

Will innovation change compliance in RT?

Innovation in adaptive EBRT

Department of Radiation Oncology, University Hospital, LMU Munich
12.04.2021 | PD Dr. Stefanie Corradini



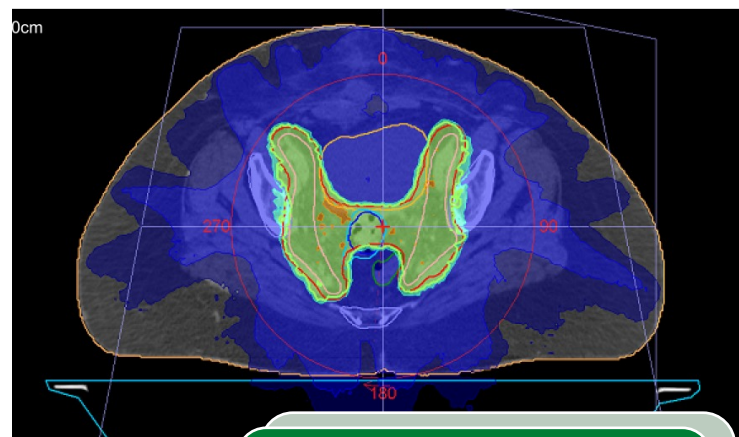
Global Disclaimer

- In keeping with our role as a university hospital, we are active in research and receive funding from various sources
- Research is supported by government agencies: Free State of Bavaria, Cancer Aid, DFG, BMBF (DKTK, DZL) and BMU
- For individual research projects and/or meeting presentations and participation in advisory boards, the department is supported by:
 AstraZeneca, MERCK, MSD, BMS, ViewRay, ELEKTA, Brainlab and C-RAD and OPASCA

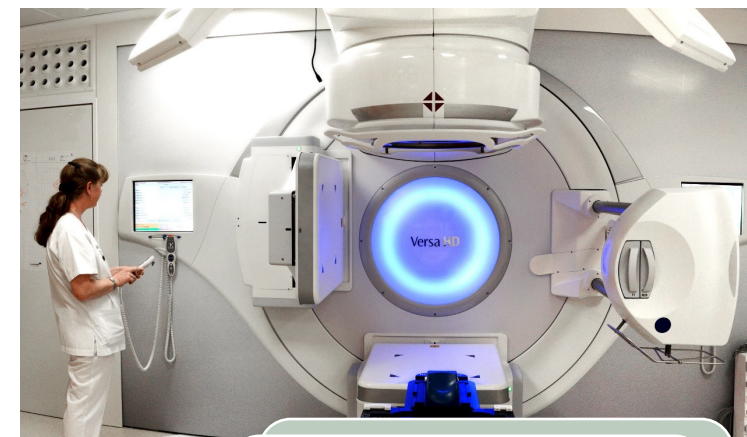
Traditional CT-based workflow



CT simulation



Treatment
planning



Dose delivery

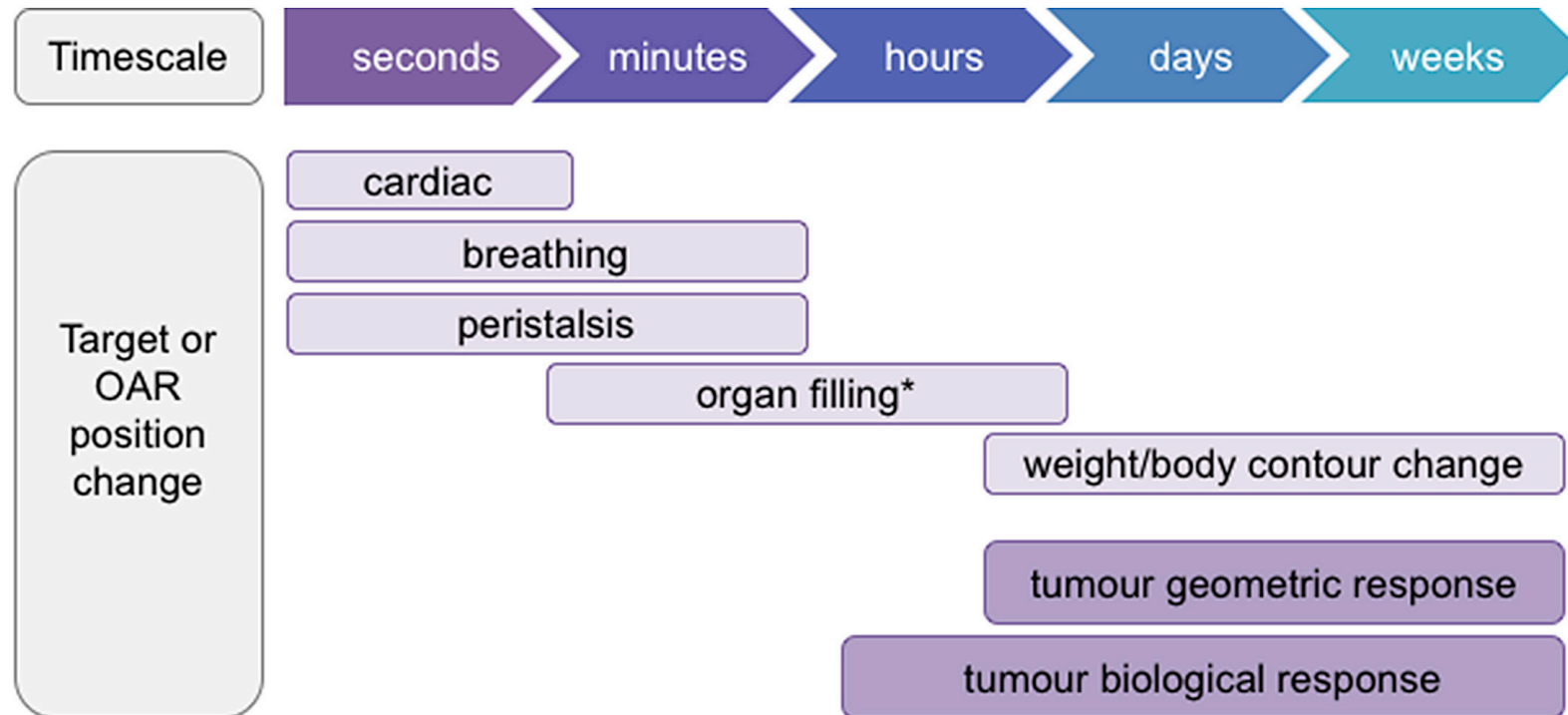


Adaptive Radiation Therapy (ART)

