

Introductie en monitoring van ML planning

17^e landelijke themadag Radiotherapie - Artificiële Intelligentie
Catharina Ziekenhuis – 28 maart 2024



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umcg

Disclosures



	COI status	Names of companies / organizations
① Post of executive / consultant	No	
② Stocks	No	
③ Patent royalties	No	
④ Stage moneys	No	
⑤ Manuscript fees	No	
⑥ Grant / Research funding	YES	Department of Radiation Oncology has research collaborations with IBA, RaySearch Laboratories, Siemens, Mirada Medical and VisionRT
⑦ Other rewards	No	

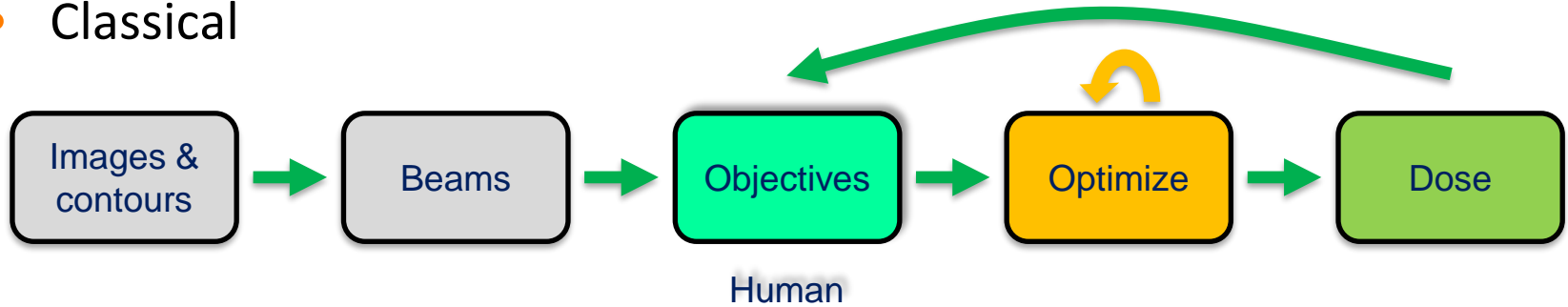
Purpose



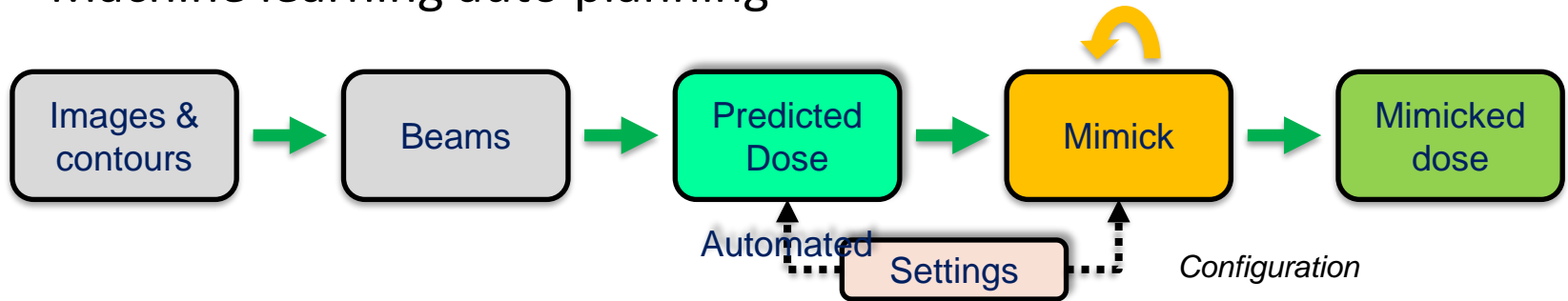
- High quality plans
- Time efficiency
- Clinical applications
 - Photon & **proton** planning
 - Model based selection
 - (Off-line) adaptive
- Research

