Selection of MOMENTUM peer-reviewed publications–May 2025

Quality of life and toxicity in patients with pancreatic ductal adenocarcinoma treated with online adaptive stereotactic MR-guided radiotherapy.

IJROBP, 2025, article in press. Westerhoff JM; Scheepens JCM; van Wolffelaar FF; Bernchou U; Bahij R; Erickson B; Christodouleas JP; Ng SSW; Gani C; Choudhury A; Alongi F; Renz P; Colonias AT; Meijer GJ; Schytte T; Intven MPW; Verkooijen HM; Daamen LA; Hall WA; doi:10.1016/j.ijrobp.2025.03.046

Background and Purpose: The article investigates the impact of MRgRT on the quality of life (QoL) and toxicity in patients with non-metastatic pancreatic ductal adenocarcinoma (PDAC).

Methods: The study evaluated 127 patients treated with a stereotactic approach using a 1.5T MR Linac. The quality of life was assessed using the EORTC QLQ C30, and toxicity was evaluated through the CTCAE at multiple follow-up points.

Results: Results indicated that functional QoL domains remained stable, with significant improvements noted in nausea and vomiting, as well as appetite, particularly at the six-month mark. Specifically, the mean differences for nausea and vomiting were MD 10 ($p<0.001$) and MD 14 for appetite ($p=0.05$). Importantly, minimal acute and late grade 3 toxicity was reported.

Conclusions: This study suggests that stereotactic MRgRT is associated with stable function, improved disease-related symptoms, and low toxicity for up to 12 months post-treatment .

Upper Urinary Tract Stereotactic Body Radiotherapy Using a 1.5 Tesla Magnetic Resonance Imaging-Guided Linear Accelerator: Workflow and Physics Considerations.

Cancers 2024, 16(23), 3987. Zhao Y, Cozma A, Ding Y, Perles LA, Reiazi R, Chen X, Kang A, Prajapati S, Yu H, Subashi ED, Brock K, Wang J, Beddar S, Lee B, Mohammedsaid M, Cooper S, Westley R, Tree A, Mohamad O, Hassanzadeh C, Mok H, Choi S, Tang C, Yang J.
doi: 10.3390/cancers16233987

Background and Purpose: Recent advancements in radiotherapy technology allow for the delivery of high-dose treatments to targets in the upper urinary tract, including primary renal cell carcinoma (RCC) and upper tract urothelial carcinomas (UTUC. MR-Linacs have shown potential to enhance the precision and adaptability of stereotactic body radiotherapy (SBRT).

Methods: This retrospective study analyzed 34 patients (31 with RCC or UTUC) and 3 with metastases from non-genitourinary histologies) who received SBRT using a 1.5T MR-Linac. Treatment plans were adjusted using "adapt-to-position" (ATP) and "adapt-to-shape" (ATS); compression belts were used for motion management.

Results: The median treatment duration was 56 minutes, with ATP treatments being significantly shorter compared to ATS treatments. Most patients (77%) experienced self-resolving grade 1-2 acute radiation-induced toxicity, with no cases of grade ≥ 3 toxicity. Three patients (9%) experienced late grade 1-2 toxicity potentially related to SBRT, and one patient (3%) experienced grade 3 toxicity.

Conclusions: MR-Linac-based SBRT, with online plan adaptation, is a feasible, safe, and highly precise treatment option for managing select upper urinary tract lesions.

Safety and Tolerability of Online Adaptive High-Field Magnetic Resonance–Guided Radiotherapy

JAMA Netw Open. 2024;7(5):e2410819. Westerhoff JM, Daamen LA, Christodouleas JP, Blezer ELA, Choudhury A, Westley RL, Erickson BA, Fuller CD, Hafeez S, van der Heide UA, Intven MPW, Kirby AM, Lalondrelle S, Minsky BD, Mook S, Nowee ME, Marijnen CAM, Orrling KM, Sahgal A, Schultz CJ, Faivre-Finn C, Tersteeg RJHA, Tree AC, Tseng CL, Schytte T, Silk DM, Eggert D, Luzzara M, van der Voort van Zyp JRN, Verkooijen HM, Hall WA. doi:10.1001/jamanetworkopen.2024.10819

Background and Purpose: The study evaluates the safety, tolerability, and technical feasibility of the 1.5T MR-Linac. It focuses on the adapt-to-shape (ATS) approach, which adjusts the radiation plan for each treatment session based on daily anatomical changes.

Methods: Adults with solid tumors treated with the 1.5-T MR-Linac from February 2019 to October 2021 were included in the MOMENTUM study. The data, collected across five countries, were analysed in August 2023. Treatments followed institutional care standards.