Rationale

Adaptive Radiotherapy Enabled by MRI Guidance

A. Hunt^{*†}, V.N. Hansen^{*†}, U. Oelfke^{*†}, S. Nill^{*†}, S. Hafeez^{*†}

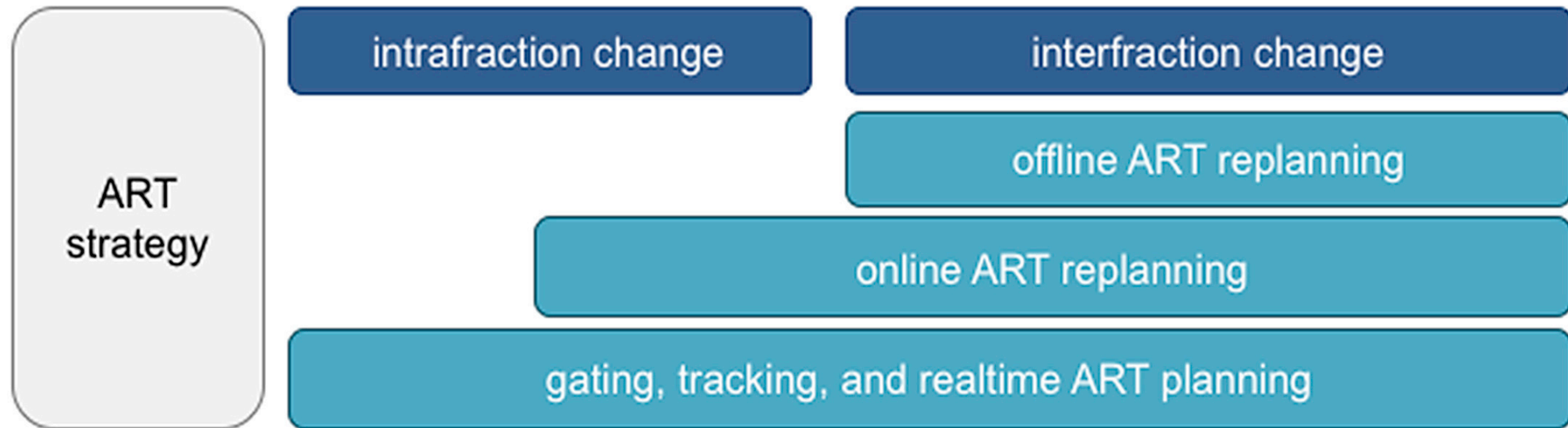




Adaptive Radiation Therapy Strategies

Adaptive Radiotherapy Enabled by MRI Guidance

A. Hunt^{*†}, V.N. Hansen^{*†}, U. Oelfke^{*†}, S. Nill^{*†}, S. Hafeez^{*†}

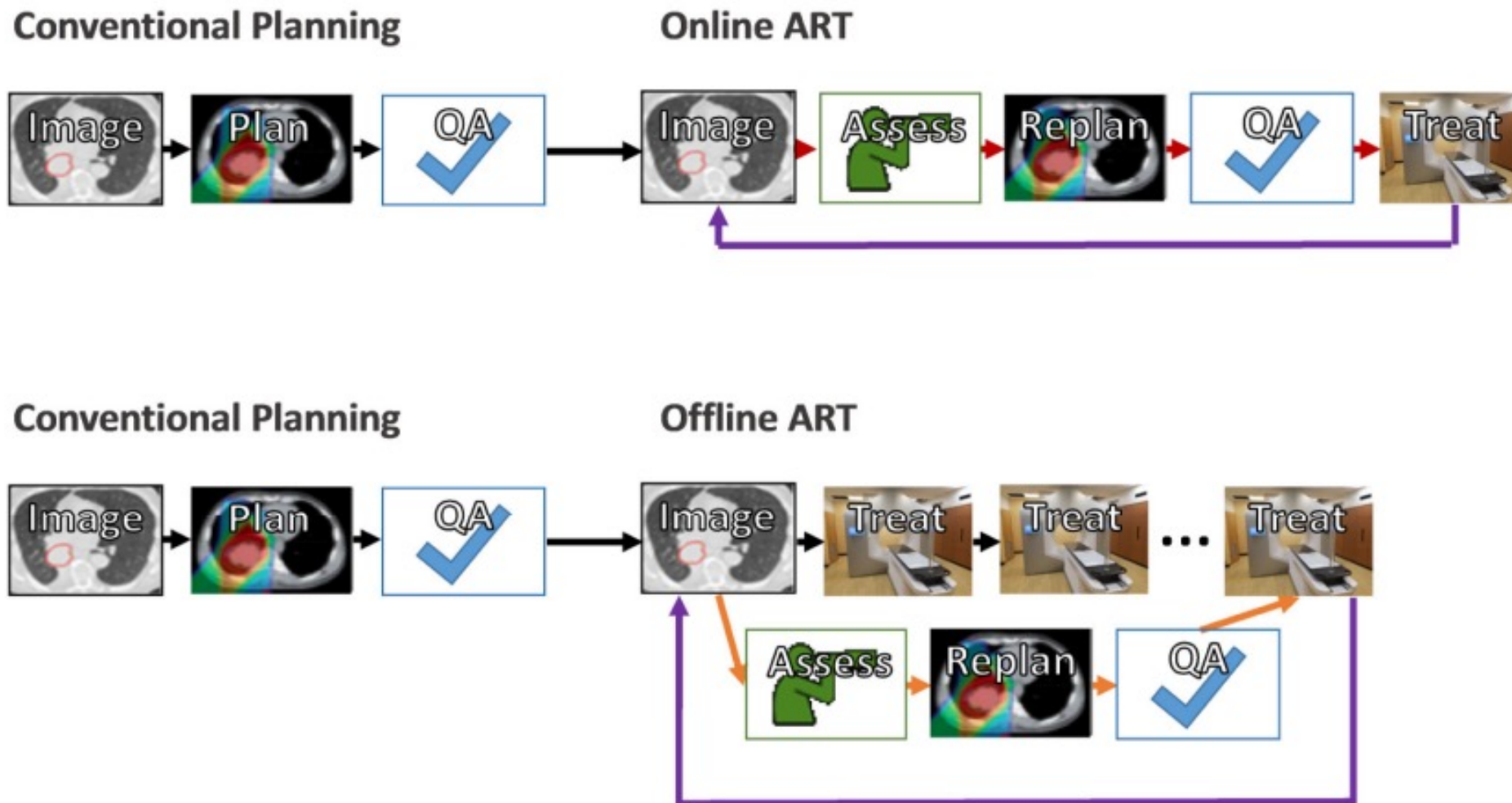


Adaptive Radiation Therapy (ART)

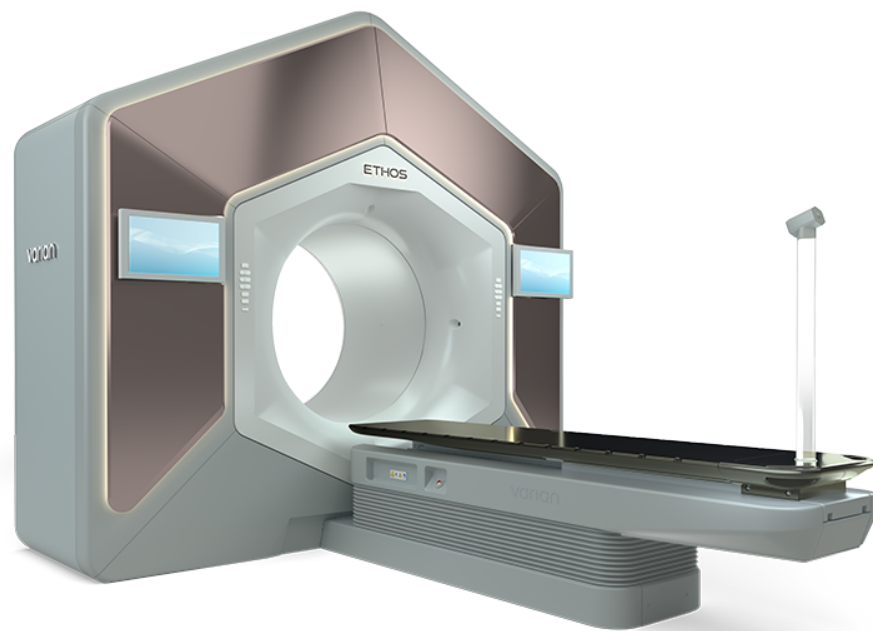
Workflow

Practical Clinical Workflows for Online and Offline Adaptive Radiation Therapy

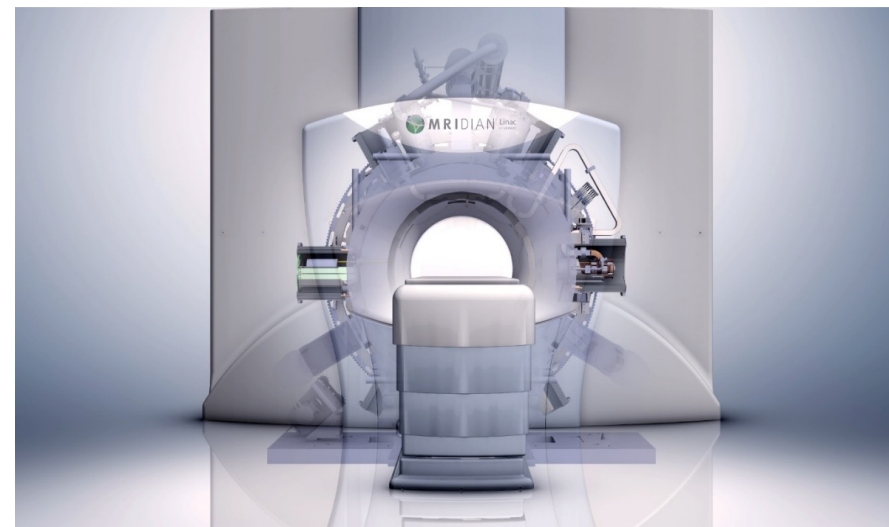
Olga L. Green, Lauren E. Henke, and Geoffrey D. Hugo
Department of Radiation Oncology, Washington University School of Medicine, St. Louis, MO



Online ART Technology



CBCT based



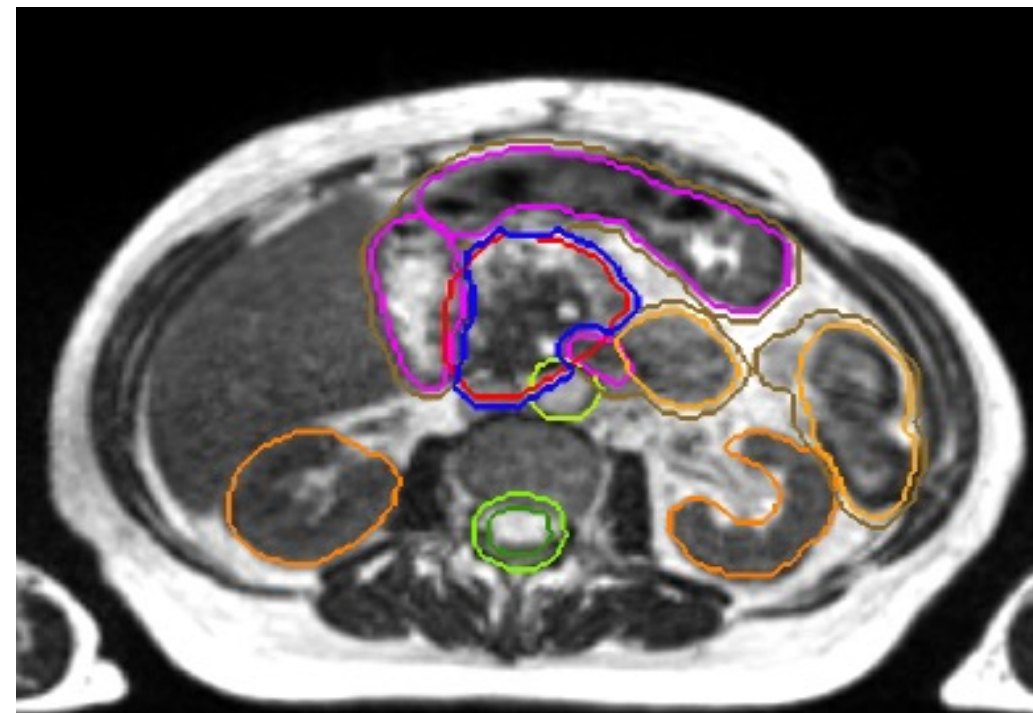
MRI based

Online ART

MR-guided RT

Benefits of MR-gRT:

- Superior image quality using MRI
- real-time adaptive radiotherapy
- respiratory-gated radiotherapy
- Potential for dose escalation while sparing organs at risk



Benefits

Online ART

MR-guided RT

Challenges:

- MRI environment
- Adaptive workflows
- Close interdisciplinary teamwork required
- Longer treatment times
- High costs





Original Article

ESTRO-ACROP recommendations on the clinical implementation of hybrid MR-linac systems in radiation oncology