Planning workflow

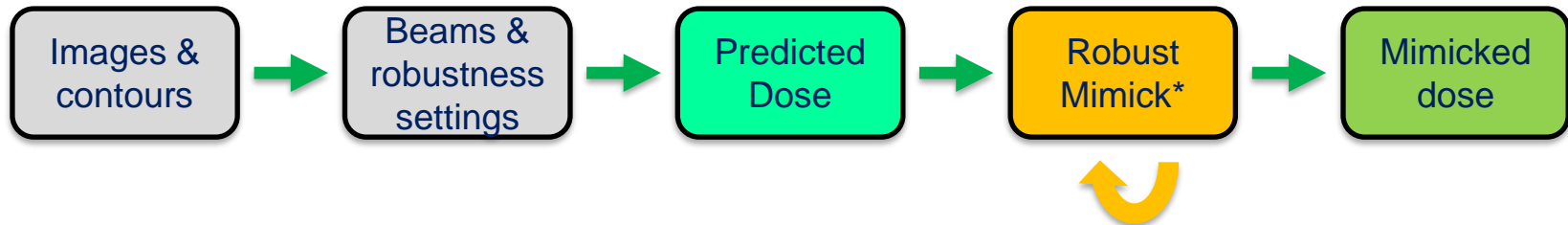
- Classical



- Machine learning auto planning



- Robust auto planning

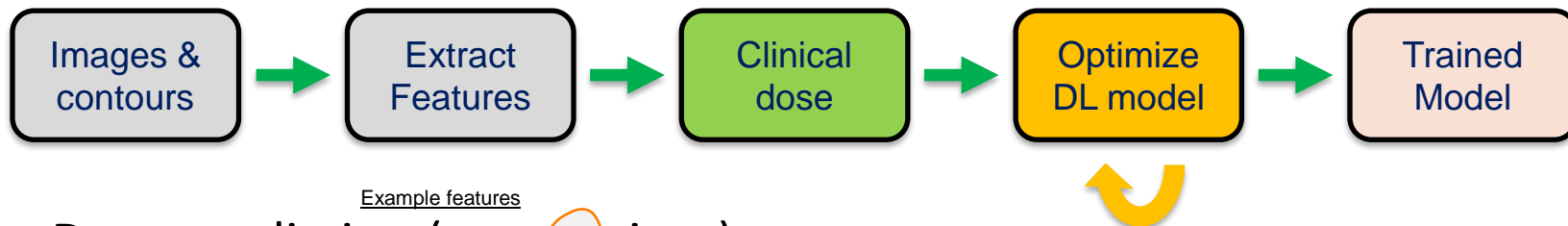


- Uncertainties

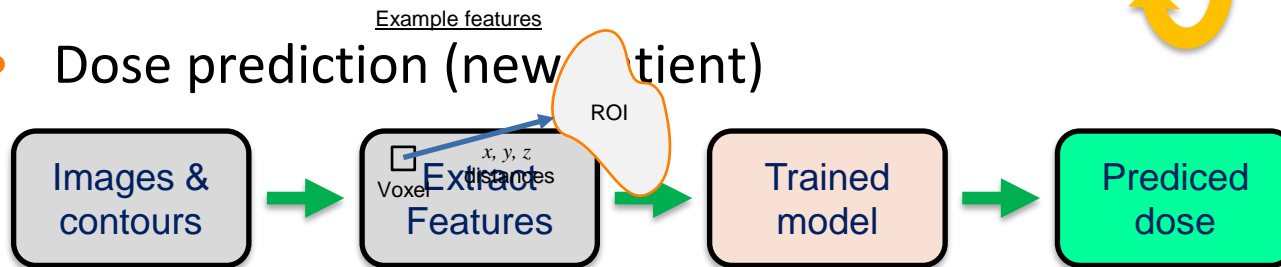
- E.g., 3mm setup & 3% range

**Roel Kierkels, Albin Fredrikson et al Automated Robust Proton Planning Using Dose-Volume Histogram-Based Mimicking .. Int J Radiat Oncol Biol Phys 2019*

