Comparing photons, protons and carbon-ions for re-irradiation of head and neck cancer.

Results of a multicenter *in silico* ROCOCO trial

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MAASTRO *clinic*
23-5-15

Disclosure

- **None**

Rationale

- HN cancer patients may develop a second primary tumor or recurrent disease after previous radiotherapy
- Surgical salvage therapy is the mainstay of therapeutic options.
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- After re-irradiation: high risk of 43% grade 3 (late) toxicity at 5 years
- Relatively low chance of locoregional control of 50% at 5 years.
- One out of three patients survives re-irradiation without recurrence and severe complications
- Improvements in both the risk of radiation-induced complications and the oncological outcome are thus warranted.

Hoebers et al. IJROBP 2011

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Radiation Oncology COllaborative COmparison

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- Initially treated in Maastricht or Nijmegen
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- Transport of data: secure collaborative platform: www.mistir.info

Re-irradiation HN ROCOCO study

ROCOCO
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- VMAT: Maastricht NL
- IMPT: Pennsylvania US
- C-ions: Marburg DE
- Dataset: Nijmegen & Maastricht NL

Penn Medicine

Radboud University Nijmegen

MAASTRO

UKGM
UNIVERSITÄTSKLINIKUM GIESSEN UND MARBURG

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- LEM1 effective dose model used for C-ions
- Dose-volume metrics compared to VMAT
- Wilcoxon signed rank test
  (Bonferroni-corrected p-value of 5/3 %)

Planning criteria

Primary treatment:

a. ≥ 50 Gy with curative intent (with or without chemo)

b. CTV includes primary tumor and at least level II-IV

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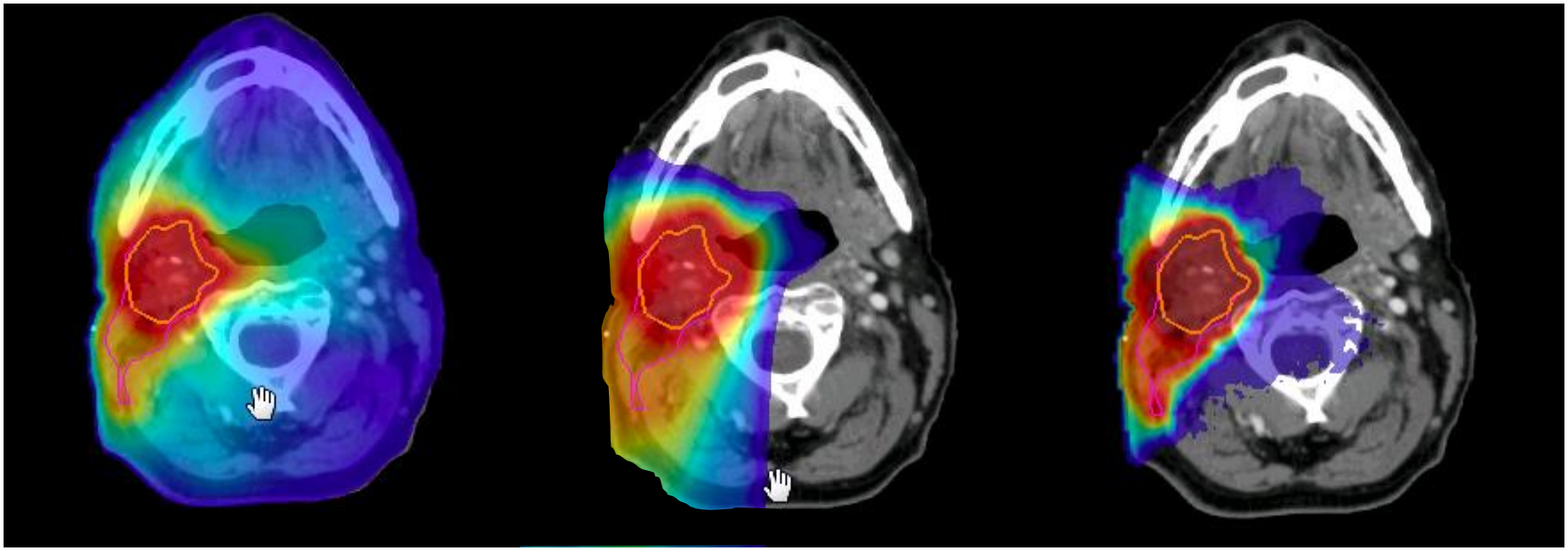
Secondary treatment after ≥ 1 year, dose 70 Gy