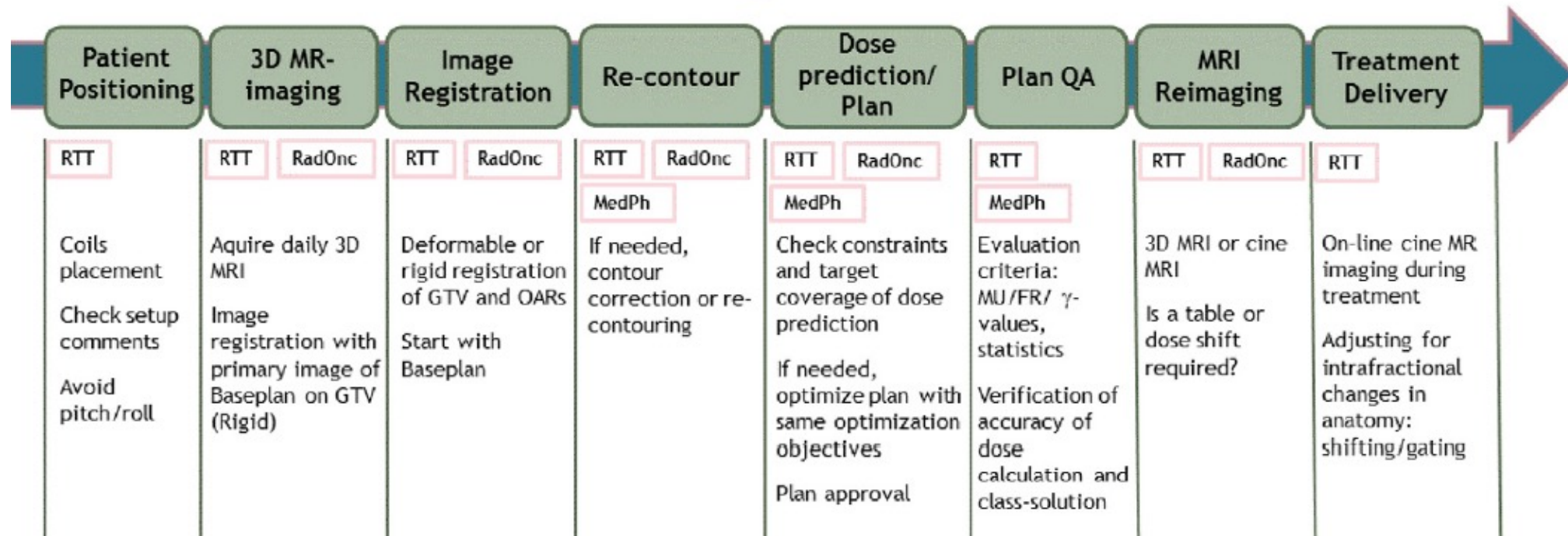


Stefanie Corradini ^{a,*}, Filippo Alongi ^b, Nicolaus Andratschke ^c, David Azria ^d, Omar Bohoudi ^e, Luca Boldrini ^f, Anna Bruynzeel ^e, Juliane Hörner-Rieber ^g, Ina Jürgenliemk-Schulz ^h, Frank Lagerwaard ^e, Helen McNair ⁱ, Bas Raaymakers ^h, Tine Schytte ^j, Alison Tree ^l, Vincenzo Valentini ^f, Lotte Wilke ^e, Daniel Zips ^k, Claus Belka ^a

Online ART

MRL workflows

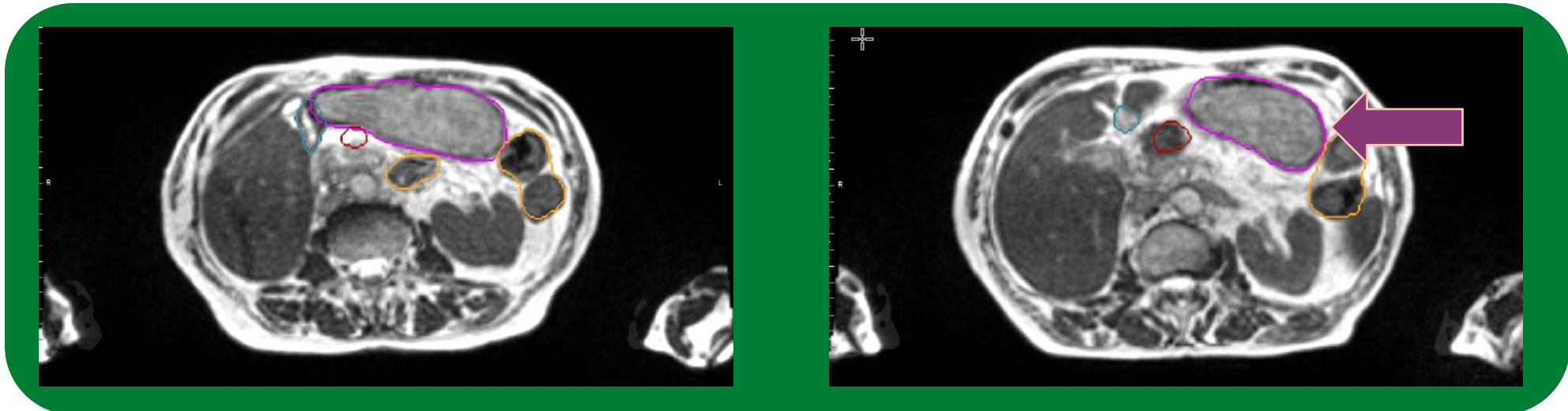
Clinical MRgRT workflow



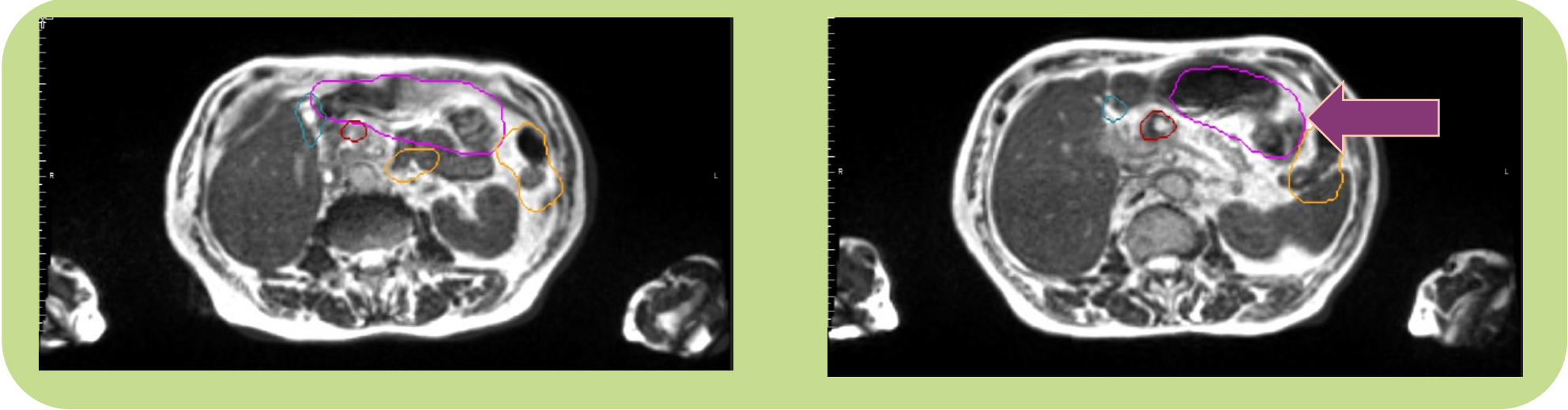
Green boxes: workflow pathway, red boxes: suggested professionals (Radiation technologists/therapist (RTT), radiation oncologists (RadOnc) and medical physicists (MedPh))