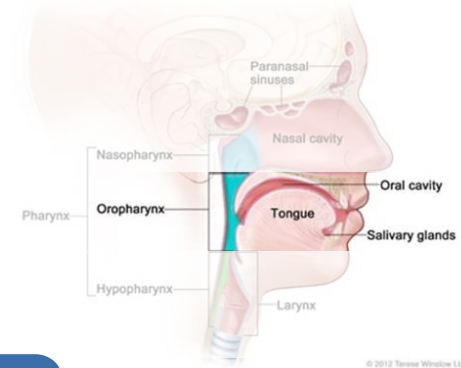
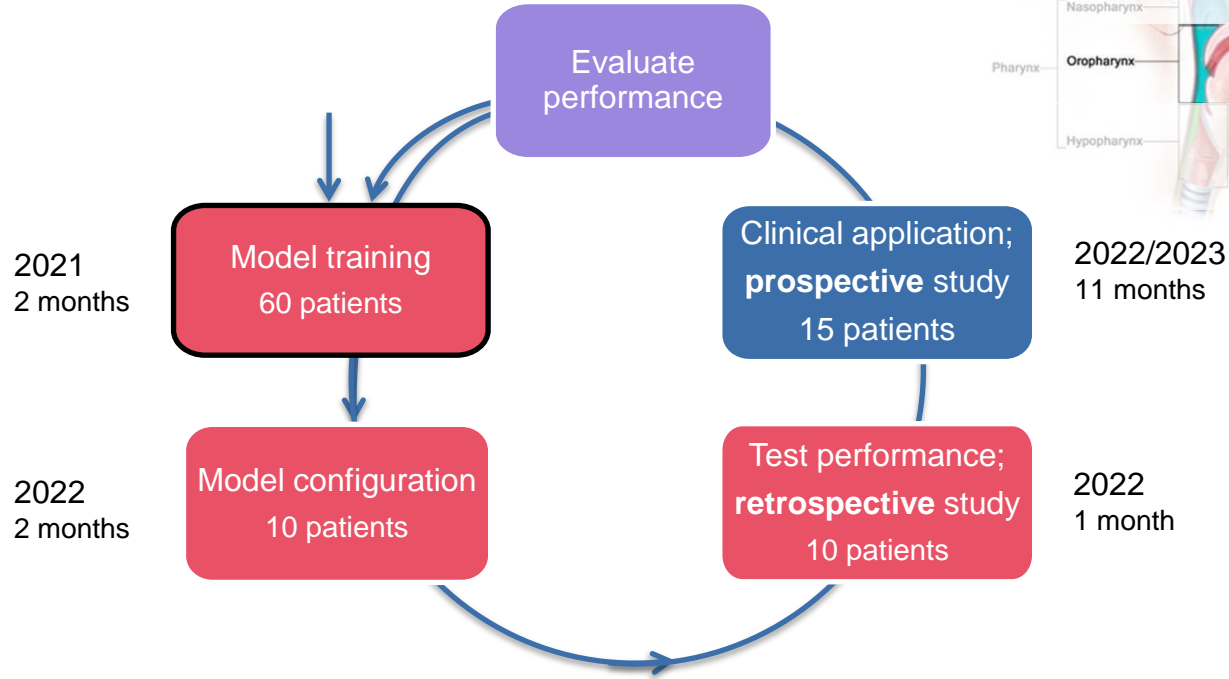
- Model Training (historical patient cohort)



- Dose prediction (new patient)

