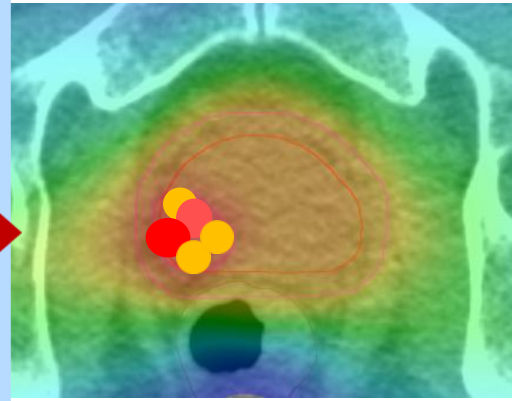


NATIONALE DEKADE GEGEN KREBS

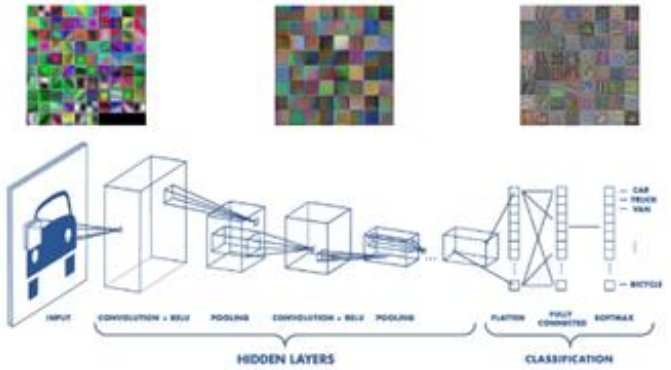
Bundesministerium für Forschung, Technologie und Raumfahrt

The goal for the future
biologically individualized radiation treatment

RTx
based on
bio-(imaging) markers:
probability of tumor,
TCP, NTCP

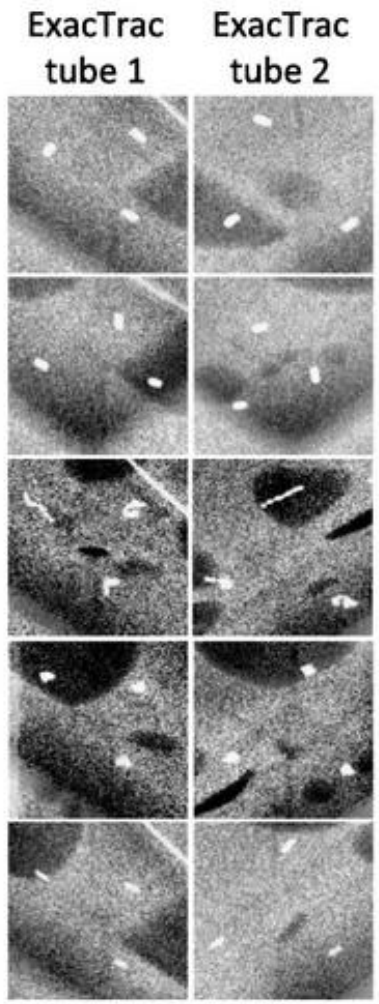


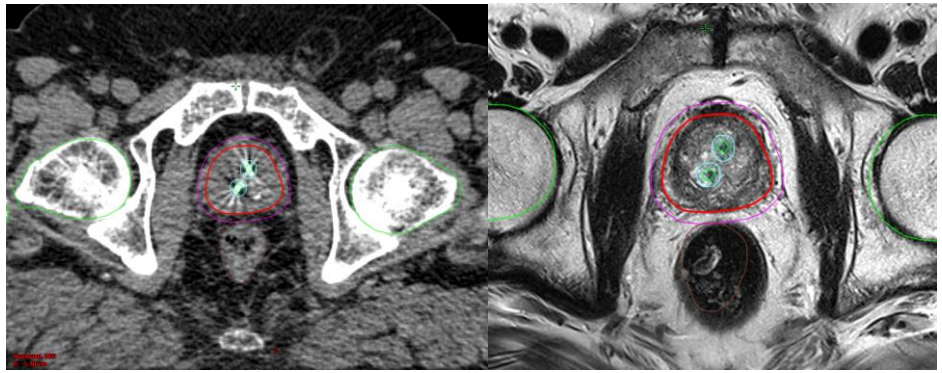
- biomarkers/-imaging
- AI tools for image interpretation and biological individualized treatment planning