Online MRgRT

Pancreatic cancer



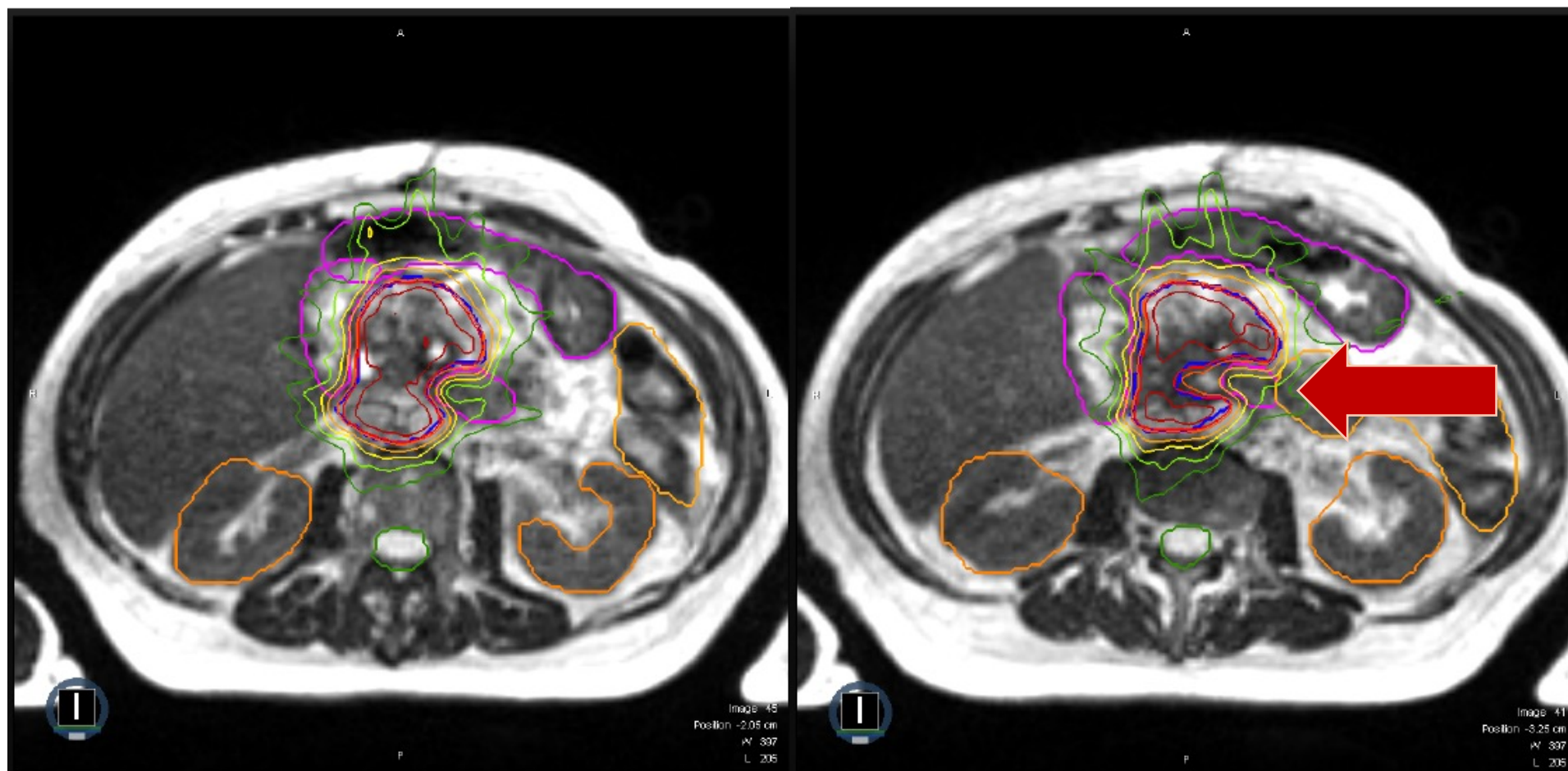
Plan



1. Fraction

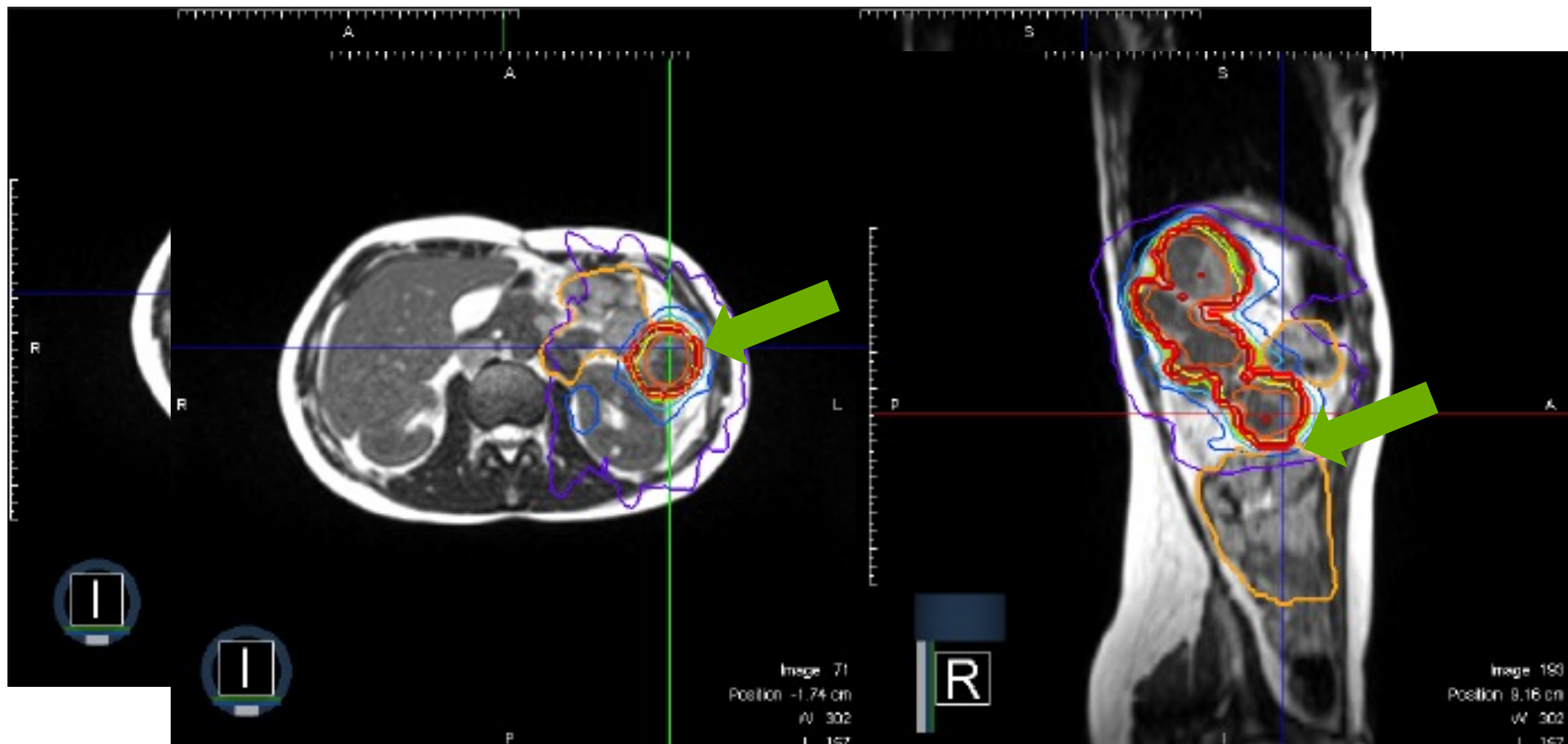
Online MRgRT

Pancreatic cancer



Online MRgRT

Abdominal Metastases



Online MRgRT

Gyn Boost






<input checked="" type="checkbox"/>	25.00 Gy 125.0 %
<input checked="" type="checkbox"/>	22.00 Gy 110.0 %
<input checked="" type="checkbox"/>	20.00 Gy 100.0 %
<input checked="" type="checkbox"/>	15.00 Gy 75.0 %
<input checked="" type="checkbox"/>	10.00 Gy 50.0 %
<input checked="" type="checkbox"/>	7.00 Gy 35.0 %

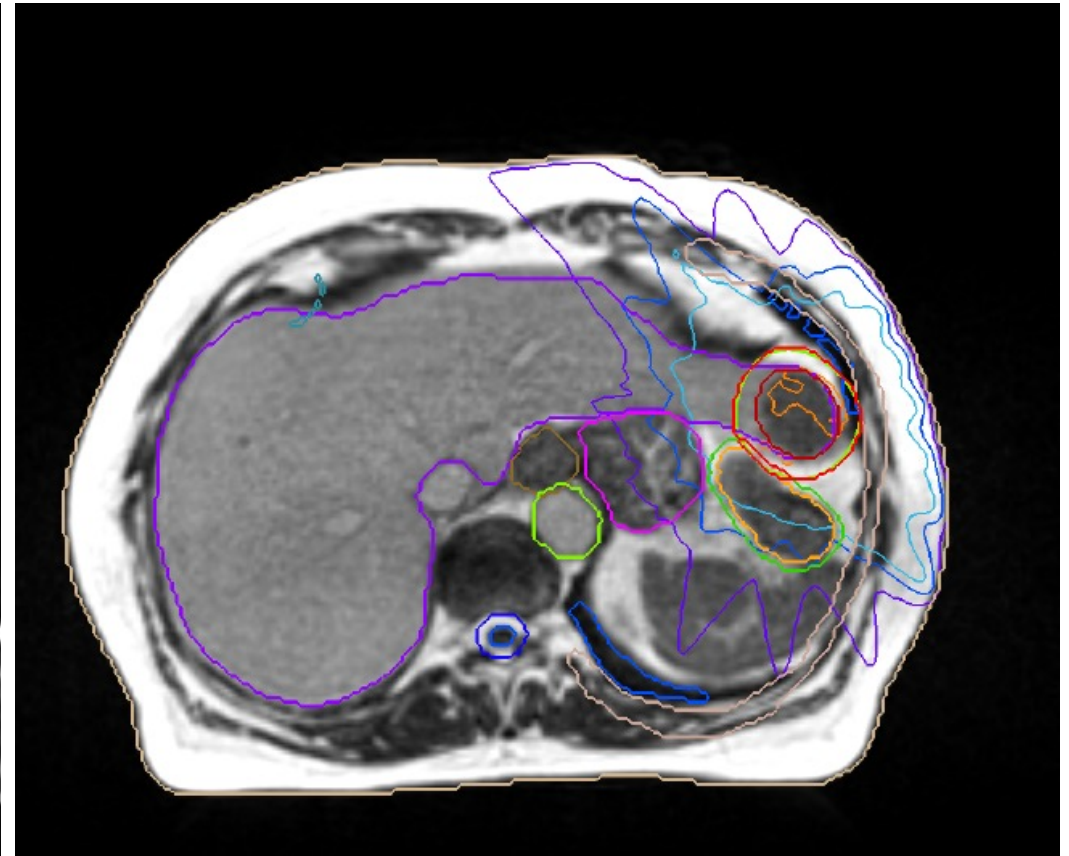
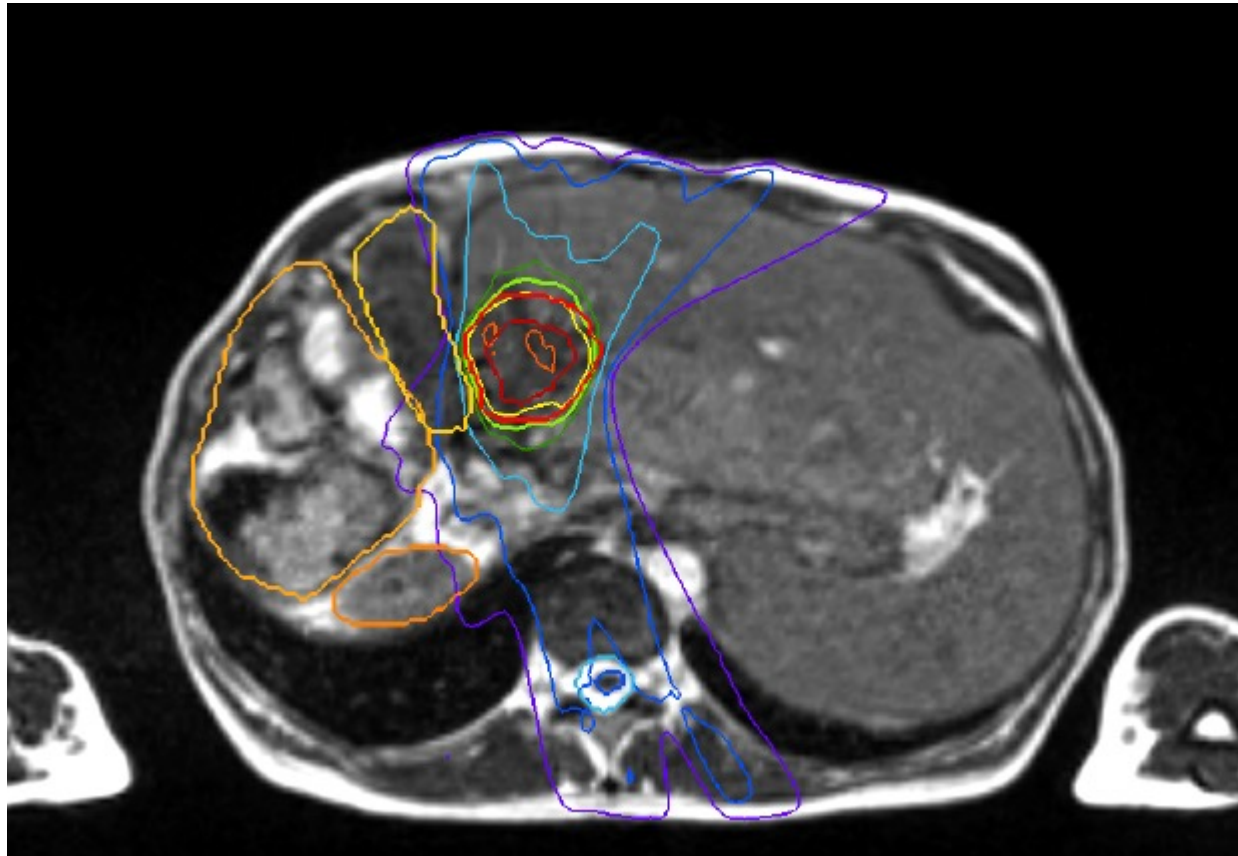
- EBRT 45Gy
- MRgRT Boost 4x5Gy (80%ID)
- PTVopt = 131,35ccm
- Gesamt-EQD2₁₀ = 69,3Gy₁₀