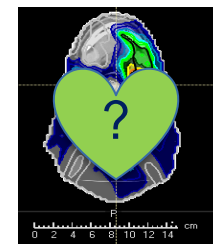
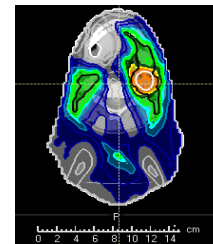
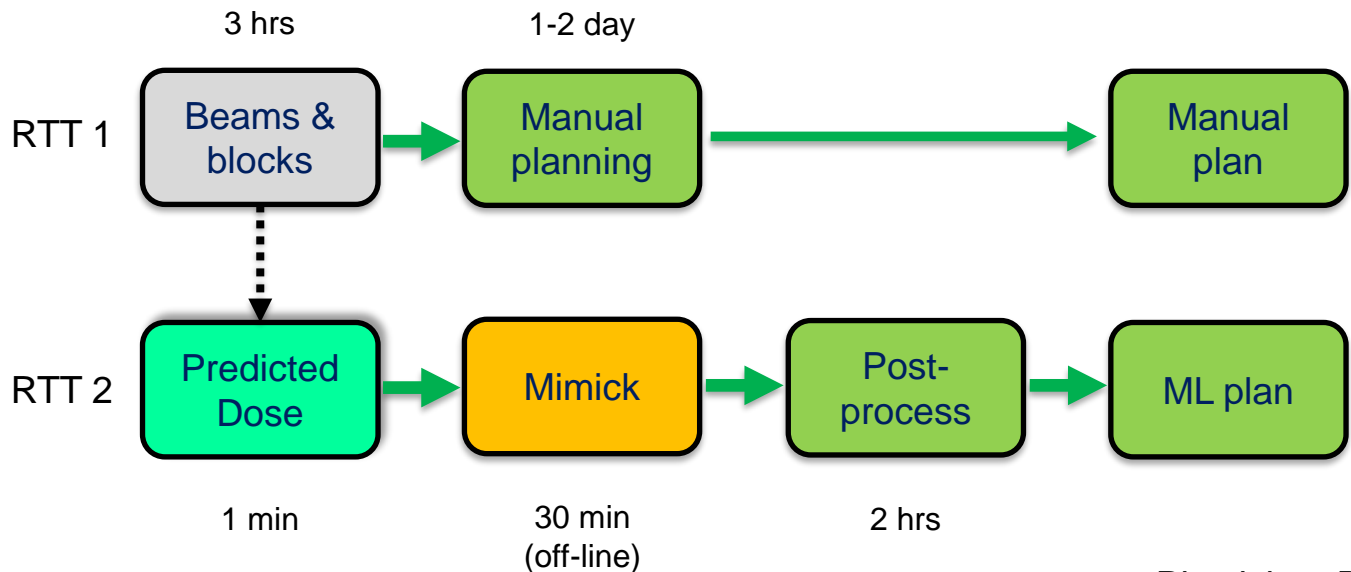


Machine learning model cycle



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Study workflow (retro- & prospective)



Favourite

Physician, RTT
& Physicist

Blind
Evaluation
0.5hr

Results - robustness



CTVprimary

$V_{94\%} > 98\%$ voxmin

$D_{1\text{cm}^3} < 78.0$ Gy (RBE) voxmax

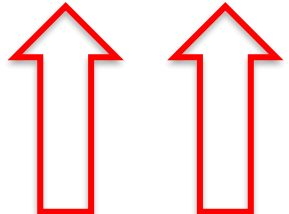
CTVelective

$V_{94\%} > 98\%$ voxmin

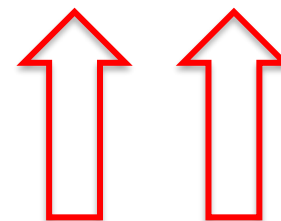
	Retrospective study (n=10)		
	Manual	sDLO	pDLO
<i>CTVprimary</i>			
V _{94%} > 98% voxmin	9 (90%)	9 (90%)	10 (100%)
D _{1cm3} < 78.0 Gy (RBE) voxmax	10 (100%)	10 (100%)	10 (100%)
<i>CTVelective</i>			
V _{94%} > 98% voxmin	8 (80%)	7 (70%)	9 (90%)

standard post-proces

	Retrospective study (n=10)		
	Manual	sDLO	pDLO
<i>CTVprimary</i>			
V _{94%} > 98% voxmin	9 (90%)	9 (90%)	10 (100%)
D _{1cm3} < 78.0 Gy (RBE) voxmax	10 (100%)	10 (100%)	10 (100%)
<i>CTVelective</i>			
V _{94%} > 98% voxmin	8 (80%)	7 (70%)	9 (90%)