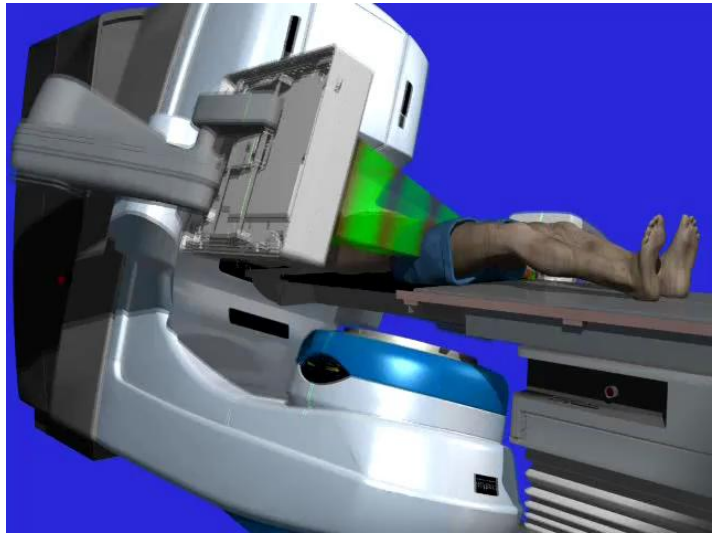


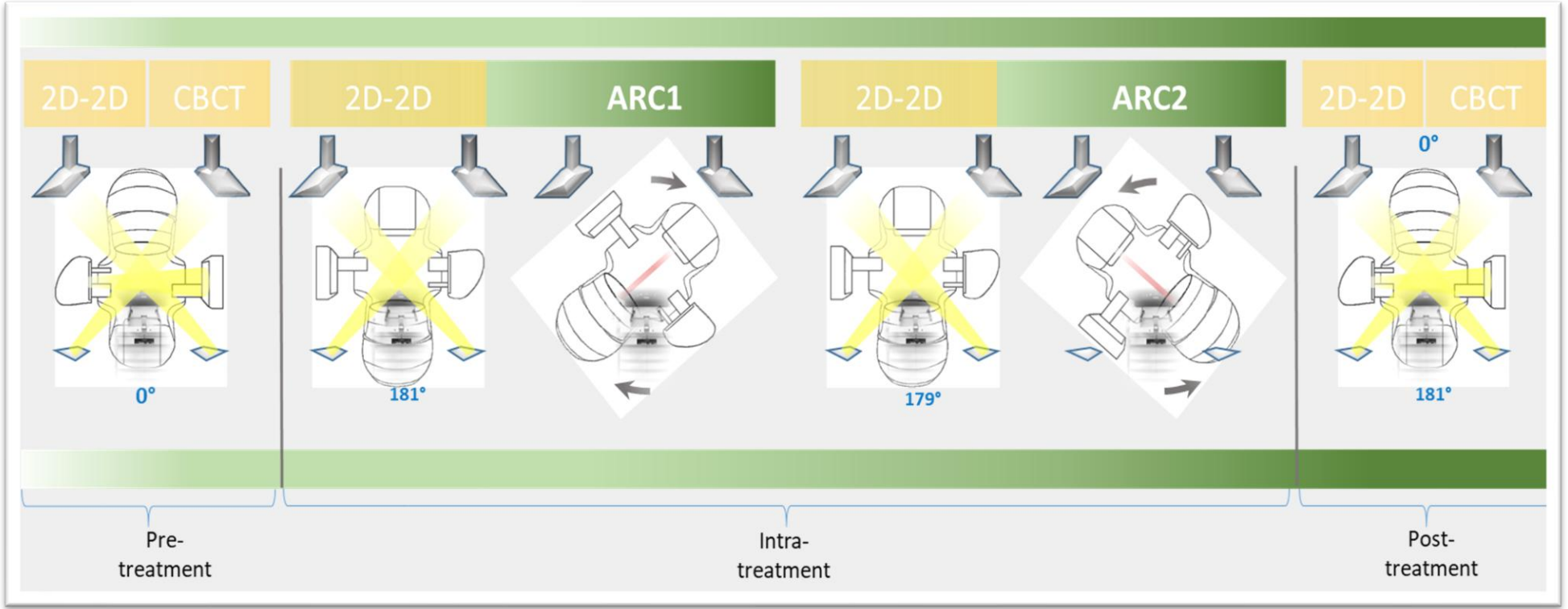
DFG Deutsche Forschungsgemeinschaft

Image Guided RTx and Adaptive RTx using AI – Prostate Cancer









UNIVERSITÄTS KLINIKUM FREIBURG
CCCF COMPREHENSIVE CANCER CENTER FREIBURG
dkfz.
German Cancer Consortium
Partner site Freiburg