- Overlap of at least one OAR in primary and secondary treatment
- Simultaneous integrated boost technique
- PTV1: 35 x 1.55Gy = 54.25 Gy elective lymph node regions
- PTV2: 35 x 2Gy = 70 Gy (equivalent) to the tumour and/or pathological lymph node

Results

- 24 cases available for analysis
- All modalities initially planned an adequate dose to CTV1 & CTV2 (V95%=99%)
- Prescribed dose to the CTV was set to 70GyE

Results



VMAT IMPT IMIT

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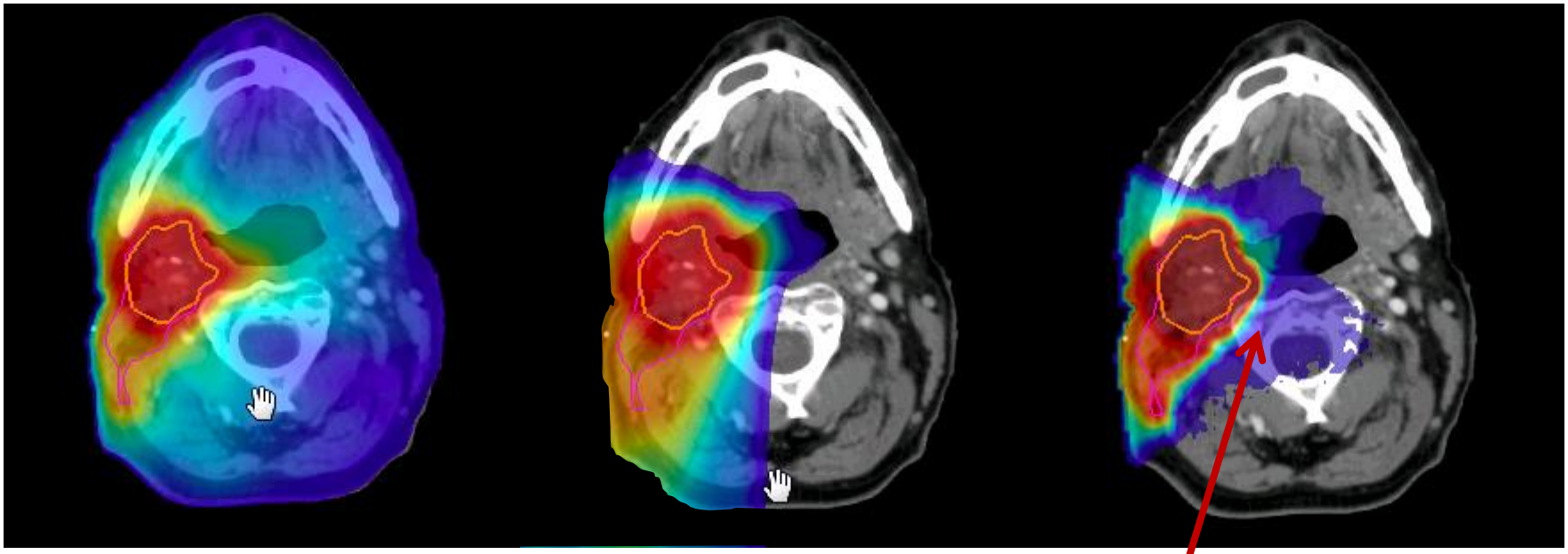