Online MRgRT
Liver tumors

Article

Feasibility and Early Clinical Experience of Online Adaptive MR-Guided Radiotherapy of Liver Tumors

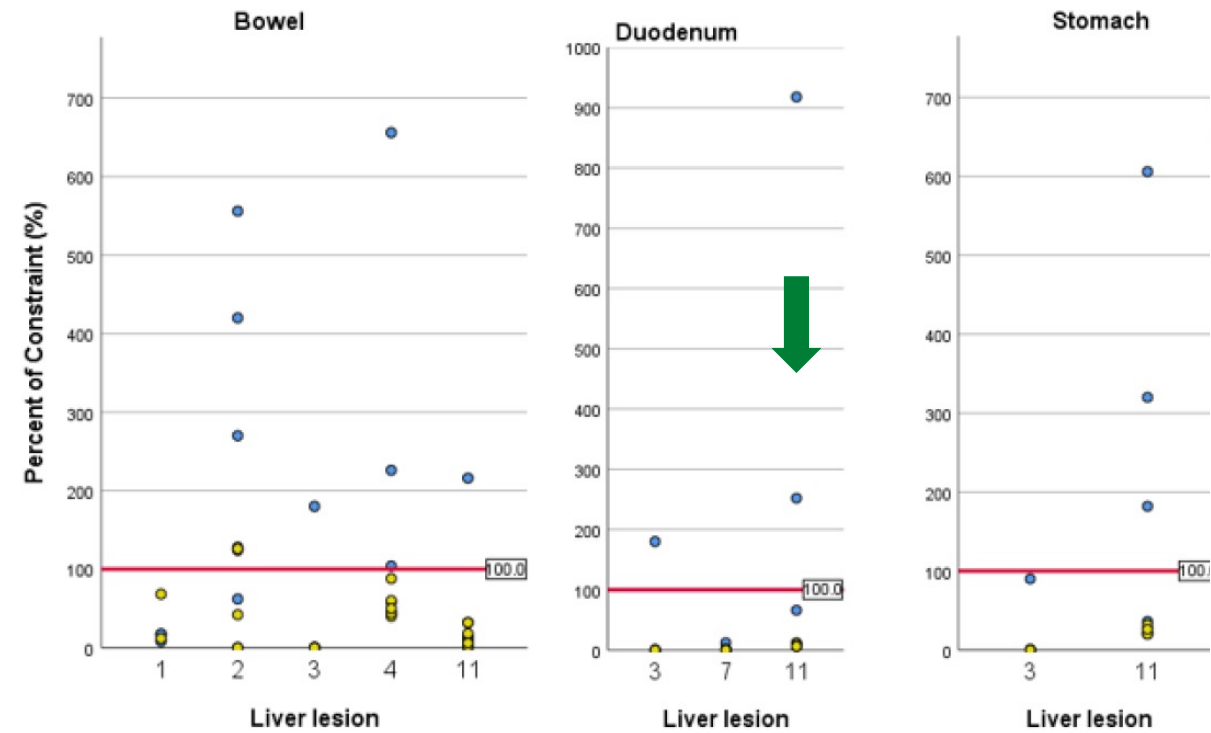
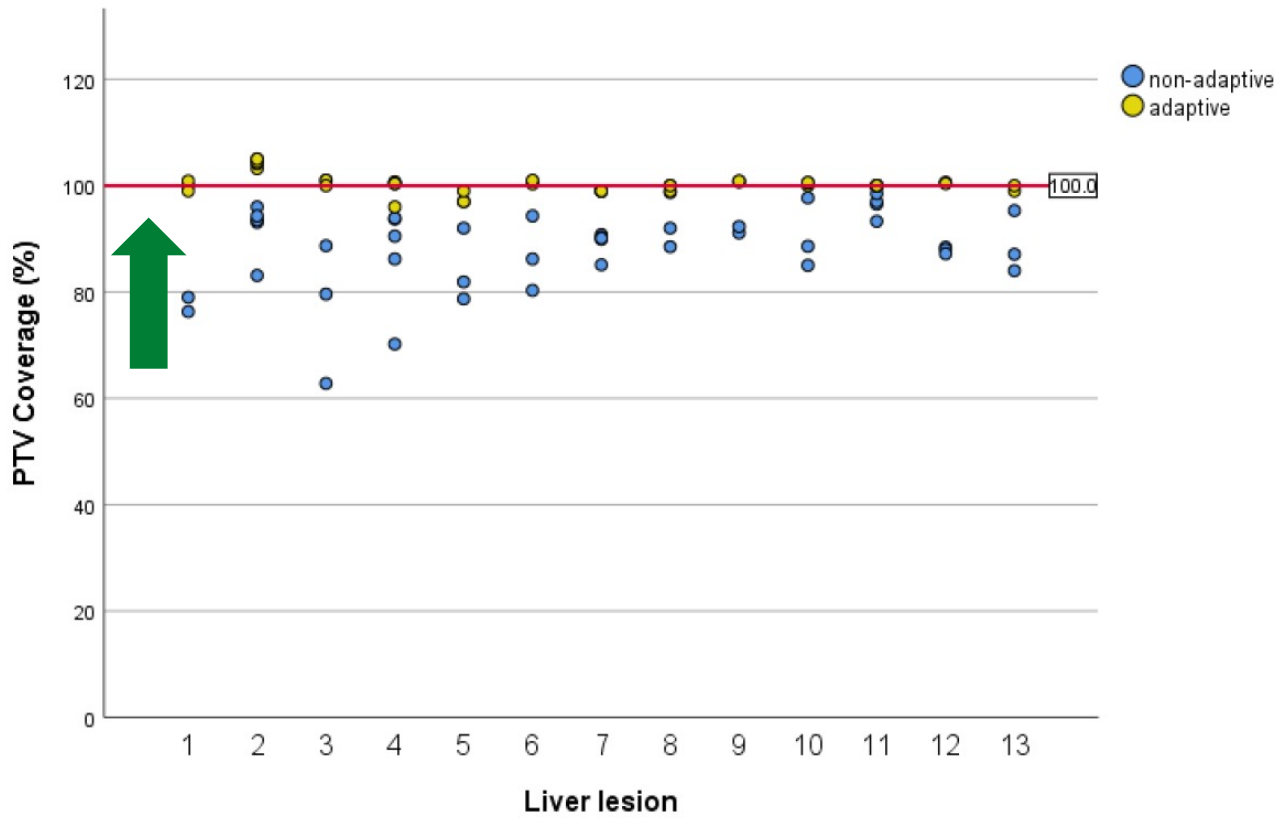
Paul Rogowski ^{1,*} , Rieke von Bestenbostel ¹, Franziska Walter ¹, Katrin Straub ¹, Lukas Nierer ¹ , Christopher Kurz ¹, Guillaume Landry ¹ , Michael Reiner ¹, Christoph Josef Auernhammer ^{2,3} , Claus Belka ^{1,4}, Maximilian Niyazi ^{1,4} and Stefanie Corradini ¹ 



Online MRgRT Liver tumors

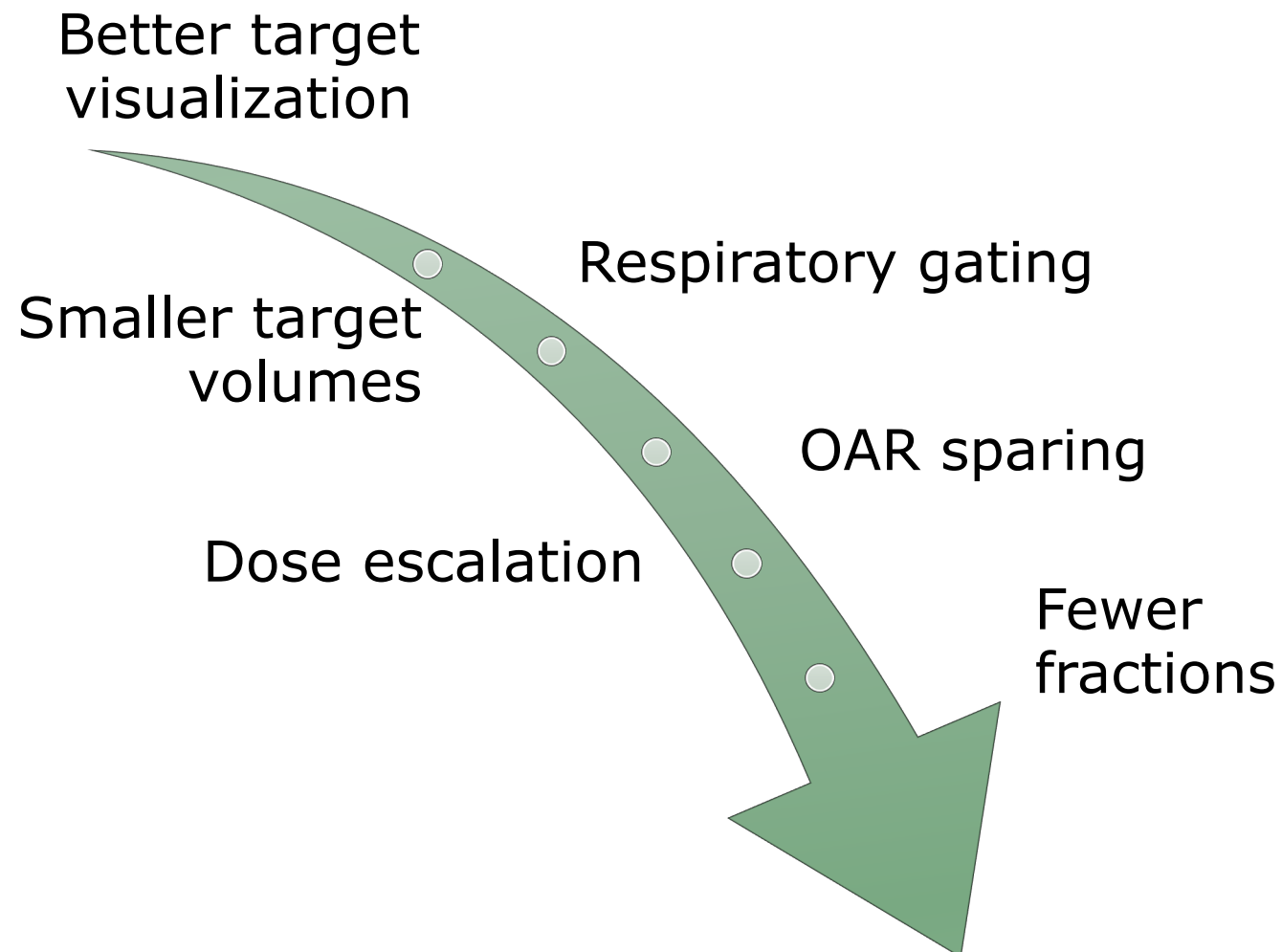
Article Feasibility and Early Clinical Experience of Online Adaptive MR-Guided Radiotherapy of Liver Tumors