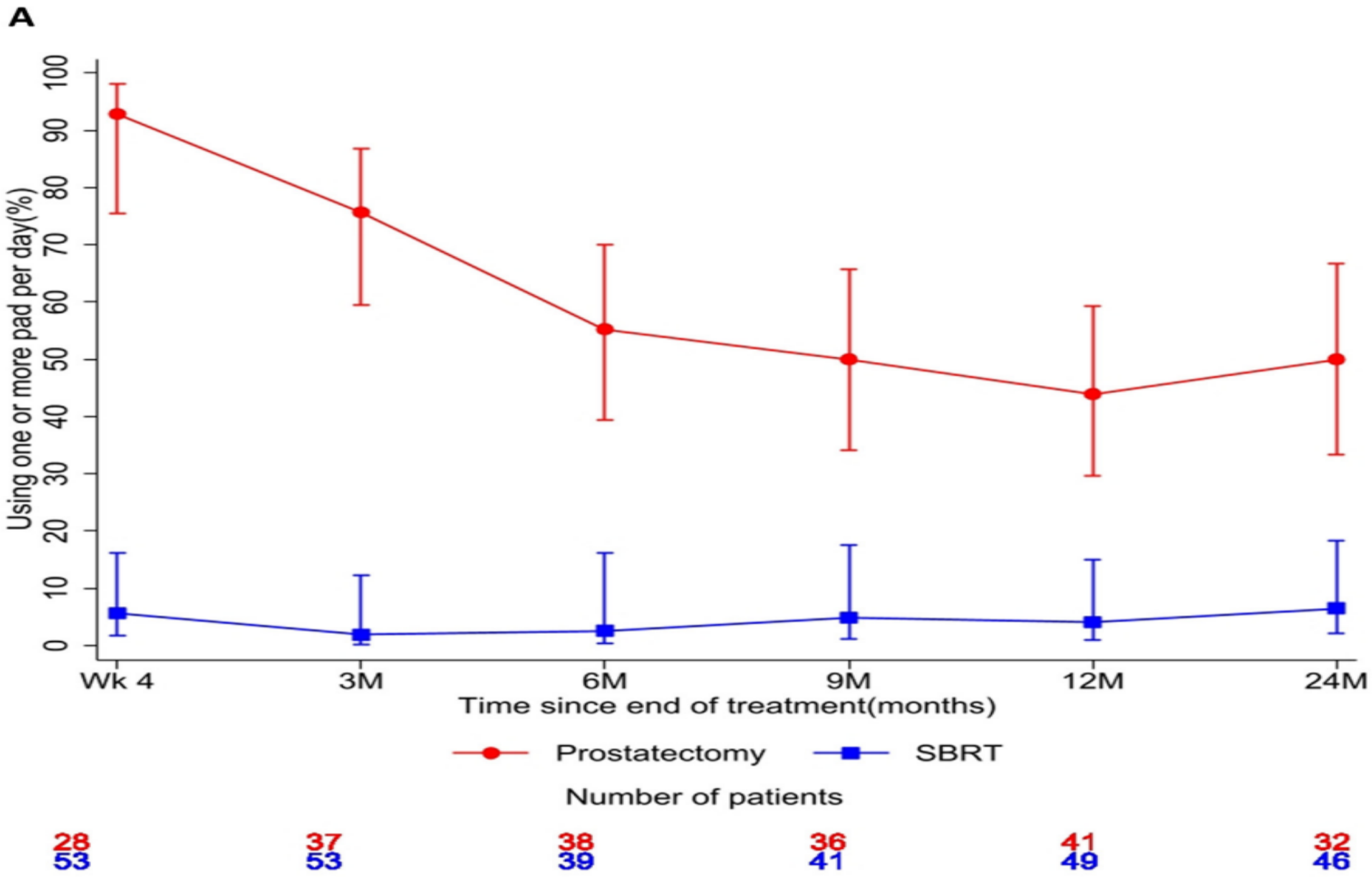
OPERATION (DA VINCI ROBOTER) VERSUS STEREOTAKTISCHE STRAHLENTHERAPIE (5 Fkt.) BEI *(Low Grade)* PROSTATAKARZINOM