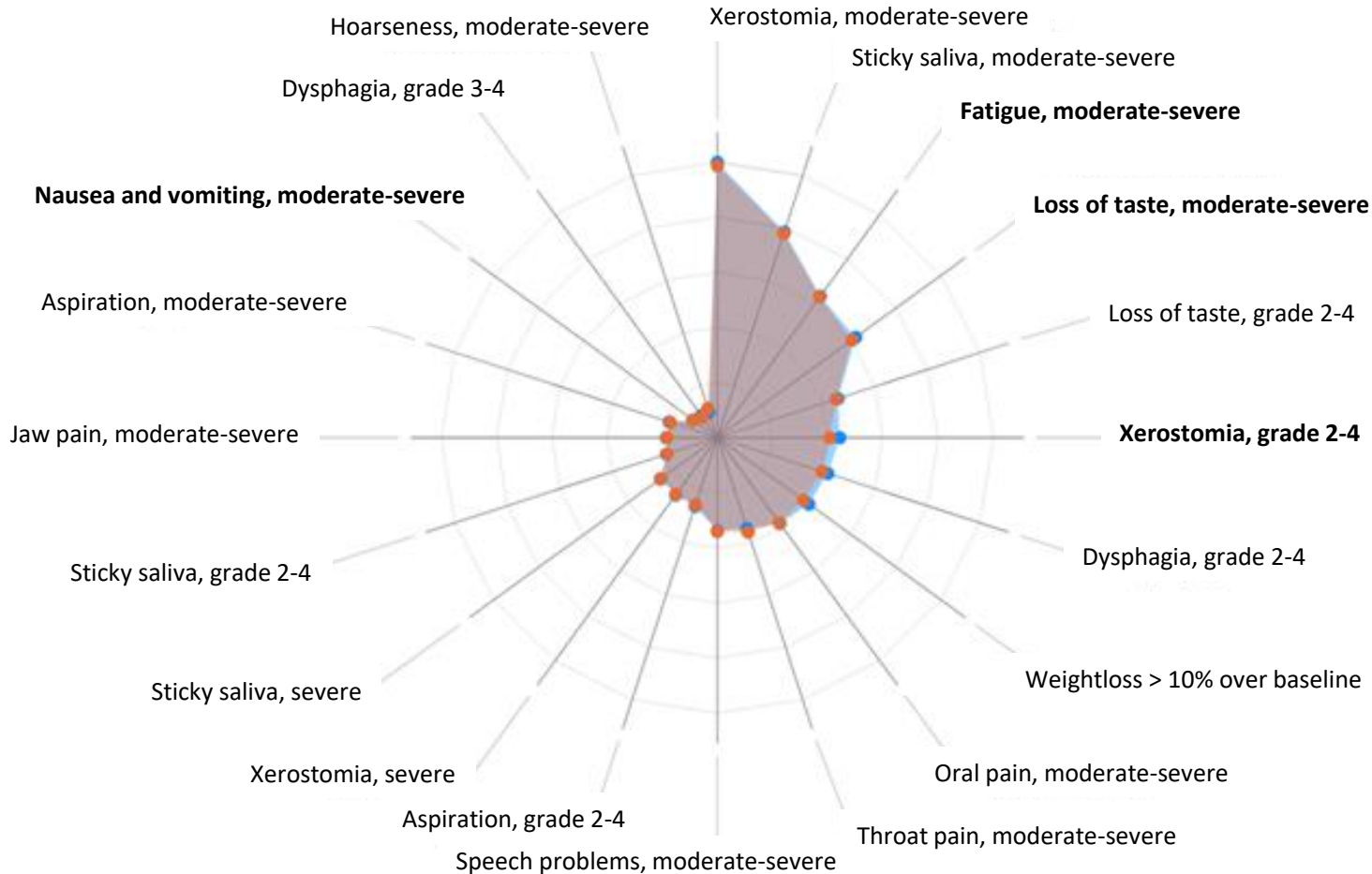
	Retrospective study (n=10)			Prospective study (n=15)		
	Manual	sDLO	pDLO	Manual	sDLO	pDLO
<i>CTVprimary</i>						
V _{94%} > 98% voxmin	9 (90%)	9 (90%)	10 (100%)	15 (100%)	15 (100%)	15 (100%)
D _{1cm3} < 78.0 Gy (RBE) voxmax	10 (100%)	10 (100%)	10 (100%)	15 (100%)	15 (100%)	15 (100%)
<i>CTVelective</i>						
V _{94%} > 98% voxmin	8 (80%)	7 (70%)	9 (90%)	15 (100%)	10 (66.7%)	14 (93.3%)