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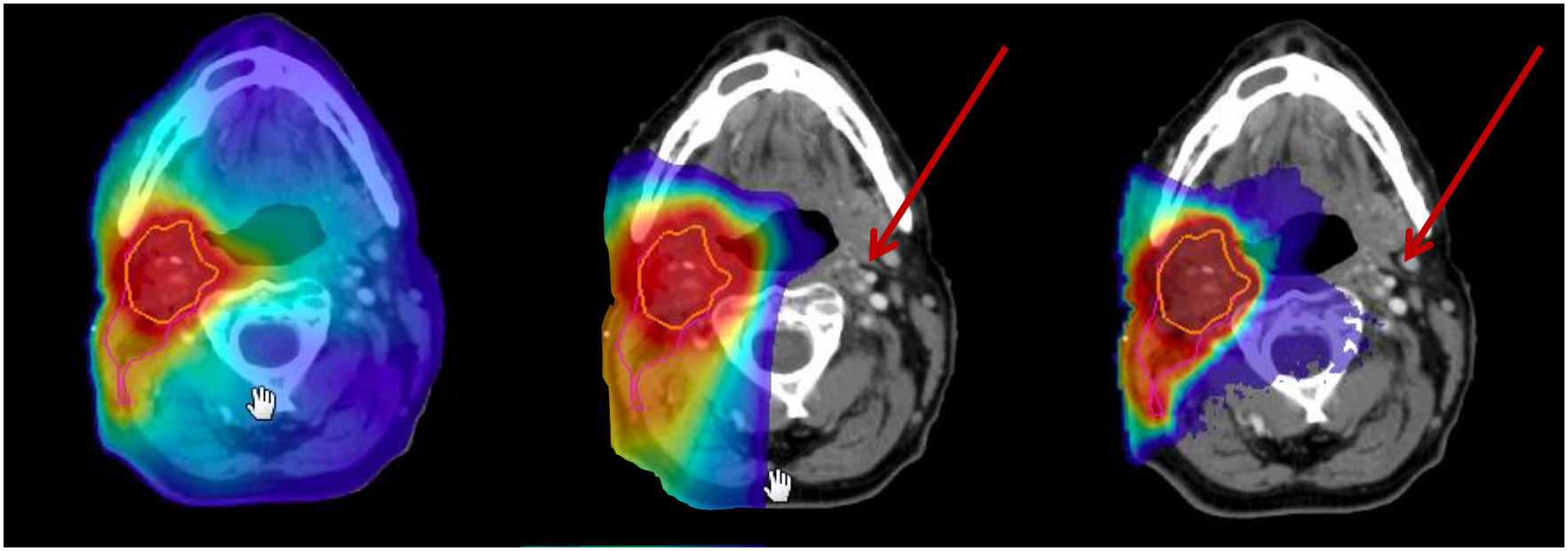