Paul Rogowski ^{1,*}, Rieke von Bestenbostel ¹, Franziska Walter ¹, Katrin Straub ¹, Lukas Nierer ¹, Christopher Kurz ¹, Guillaume Landry ¹, Michael Reiner ¹, Christoph Josef Auernhammer ^{2,3}, Claus Belka ^{1,4}, Maximilian Niyazi ^{1,4} and Stefanie Corradini ¹



Potential benefits

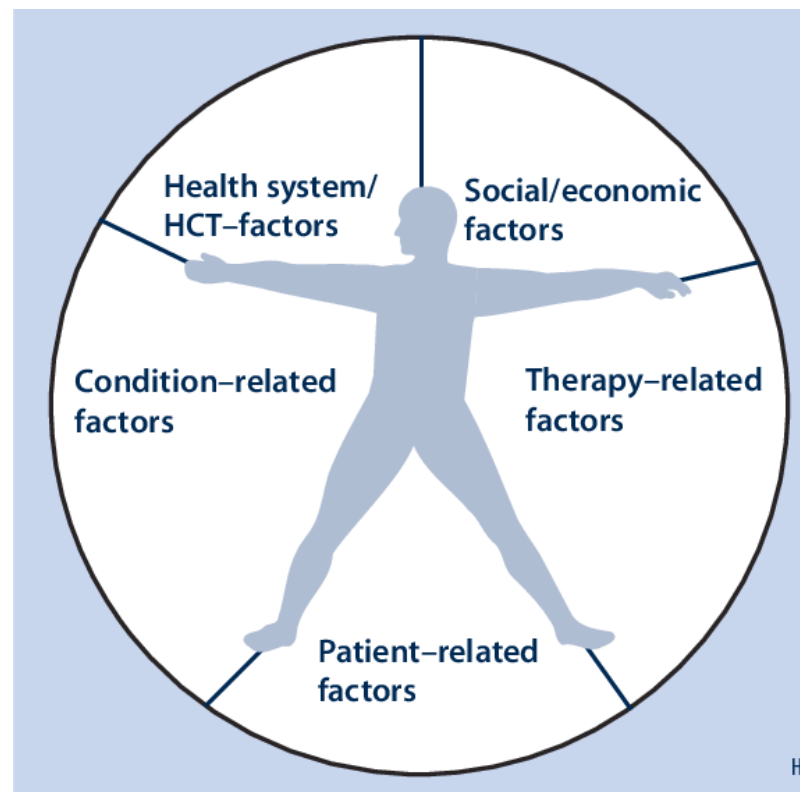
Which could improve patient compliance



Patient compliance in MRg ART

Factors

- Education
- Financial support
- Social support



- MR compatibility
- Symptoms
- Comorbidities
- Claustrophobia

- Duration of treatment
- Number of fractions
- MR environment

- Gender
- Age
- Preferences



Original Article

ESTRO-ACROP recommendations on the clinical implementation of hybrid MR-linac systems in radiation oncology



Stefanie Corradini ^{a,*}, Filippo Alongi ^b, Nicolaus Andratschke ^c, David Azria ^d, Omar Bohoudi ^e, Luca Boldrini ^f, Anna Bruynzeel ^e, Juliane Hörner-Rieber ^g, Ina Jürgenliemk-Schulz ^h, Frank Lagerwaard ^e, Helen McNair ⁱ, Bas Raaymakers ^h, Tine Schytte ^j, Alison Tree ^l, Vincenzo Valentini ^f, Lotte Wilke ^e, Daniel Zips ^k, Claus Belka ^a

Online MRgRT

Patient selection criteria



Patient screening for MR-compatibility

- ✓ metal screening
- ✓ implant screening
- ✓ pacemaker/ICD screening





Original Article

ESTRO-ACROP recommendations on the clinical implementation of hybrid MR-linac systems in radiation oncology



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Online MRgRT

Patient selection criteria



- **Physically incompatible** (i.e. non-MR conditional pacemaker)
- **Clinically incompatible** (i.e. major psychiatric disorder, severe claustrophobia, inability to understand instructions)
- **Borderline compatible** (i.e. mild claustrophobia)
- **Fully compatible** for MRgRT

- Patients who are assessed as **incompatible** or who **refuse** oMRgRT treatment, should be directly referred to **standard RT delivery units**
- **Appropriate interventions** (e.g. psychological intervention, anesthesia, pharmacological or supportive techniques (music, aromatherapy, hypnosis) could be used for **borderline compatible patients**.

Online MRgRT Treatment duration

Physics Contribution

Role of On-Table Plan Adaptation in MR-Guided Ablative Radiation Therapy for Central Lung Tumors

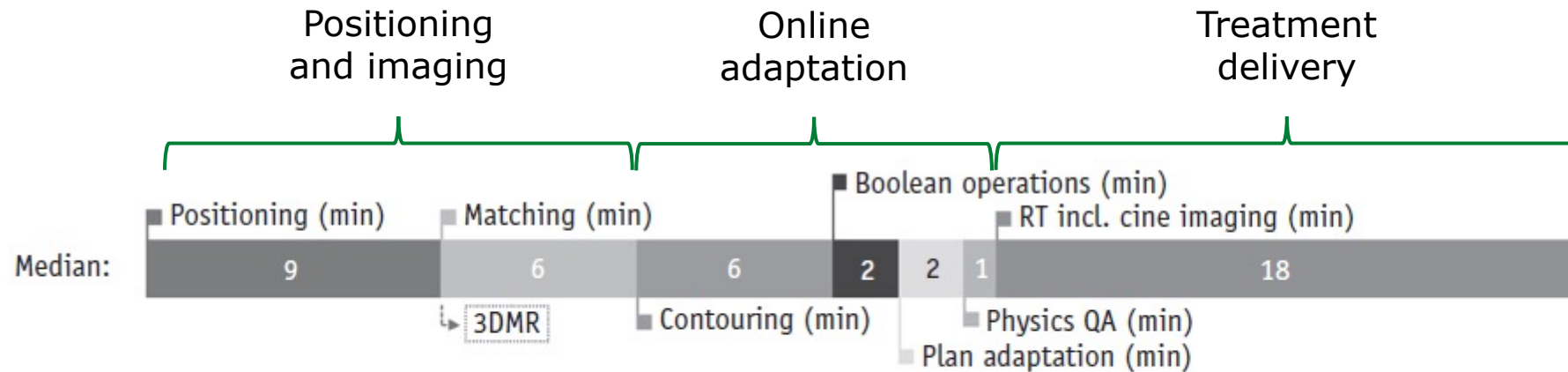
Tobias Finazzi, MD, Miguel A. Palacios, PhD,
Femke O.B. Spoelstra, MD, PhD, Cornelis J.A. Haasbeek, MD, PhD,
Anna M.E. Bruynzeel, MD, PhD, Ben J. Slotman, MD, PhD,
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Received Dec 10, 2018. Accepted for publication Mar 20, 2019.