Results: The study included 1793 treatment courses for 1772 patients. The most frequently treated sites were the prostate, metastatic lymph nodes, and brain. The ATS strategy was applied in 58.6% of the treatments. The occurrence of acute high-grade toxic effects was low, with 1.4% of the entire cohort and only 0.4% among those treated with ATS experiencing such effects. Additionally, there were no reports of grade 4 or 5 toxic effects.

Conclusions: The 1.5T MR-Linac treatment was found to be safe and well-tolerated. Online adaptive radiotherapy was associated with a low risk of severe acute toxic effects, demonstrating its technical feasibility and potential benefits for patients with solid tumors.

Quality of life and clinical outcomes in rectal cancer patients treated on a 1.5T MR-Linac within the MOMENTUM study

Clin Transl Radiat Oncol. 2024;45:100721. Daamen L.A.; Westerhoff J.M.; Couwenberg A.M.; Braam P.M.; Rütten H.; den Hartogh M.D.; Christodouleas J.P.; Hall W.A.; Verkooijen H.M.; Intven M.P.W.. doi: 10.1016/j.ctro.2023.100721

Background and Purpose: This study investigated quality of life (QoL) and clinical outcomes in rectal cancer patients treated with MR-guided short-course radiation therapy (SCRT) using a 1.5T MR-Linac during the initial 12 months after treatment.

Methods: Patients receiving 25 Gy SCRT in five fractions for curative intent were included. Toxicity and QoL were assessed, and clinical and pathological complete response rates were calculated. Dosimetric parameters were compared to standard non-adaptive treatment plans.

Results: Among 172 patients, complete response rates were observed at three, six, and twelve months. Diarrhea, blood and mucus in stool, and anxiety were improved after 12 months.

Conclusions: High-field MR-guided SCRT for rectal cancer is associated with improved symptom management and functioning one year after treatment.

MRI-guided radiotherapy in twenty fractions for localised prostate cancer; results from the MOMENTUM study

Clin Transl Radiat Oncol. 2024;46:100742. Sritharan Kobika; Daamen Lois; Pathmanathan Angela; Schytte Tine; Pos Floris; ChoudhuryAnanya; van der Voort van Zyp Jochem; Kerkmeijer Linda; Hall William; Hall Emma; Verkooijen Helena; Herbert Trina; Hafeez Shaista; Mitchell Adam; Tree Alison. doi: 10.1016/j.ctro.2024.100742

Background and Purpose: This study evaluated MRgRT for localized prostate cancer using a 1.5 T MR-Linac. Two-year toxicity outcomes, early biochemical response, and patient-reported outcomes were assessed.

Methods: Patients enrolled in the MOMENTUM study received radical treatment with 60 Gy in 20 fractions. PSA levels and toxicity data were measured at follow-up visits. Patient-reported outcomes were also collected.

Results: 146 patients received MRgRT for localized prostate cancer. Gastro-intestinal (GI) toxicity was 3% at three months, and genitourinary (GU) toxicity was 7%. Median PSA decreased at 12 months. Quality of life declined initially but improved by 24 months.

Conclusions: Online MRgRT with a 1.5 T MR-Linac is feasible and is associated with low rates of toxicity.

Interim toxicity analysis from the randomised HERMES trial of 2- and 5-fraction MRI-guided adaptive prostate radiotherapy.

Int J Radiat Oncol Biol Phys. 2023. Westley DRL; Biscombe K; Dunlop A; Mitchell A; Oelfke U; Nil S; Murray J; Pathmanathan A; Hafeez S; Parker C; Ratnakumaran R; Alexander S; Herbert T; Hall E; Tree AC. doi: 10.1016/j.ijrobp.2023.09.032

Background and Purpose: Ultra-hypofractionated radiotherapy is effective for localized prostate cancer. Boosting the visible intraprostatic tumor can improve biochemical disease-free survival without significant toxicity.

Methods: The HERMES trial enrolled men with intermediate or lower high-risk prostate cancer. Patients received either 36.25 Gy in 5 fractions over 2 weeks or 24 Gy in 2 fractions over 8 days, with an integrated boost to the MRI-visible tumor. Acute genitourinary (GU) toxicity was the primary endpoint.

Results: In this interim analysis, grade 2 GU toxicity was reported in 10% (5-fraction group) and 20% (2-fraction group). No grade 3 or higher toxicities were observed.

Conclusions: As the rate of GU toxicity in the 2-fraction and 5-fraction study groups was below the pre-specified threshold the study will continue patient recruitment.