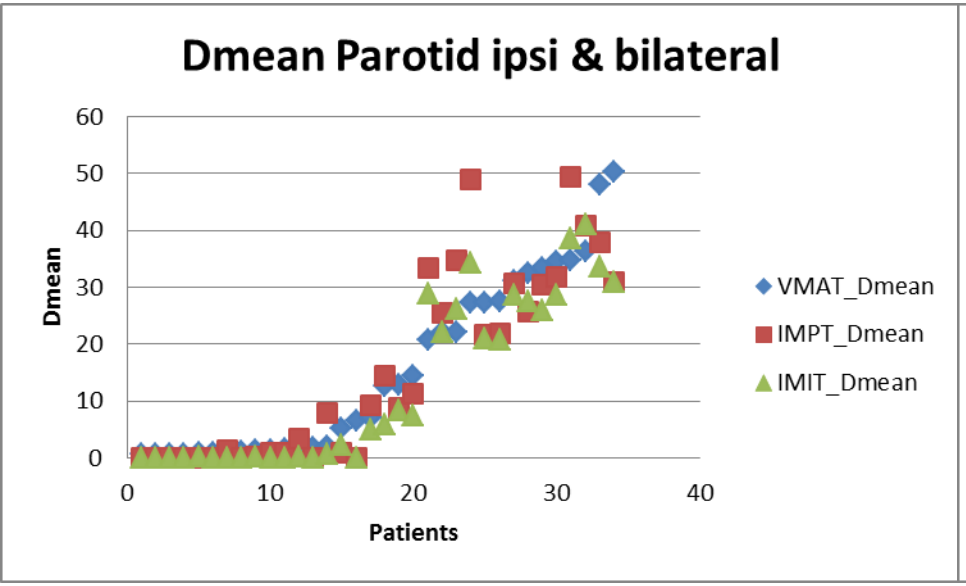
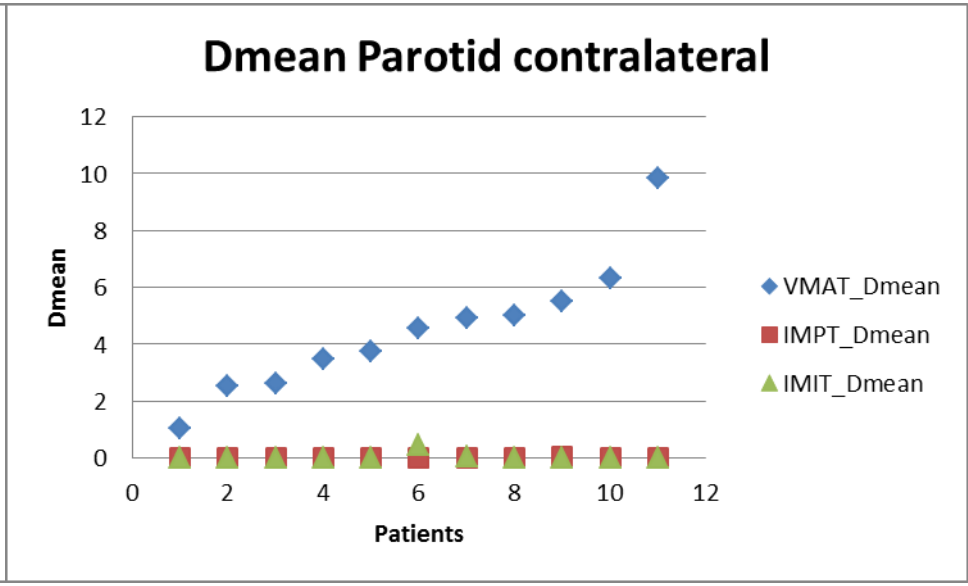