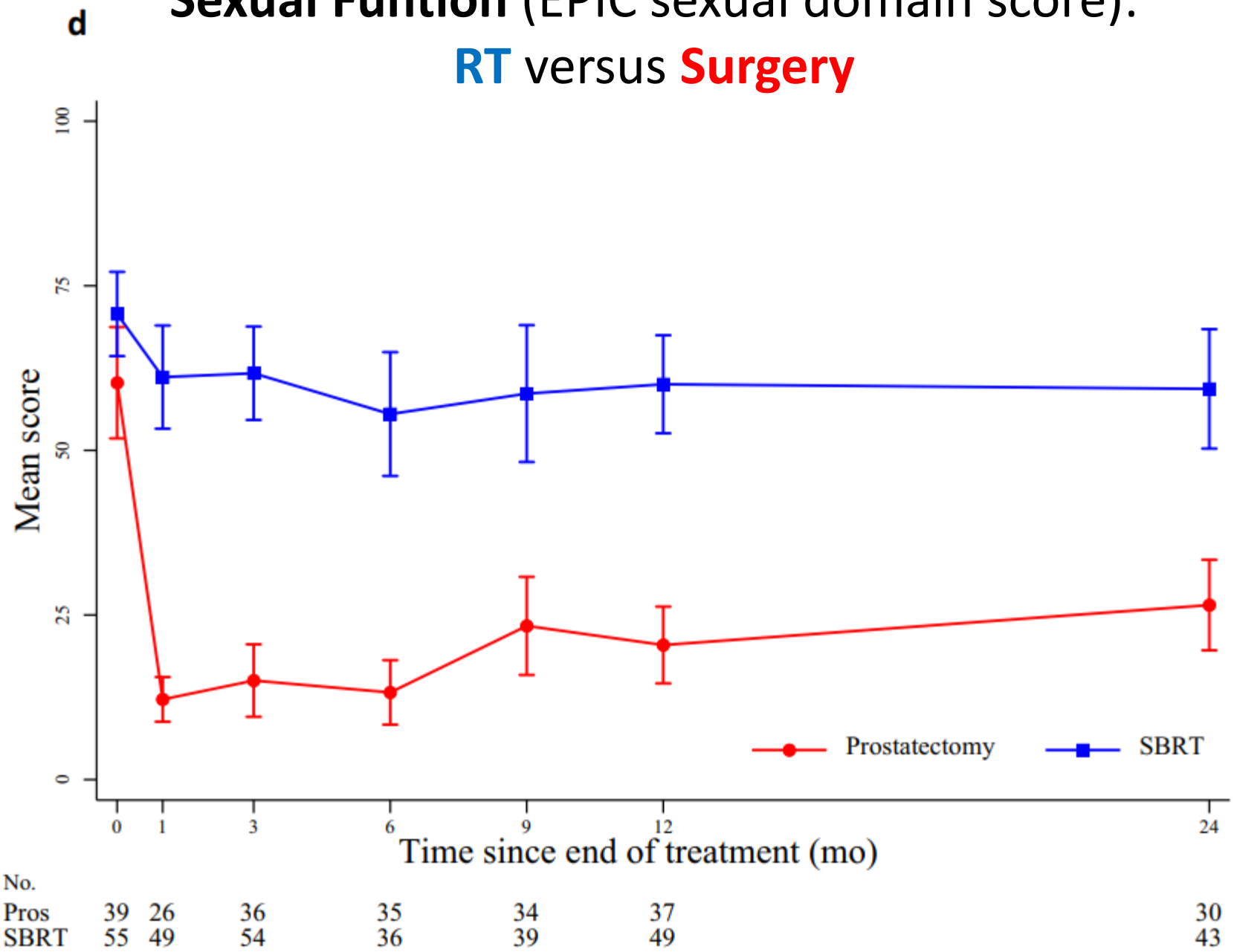


Das Bild stammt aus einem Vortrag des Studienleiters Dr. Nicholas van As.

Urinary Function after RT versus Surgery



Sexual Funtion (EPIC sexual domain score): RT versus Surgery



AI in Health Care

1. Medical Imaging Analysis
2. Clinical Decision Support
3. Personalized Medicine: Omnics Analysis
4. Patient Monitoring
5. Robotics Surgery and Radiation Therapy

Challenges and Cosiderations

1. Data Quality and Privacy
2. Ethical and Regulatory Issues
3. Implementation and Adoption



Demis Hassabis, geb. 1976
Nobel 2024, Chemistry

Question: What does a completely new world, largely based on AI, need in order to function properly?

DH: Philosophers!

Question: What is the next revolution in science after AI?

DH: The development of intelligent materials.

(Interview Davos WWF, 2025 – Symposium AI in Health Care)

THANK YOU!