Clinical outcomes after online adaptive MR-guided stereotactic body radiotherapy for pancreatic tumors on a 1.5 T MR-linac

Front Oncol. 2023;13:1040673. Eijkelenkamp Hidde; Grimbergen Guus; Daamen Lois; Heerkens Hanne; van de Ven Saskia; Mook Stella; Meijer Gert; Molenaar Izaak; van Santvoort Hjalmar; Paulson Eric; Erickson Beth; Verkooijen Helena; Hall William; Intven Martijn. doi: 10.3389/fonc.2023.1040673

Background and Purpose: Online adaptive MRgRT is a promising treatment for pancreatic cancer. However, clinical outcomes have been reported on a small scale, often from single institutes and clinical trials. This study presents outcomes of a large international cohort of patients with (peri)pancreatic tumors treated with online adaptive MRgRT.

Methods: Patients with (peri)pancreatic tumors were treated on a 1.5T MR-linac in two large-volume centers. Acute and late toxicity were assessed, and quality of life (QoL) was evaluated using the EORTC QLQ-C30 questionnaire. Overall survival was calculated using Kaplan–Meier analysis.

Results: Among 80 patients, 357 of 358 fractions were delivered as planned. Acute grade 3–4 toxicity occurred in 5% (hypofractionated MRgRT), and late grade 3–4 toxicity in 12%. Six patients died within 3 months after MRgRT. QoL remained stable from baseline to 3 months follow-up.

Conclusions: Online adaptive MRgRT for (peri)pancreatic tumors is well-tolerated and were associated with limited grade 3-4 toxicity and stable QoL at 3 months follow-up.

Online adaptive MR-guided stereotactic radiotherapy for unresectable malignancies in the upper abdomen using a 1.5T MR-linac.

Acta Oncol. 2022;61:111-115. Daamen LA; de Mol van Otterloo SR; van Goor IWJM; Eijkelenkamp H; Erickson BA; Hall WA; Heerkens HD; Meijer GJ; Molenaar IQ; van Santvoort HC; Verkooijen HM; Intven MPW. doi: 10.1080/0284186X.2021.2012593

Background and Purpose: Online adaptive MR-guided radiotherapy enables stereotactic body radiation therapy (SBRT) for upper abdominal tumors. This study evaluated the feasibility of MR-guided SBRT on a 1.5 T MR-linac in patients with unresectable upper abdominal malignancies.

Methods: Patients treated at UMC Utrecht were assessed. Feasibility was defined as an on-table time interval of ≤60 minutes for >75% of delivered fractions and completion of >95% of scheduled fractions. Acute toxicity was evaluated at 3 months follow-up.

Results: Twenty-five patients received 35 Gy (n=4) or 40 Gy (n=21) in five fractions over 2 weeks. Adapted treatment was completed within 1 hour for 84% of fractions. No acute grade 3 or higher toxicity was reported. Pain alleviation occurred in 11 out of 13 patients.

Conclusions: Online adaptive MR-guided SBRT on a 1.5 T MR-linac is feasible and well-tolerated for unresectable upper abdominal malignancies. Further dose escalation and comparative studies are needed to determine optimal radiation doses.

First multicentre experience of SABR for lymph node and liver oligometastatic disease on the unity MR-Linac.

Tech Innov Patient Support Radiat Oncol. 2022;22:50-54. Janssen TM; Aitken K; Alongi F; Barry A; Bernchou U; Boeke S; Hall WA; Hosni A; Kroon PS; Nachbar M; Saeed H; Jürgenliemk-Schulz IM; Schytte T; Verkooijen HM; Nowee ME. doi: 10.1016/j.tipsro.2022.04.005

The management of oligometastatic disease with MR guidance is an area of ongoing development. Since August 2018, patients have been receiving treatment using a 1.5 Tesla MR-Linac (MRL). In this study, current workflows and practice standards from seven institutions for the initial treatment of patients with lymph node and liver metastases are shared.

Magnetic Resonance-Guided Adaptive Radiation therapy for Prostate Cancer: The First Results from the MOMENTUM study-An International Registry for the Evidence-Based Introduction of Magnetic Resonance-Guided Adaptive Radiation Therapy.