VMAT IMPT IMIT

Dmean Parotid (ipsi & bi) Dmean Parotid (contra)

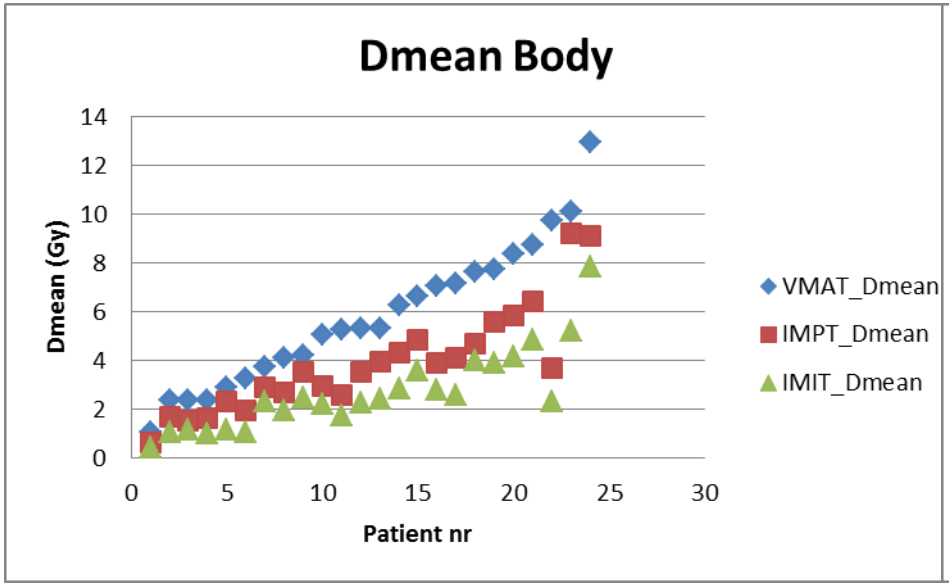


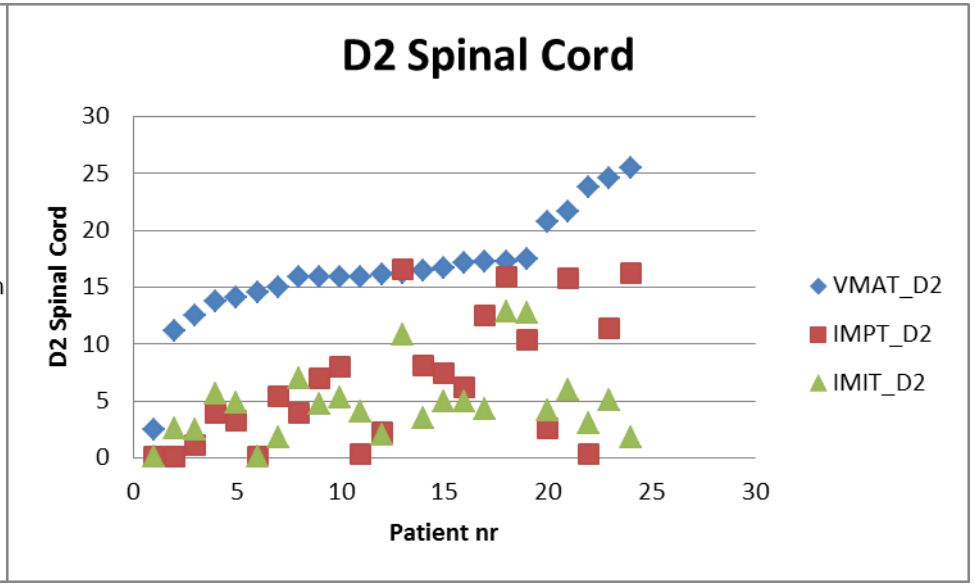


- Contralateral particle therapy superior for all patients
- No gain for ipsilateral glands

Body (integral dose)

D2 Spinal cord (max)





- IMIT< IMPT < VMAT
- 100%

- Particle therapy lowest D2 Spinal cord

Results

OAR	VMAT_Dmean	IMPT_Dmean	IMIT_Dmean
BODY	5.8 (2.9)	3.9 (2.2)*	2.7 (1.7)*
Arythenoid_L	25.0 (22.2)	15.2 (20.1)*	9.8 (18.5)*
Arythenoid_R	29.2 (21.3)	17.6 (22.0)*	12.3 (18.1)*
B_of_tongue	32.9 (20.0)	26.9 (23.3)	20.0 (22.2)*
Carotid_bi	34.2 (17.7)	34.7 (19.9)	30.8 (20.4)*
Carotid_co	12.1 (8.9)	2.2 (4.6)*	0.87 (1.5)*
Brainstem	2.6 (3.2)	0.4 (0.91)*	0.2 (0.43)*
Jugular_bi	31.3 (20.9)	30.2 (23.4)	26.2 (23.8)*
Jugular_co	9.5 (6.9)	1.1 (3.3)*	0.66 (1.8)*
Larynx	34.9 (18.6)	27.8 (18.7)*	21.1 (17.8)*
Mandible	13.8 (12.0)	10.2 (11.0)*	7.2 (10.3)*

OAR	VMAT_Dmean	IMPT_Dmean	IMIT_Dmean
Oral_cavity	15.3 (15.0)	9.6 (14.1)*	8.1 (15.4)*
Parotid_bi	15.4 (15.5)	15.4 (16.4)	12.9 (14.5)*
Parotid_co	4.5 (2.3)	<0.01 (0.016)*	0.045 (0.13)*
Spinal_cord	7.1 (3.2)	1.5 (1.9)*	1.1 (0.94)*
S.C.M_R_bi	31.7 (18.0)	31.1 (21.3)	27.0 (20.9)*
S.C.M_R_co	10.2 (6.9)	1.7 (3.2)*	0.73 (1.5)*
Submnd_salv_bi	33.8 (19.9)	34.3 (20.1)	28.4 (19.0)*
Submnd_salv_co	17.8 (9.3)	0.88 (1.9)*	1 (1.3)*
Swall_muscles	32.2 (22.1)	25.8 (21.8)*	19.7 (21.3)*
Thyroid	30.6 (25.9)	29.7 (25.9)	25.7 (25.3)*
Vertebrae	18.2 (8.3)	11.2 (7.3)*	6.1 (4.8)*