- Longer treatment times than in conventional RT

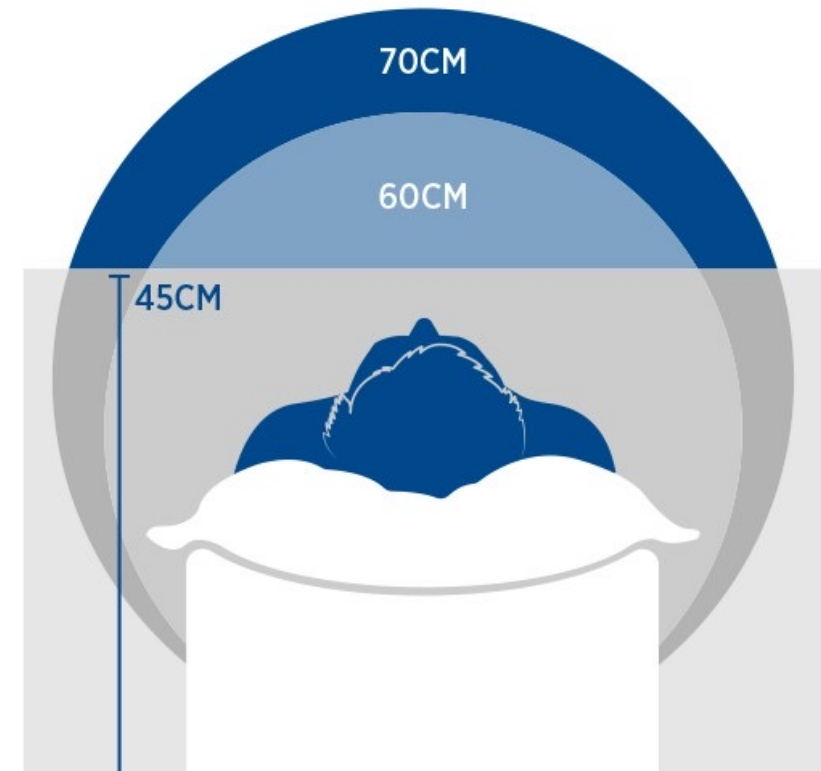
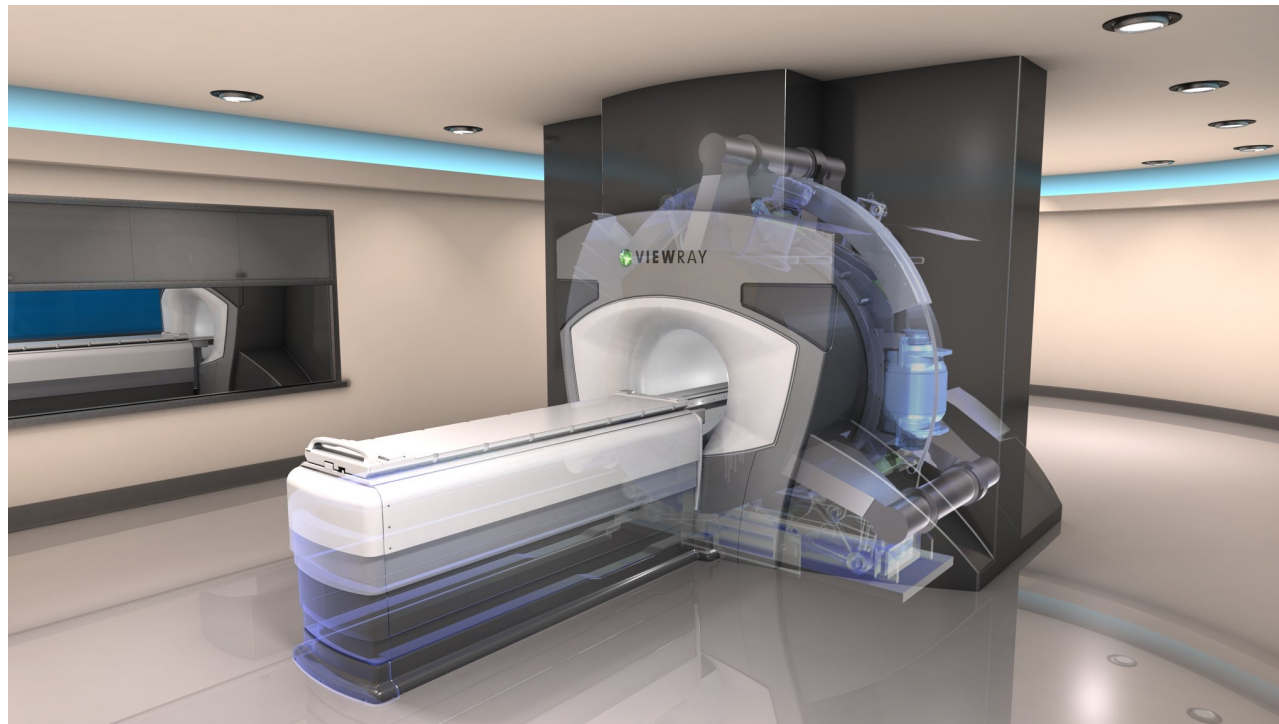


LMU	Mean treatment time ADAPTIVE	43 Min
	Mean treatment time Non-Adaptive	23 Min

Online MRgRT

Bore size

- Limited bore size in all available systems <70cm
- Length of tunnel (232cm) – risk for claustrophobia



Visual Feedback oMRgRT



FIGURE 1 | Patient set-up during magnetic resonance-guided radiation therapy.

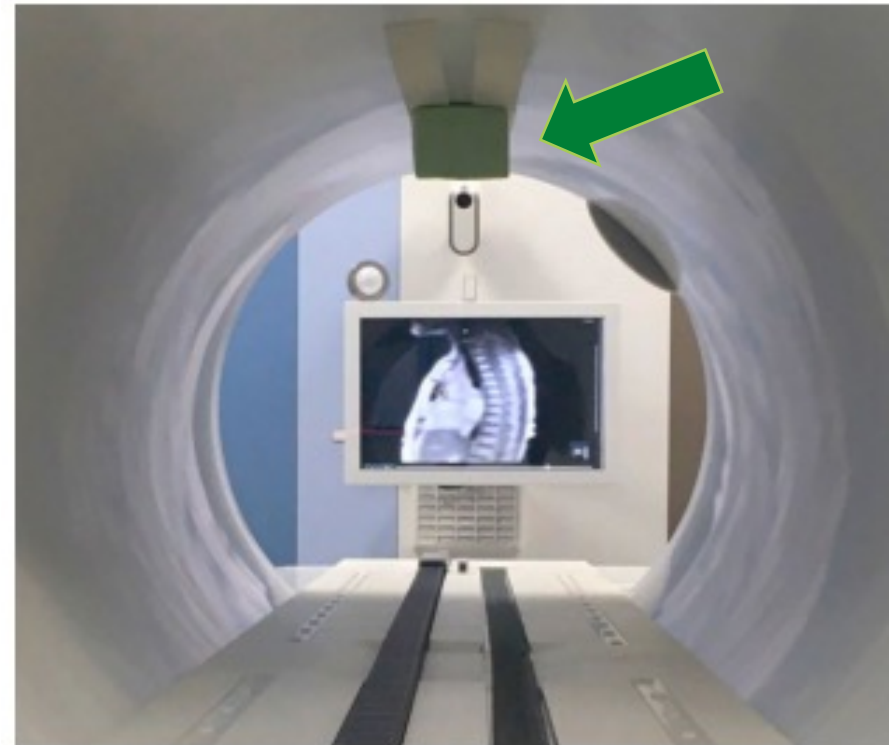


First prospective clinical evaluation of feasibility and patient acceptance of magnetic resonance-guided radiotherapy in Germany

Sebastian Klüter^{1,2,3} · Sonja Katayama^{1,2,3} · C. Katharina Spindeldreier^{1,2,3} · Stefan A. Koerber^{1,2,3} · Gerald Major^{1,2,3} · Markus Alber^{1,2,3} · Sati Akbaba^{1,2,3} · Jürgen Debus^{1,2,3,4,5} · Juliane Hörner-Rieber^{1,2,3,5}

Patient-Reported Tolerance of Magnetic Resonance-Guided Radiation Therapy

Mutlay Sayan^{1*}, Ilkay Serbez², Bilgehan Teymur², Gokhan Gur², Teuta Zoto Mustafayev², Gorkem Gungor², Banu Atalar² and Enis Ozyar^{2*}



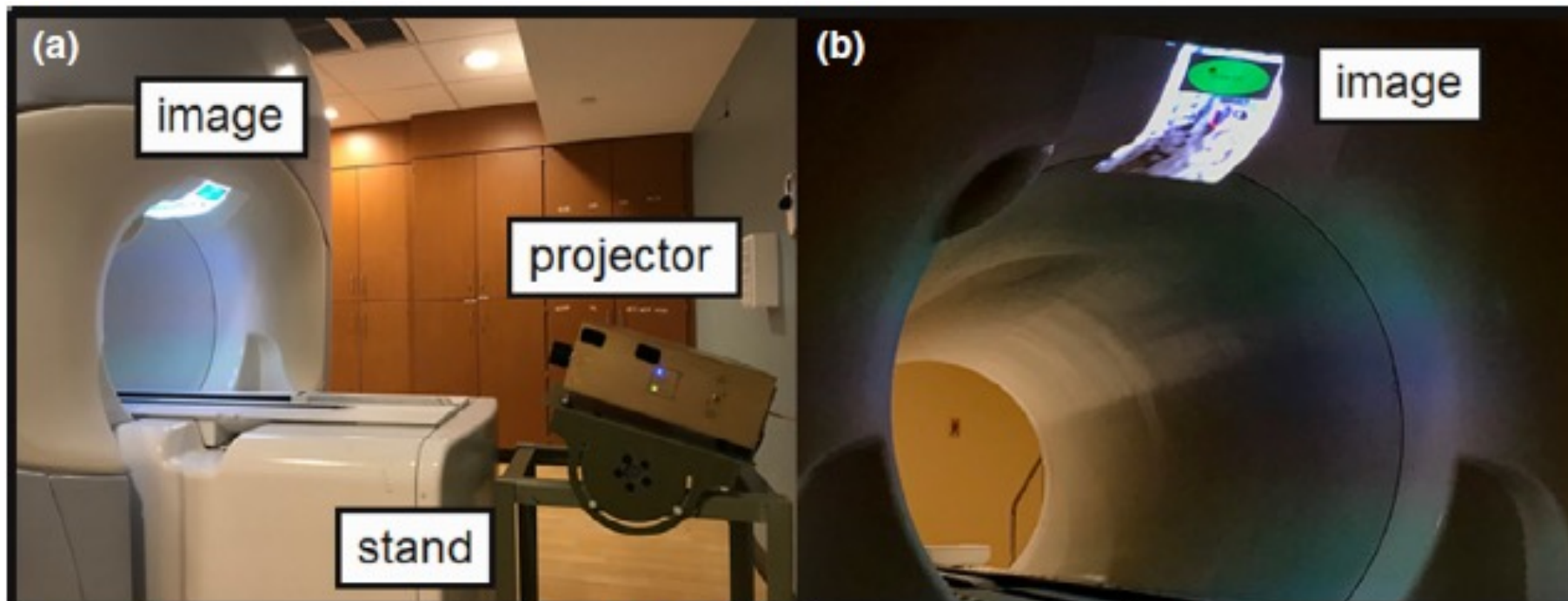
Visual Feedback

oMRgRT

TECHNICAL NOTE

Direct tumor visual feedback during free breathing in 0.35T MRgRT

Taeho Kim¹ | Benjamin C. Lewis¹  | Alex Price¹ | Thomas Mazur¹ |
H. Michael Gach^{1,2} | Justin C. Park¹ | Bin Cai¹ | Erin Wittland¹ | Lauren Henke¹ |
Hyun Kim¹ | Sasa Mutic¹ | Olga Green¹