Pract Radiat Oncol. 2022.Teunissen FR; Willigenburg T; Tree AC; Hall WA; Choi SL; Choudhury A; Christodouleas JP; de Boer JCJ; Groot-van Breugel EN; Kerkmeijer LGW; Pos FJ; Schytte T; Vesprini D; Verkooijen HM; Voort van Zyp JRNV. doi: 10.1016/j.prro.2022.09.007

Background and Purpose: MR-guided radiotherapy (MRgRT) is a novel technique for treating localized prostate cancer. We present 12-month outcomes for the first patients treated within the international MOMENTUM study using a 1.5T MR-Linac system with ultrahypofractionated radiation therapy (RT).

Methods: Patients receiving 5 × 7.25 Gy were evaluated. Prostate-specific antigen levels, physician-reported toxicity, and patient-reported outcomes were recorded at baseline and at 3, 6, and 12 months of follow-up (FU). Comparative statistics were used to compare outcomes between baseline and FU.

Results: The study included 425 patients with localized prostate cancer (11.4% low-risk, 82.0% intermediate-risk, and 6.6% high-risk). Median prostate-specific antigen levels significantly declined to 1.2 ng/mL and 0.1 ng/mL at 12 months FU for the non-androgen deprivation therapy (ADT) and ADT groups, respectively. Genitourinary and gastrointestinal toxicity peaked at 3 months FU (18.7% and 1.7% grade ≥2, respectively). The QLQ-PR25 questionnaire revealed significant deterioration in urinary domain score at all FU time points. For the non-ADT group, both physician- and patient-reported erectile function worsened significantly between baseline and 12 months FU.

Conclusions: Ultrahypofractionated MR-guided radiation therapy for localized prostate cancer using a 1.5T MR-Linac is effective and safe. Genitourinary and gastrointestinal toxicity was highest at 3 months FU and erectile dysfunction was significantly increased at 12 months follow-up. These data inform patient education and future study design.

Clinical implementation and feasibility of long-course fractionated MR-guided chemoradiotherapy for patients with esophageal cancer: An R-IDEAL stage 1b/2a evaluation of technical innovation.

Clin Transl Radiat Oncol. 2022;34:82-89. Boekhoff MR; Bouwmans R; Doornaert PAH; Intven MPW; Lagendijk JJW; van Lier ALHMW; Rasing MJA; van de Ven S; Meijer GJ; Mook S. doi: 10.1016/j.ctro.2022.03.008

Background and Purpose: This study describes the workflow and feasibility of long-course fractionated online adaptive MR-guided chemoradiotherapy with reduced CTV-to-PTV margins on the 1.5T MR-Linac for patients with esophageal cancer.

Methods: Patients undergoing chemoradiation were treated on a 1.5T MR-Linac. Daily MR images were used for contour adaptation. An isotropic CTV-to-PTV margin of 6 mm was applied. Feasibility and patient tolerability were defined. Dosimetric parameters were compared to standard non-adaptive treatment plans.

Results: Nine patients received chemoradiation. Most fractions were successfully delivered on the MR-Linac. Daily adapted MR-Linac plans maintained target coverage while reducing dose to organs-at-risk.

Conclusions: Daily online adaptive fractionated chemoradiotherapy with reduced PTV margins is moderately feasible for esophageal cancer, resulting in better sparing of heart and lungs.

Patterns of Care, Tolerability, and Safety of the First Cohort of Patients Treated on a Novel High-Field MR-Linac Within the MOMENTUM Study: Initial Results From a Prospective Multi-Institutional Registry.

Int J Radiat Oncol Biol Phys. 2021;111:867-875. Christodouleas JP; Blezer ELA; Akhiat H; Brown K; Choudhury A; Eggert D; Erickson BA; Daamen LA; Faivre-Finn C; Fuller CD; Goldwein J; Hafeez S; Hall E; Harrington KJ; van der Heide UA; Huddart RA; Intven MPW; Kirby AM; Lalondrelle S; McCann C; Minsky BD;. doi: 10.1016/j.ijrobp.2021.07.003

Background and Purpose: High-field MR-Linacs have the potential to revolutionize radiation therapy. We report the initial experience within the MOMENTUM Study, a prospective international registry of the MR-Linac Consortium.

Methods: Patients from 7 institutions in 4 countries were included. Descriptive statistics were used to describe patterns of care, tolerability, and safety. Acute toxicity was assessed within 3 months after treatment.

Results: A total of 943 patients participated in the study. Most patients were male (79%) with a median age of 68 years. The most common indications were prostate, oligometastatic lymph node, brain, and rectal cancers. Six patients discontinued MR-Linac treatments, but none due to inability to tolerate repeated high-field MRI. Acute toxicity related to radiation was minimal.

Conclusions: High-field MR-Linac treatment was well-tolerated, and acute radiation toxicity was encouraging.

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