Table: Mean doses at clinical relevant OARs in Gy(E) for IMPT and IMIT compared to VMAT; * is significant (P < 0.02)

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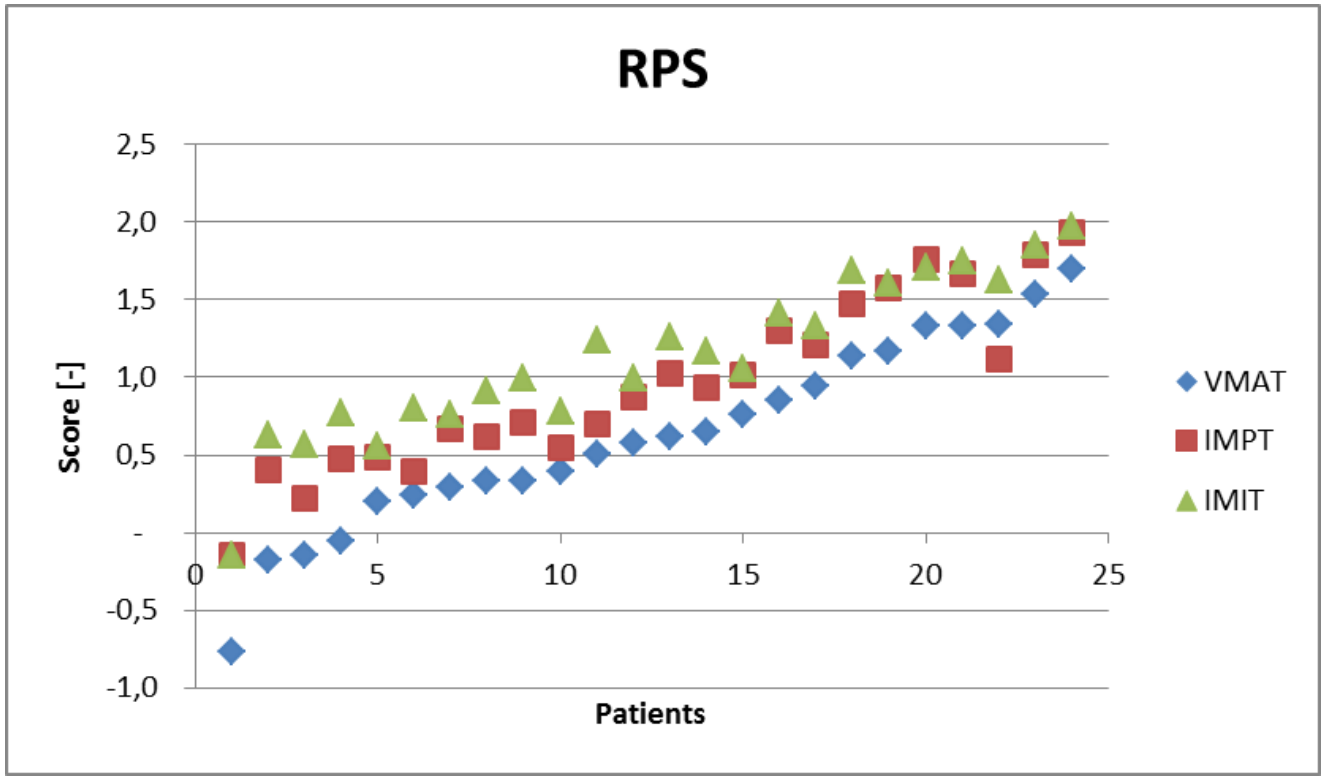
Swall_muscles	32.2 (22.1)	25.8 (21.8)*	19.7 (21.3)*
Thyroid	30.6 (25.9)	29.7 (25.9)	25.7 (25.3)*
Vertebrae	18.2 (8.3)	11.2 (7.3)*	6.1 (4.8)*