TECHNICAL NOTE

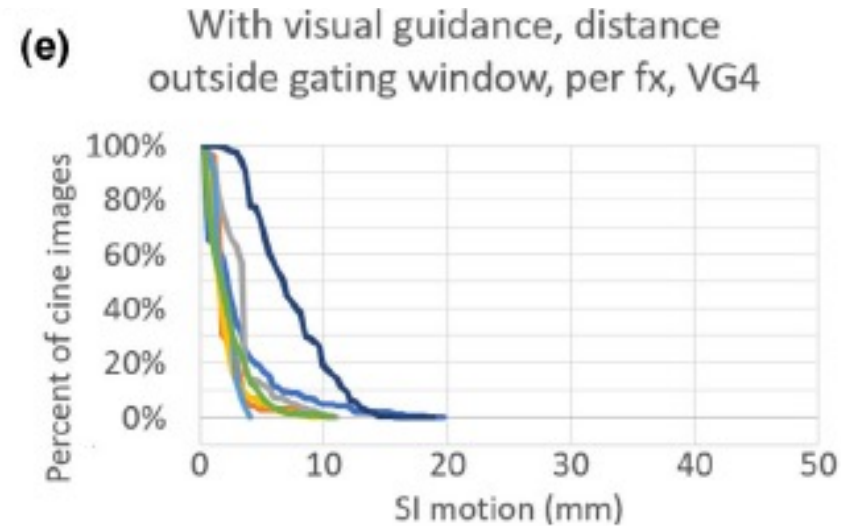
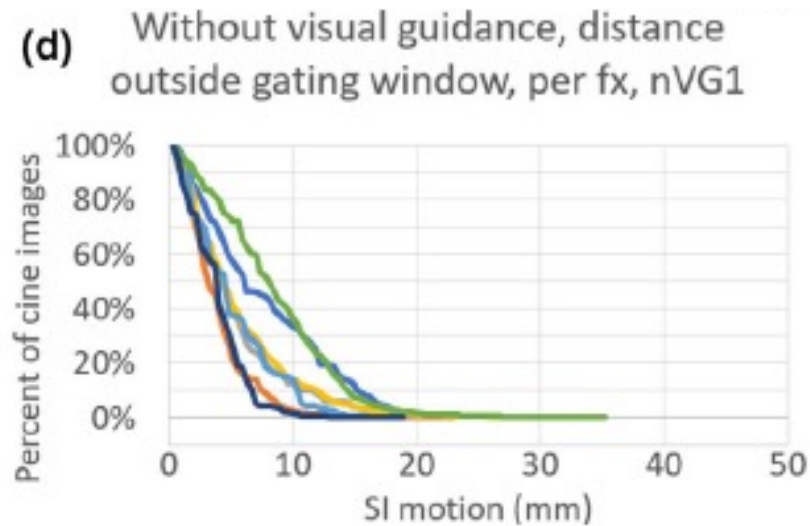
Visual Feedback

oMRgRT

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 Hyun Kim¹ | Sasa Mutic¹ | Olga Green¹

- Visual feedback improved:
 - Smaller tumor motion outside gating contour
 - Beam on time: 43.9% without vs 48.0% with visual guidance (P = 0.34)





oMRgRT

Patient acceptance

First prospective clinical evaluation of feasibility and patient acceptance of magnetic resonance-guided radiotherapy in Germany

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- 43 patients – PROM
- **65% complaint rate of at least 1 item**
 - cold temperature
 - Noise
 - Duration of treatment
 - Paresthesia
 - uncomfortable positioning

Table 4 Results of the patient-reported outcome questionnaires

How do you rate ...	After the first fraction (n = 34)	At the end of treatment (n = 34)	p-value
	Mean (range)	Mean (range)	
... the treatment at the MRlinac in total?	1.3 (1–4)	1.4 (1–3)	0.739
... the information provided by the staff before treatment?	1.1 (1–2)	1.1 (1–2)	1.000
... the friendliness of the staff?	1.0 (1–2)	1.0 (1–2)	0.317
... the duration of treatment?	2.2 (2–5)	2.1 (2–4)	0.741
... the size of the MRI bore?	1.9 (1–4)	1.8 (1–4)	1.000
... the positioning during RT?	2.2 (1–4)	2.2 (1–4)	0.604
... having to lie still?	2.0 (1–3)	1.8 (1–4)	0.662
... the noise in the MRI?	2.1 (1–4)	2.0 (1–3)	0.817
... the temperature in the MRI?	3.6 (1–4)	3.4 (1–3)	0.067
... the local temperature of your body parts?	3.5 (1–3)	3.2 (1–4)	0.302
... potential tingling sensations in your fingers and toes?	1.9 (1–4)	1.7 (1–4)	0.090
... the breathing instructions?	1.1 (1–3)	1.2 (1–2)	0.102
... holding your breath during RT?	1.4 (1–3)	1.5 (1–3)	0.305
Were you anxious during treatment?	1.4 (1–3)	1.3 (1–3)	0.157
Respiratory gated dose delivery (N = 22)			
Was it difficult to control the target by holding your breath?	1.3 (1–3)	1.2 (1–2)	0.739
Was it confronting to watch your tumor on the monitor?	1.2 (1–2)	1.1 (1–2)	0.564
How did you like the possibility to have an active role in controlling the duration of treatment?	1.2 (1–2)	1.1 (1–2)	1.000

oMRgRT

Patient acceptance

Patient-Reported Tolerance of
Magnetic Resonance-Guided
Radiation TherapyMutlay Sayan^{1*}, Ilkay Serbez², Bilgehan Teymur², Gokhan Gur², Teuta Zoto Mustafayev²,
Gorkem Gungor², Banu Atalar² and Enis Ozyar^{2*}

- 90 patients – PROM
- Main complaints: cold temperature (61%), paresthesia (57%)
- **Anxiety (45%) was significantly decreased after completion of the treatment ($p=0.01$)**

TABLE 3 | Result of the patient reported outcomes.

How do you rate. . .	After the first fraction, Mean (SD)	After the last fraction, Mean (SD)	<i>p</i>
... your anxiety level during treatment?	1.44 (0.656)	1.26 (0.567)	0.01
... the duration of treatment?	2.73 (0.747)	2.80 (0.741)	0.38
... the sensation of local heat?	1.14 (0.436)	1.12 (0.364)	0.63
... the feeling of cold during treatment?	1.83 (0.604)	1.74 (0.728)	0.19
... dizziness?	1.63 (0.661)	1.53 (0.640)	0.09
... potential tingling sensations in your extremities	1.78 (0.790)	1.70 (0.729)	0.22
... a metallic taste?	1.03 (0.184)	1.07 (0.252)	0.32
... perceptions of light flashes?	1.04 (0.207)	1.04 (0.208)	0.99
... the noise in the MRI?	1.66 (0.823)	1.53 (0.694)	0.26
Was music relaxing?	3.21 (1.258)	3.10 (1.274)	0.22
Was it difficult to control the target by holding your breath?	2.00 (0.788)	1.86 (0.805)	0.21
Was it disturbing to see your tumor during treatment?	1.34 (0.745)	1.25 (0.606)	0.35
Did you like having an active role during treatment?	2.96 (0.852)	3.11 (0.867)	0.15
Did you worry about your contribution to the treatment?	1.32 (0.640)	1.22 (0.623)	0.20

oMRgRT**Can we also treat elderly patients?**

oMRgRT Elderly patients

- 30 patients >75 years. Mean age was 81.4 ± 3.4 years
- MASTER scoring system for patient selection

Score <4



Table 3. MASTER score items and corresponding values.

Condition	MASTER score value
MRI incompatibility (i.e. pacemaker)	4
Major cognitive impairment	4
Severe claustrophobia	4
ECOG PS value ≥ 3	3
ECOG PS value ≥ 2	2
Mild cognitive impairment	1
Frailty	1
Essential tremor	1
Visual deficit	1
Deafness	1
Gated treatment foreseen	1
Urinary or fecal incontinence	1

ECOG PS: Eastern Cooperative Oncology Group Performance Status;
MRI: magnetic resonance imaging.

Magnetic resonance-guided radiotherapy feasibility in elderly cancer patients: proposal of the MASTER scoring system

Luca Boldrini^{1,2}, Giuseppe F. Colloca², Emanuele Villani³,
Giuditta Chiloiro^{1,2}, Andrea Bellieni³, Stefania Manfrida¹,
Francesco Cellini¹, Maria Antonietta Gambacorta^{1,2}
and Vincenzo Valentini^{1,2}

Score > 4
Clinically incompatible





oMRgRT

Elderly patients

Feasibility and safety of 1.5 T MR-guided and daily adapted abdominal-pelvic SBRT for elderly cancer patients: geriatric assessment tools and preliminary patient-reported outcomes

Rosario Mazzola¹ · Vanessa Figlia¹ · Michele Rigo¹ · Francesco Cuccia¹ · Francesco Ricchetti¹ · Niccolò Gaj-Levra¹ · Luca Nicosia¹ · Claudio Vitale¹ · Gianluisa Sicignano¹ · Antonio De Simone¹ · Stefania Naccarato¹ · Ruggero Ruggieri¹ · Filippo Alongi^{1,2}

- 40 patients - mean age was 73 years (65-85)
- Quality of life
- “SBRT is feasible, safe and does not impact QoL”

Patients	40
Lesions (n, %):	42
Age	
Median (years)	73
Range (years)	65–85
Gender (n, %)	
Male	38 (95%)
Female	2 (5%)
Treatment site (n, %)	
Prostate	13 (30.9%)
Prostate + seminal vesicles	14 (33.3%)
Prostate bed	1 (2.4%)
Pelvic lymph node	8 (19.1%)
Abdominal lymph node	4 (9.5%)
Bones	2 (4.8%)
Overall treatment time	
Median (minutes)	41
Range (minutes)	20–61

Patient Compliance

Online MRgRT



The patient perspective

**Successful
treatment**

**Successful
treatment**

→ **Ask your patients what they value
in their care & how you can improve
their treatment experience**

Conclusions



The Future
NEXT EXIT

Adaptive Radiotherapy:

- RT plan **adapted to account for internal anatomical changes**
- Potential **benefits of ART** → could **improve patient compliance**
- **Patient selection** in oMRgRT is key to success
- Measures to improve patient compliance

Thank you

For your attention!



@stef_corradini



Stefanie Corradini



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