CITOR profile*

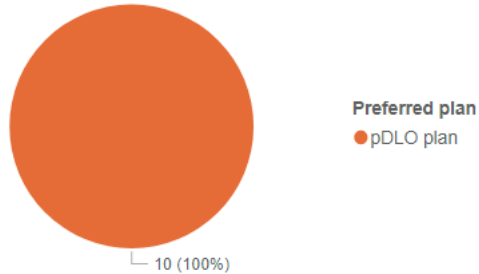


- Manual
- pDLO
- Bold:** significant



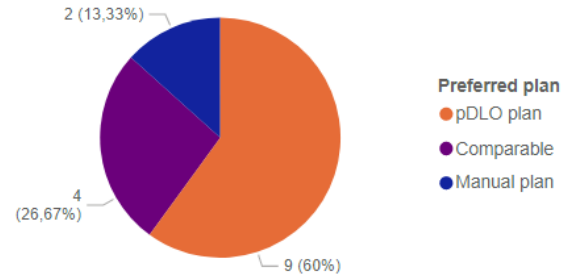
Results – plan preference

Preferred plan retrospective study



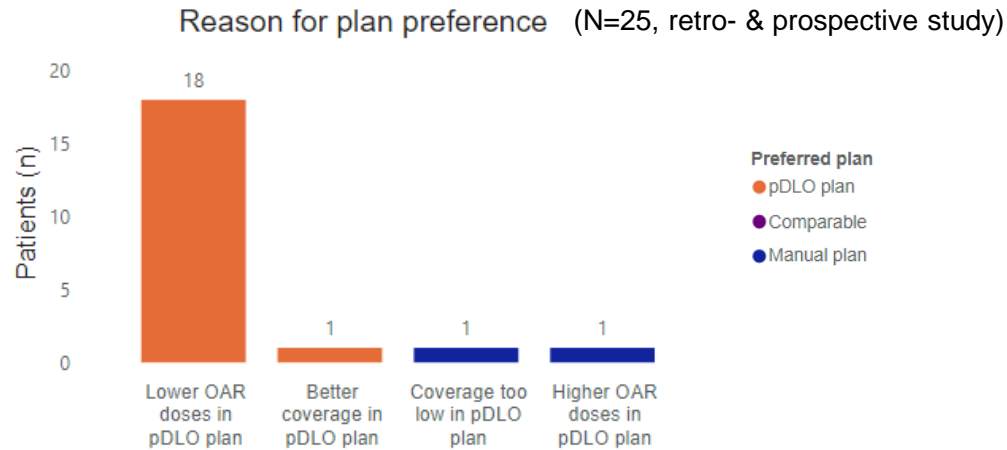
0/0 manual preferred

Preferred plan prospective study



2/15 manual preferred

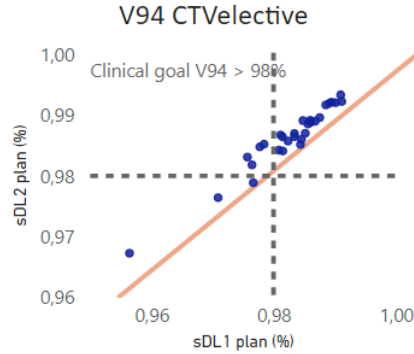
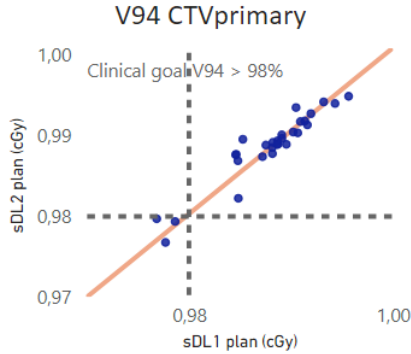
Results – plan preference