Table: Mean doses at clinical relevant OARs in Gy(E) for IMPT and IMIT compared to VMAT; * is significant (P < 0.02)

- Overall mean dose benefit comparing IMPT to VMAT = **40%**
- Overall mean dose benefit comparing IMIT to VMAT = **54%**

Performance HN re-irradiation



H&N priorities

Priority	Prio.Factor	rel.fact.
1	5	**0.333**
2	4	**0.267**
3	3	**0.200**
4	2	**0.133**
5	1	**0.067**
sum	15	1

$$\text{RPS} = \sum_{i=1}^{N} \left(1 - \frac{M_i}{L_i}\right) \cdot \frac{p_i}{\sum p}, \text{ for all OAR}$$

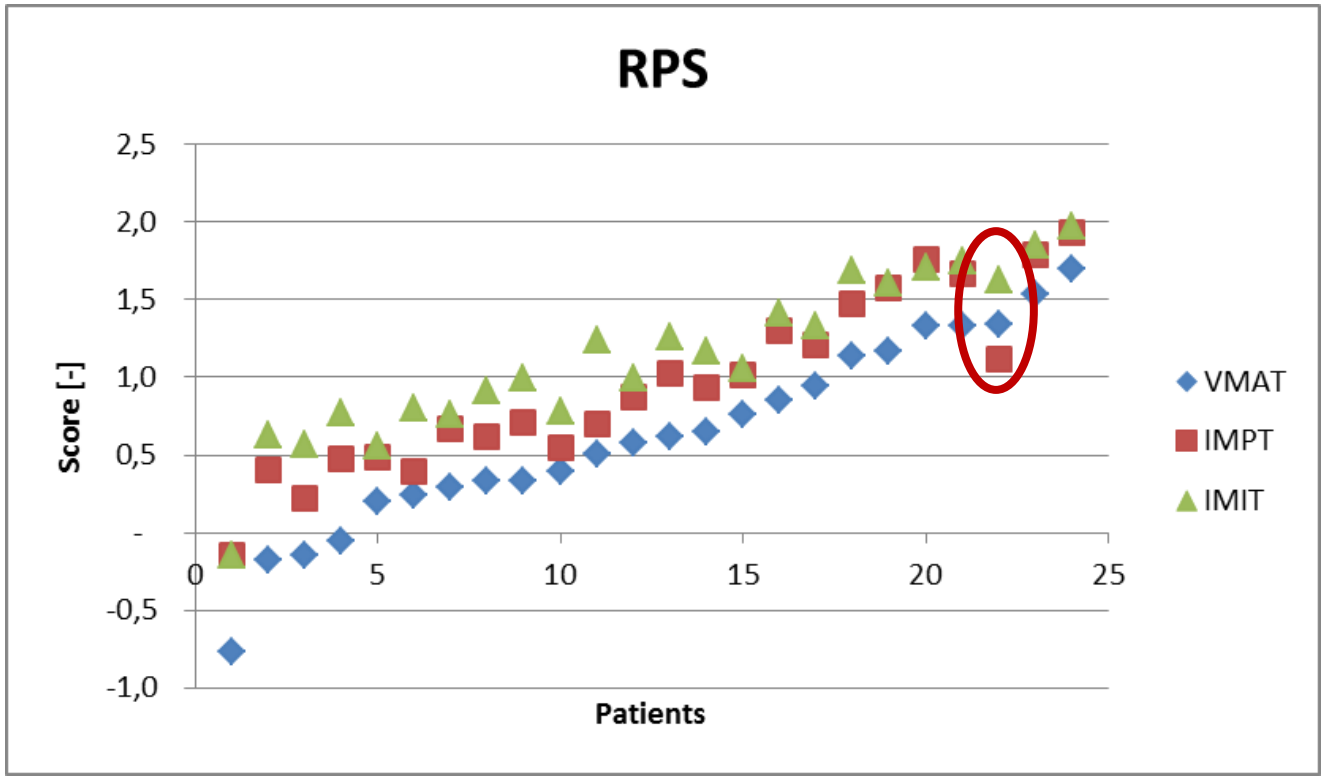
$M_i = i^{th}$ OAR metric

$L_i = i^{th}$ OAR limit

$p_i = i^{th}$ priority factor

Performance HN re-irradiation

ROCOCO Radiation Oncology COllaborative COmparison



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Conclusions

- Reduction in dose to OAR's using particle therapy compared to photons

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- Reduction in dose to OAR's using particle therapy compared to photons
- Potential dosimetric benefit favoring C-ions above proton therapy
- These dose reductions may translate into:
  - less treatment related acute and late toxicity
  - a lower rate of severe complications related to the re-irradiation (e.g. osteoradionecrosis, soft tissue necrosis, and / or vascular complications)

Future work

- Confirmation needed in future prospective trials

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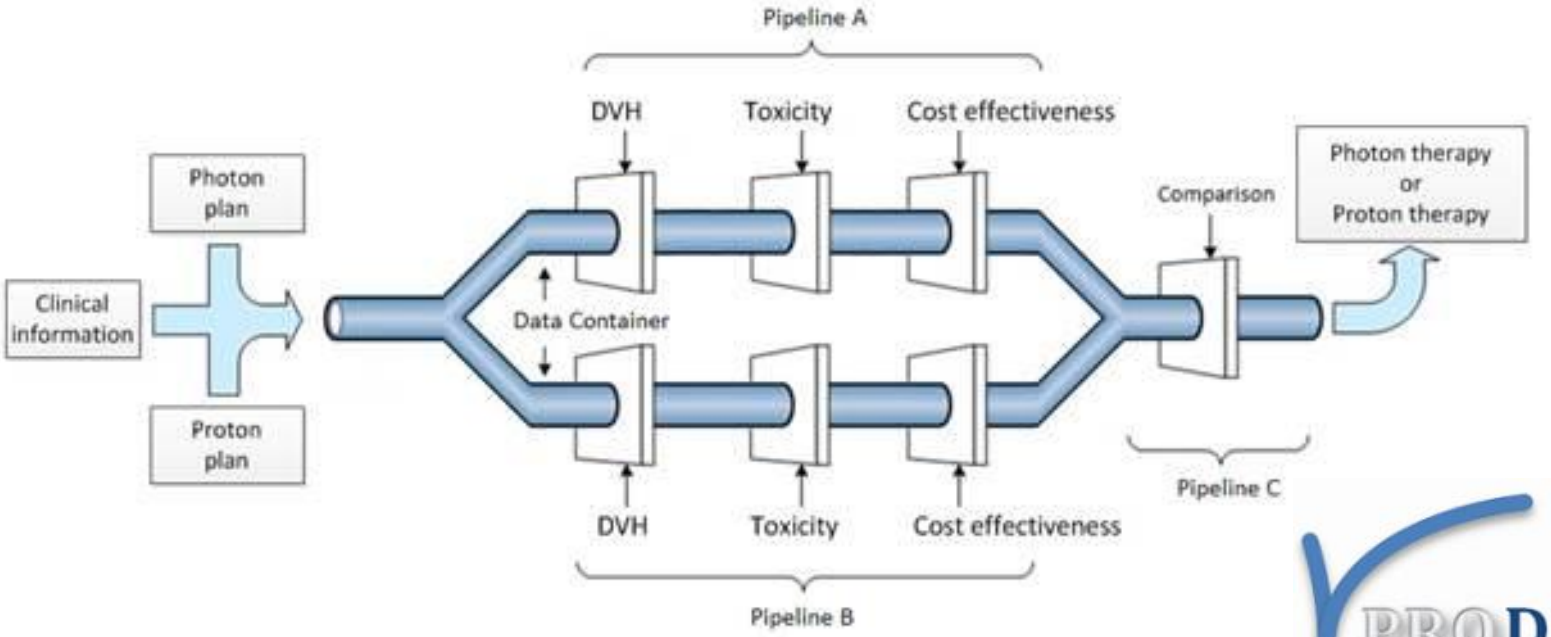
- The prospective Dutch model-based approach.



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Proton Decision Support System

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