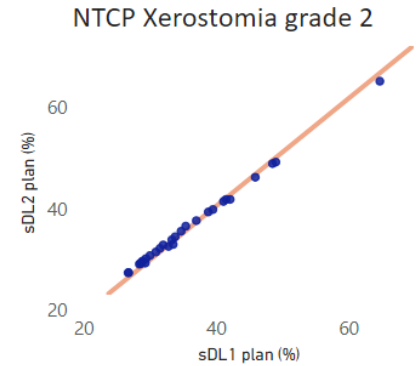
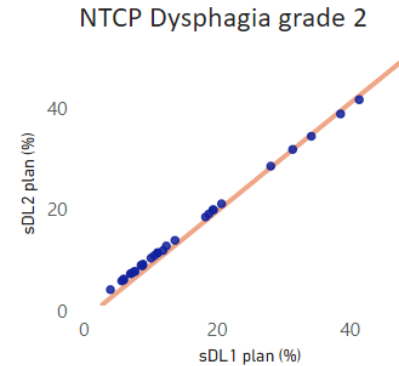
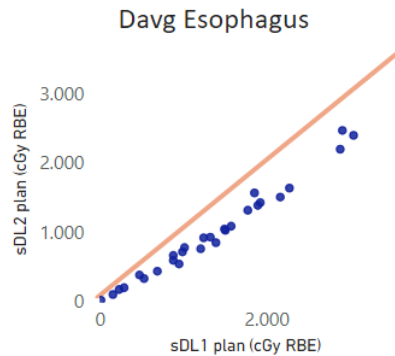
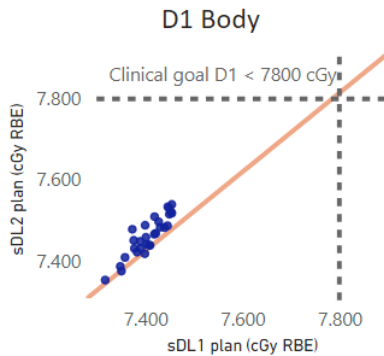
Workflow after clinical introduction

- Live: no double planning (ML only)
 - Manual plan (at least) every x^{th} patient
- ML expert group(s)
 - RTT/physician/physicist
 - Train colleagues
 - Evaluate & update ML model(s)

Model update: version 1 → 2



sDLO : standard (no post process)



Conclusions

- IMPT auto planning OPC clinically introduced
- High quality plans
 - Consistency
- Time efficiency
 - Semi automatic
 - Beam set-up
 - Fine tuning (post-processing)
 - Commissioning & maintenance



Acknowledgements



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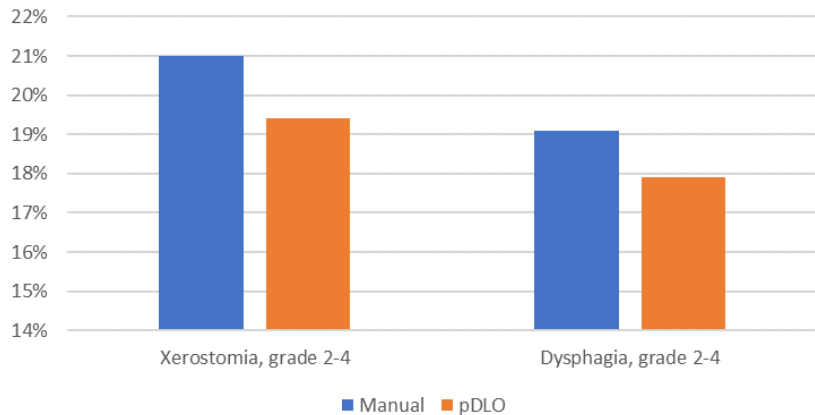
Results – toxicities

Table 3 Target parameters, OAR doses and NTCP values for plans of the prospective study (n=15). Average (min – max)

	Manual	sDLO	pDLO
OARs			
Dmean parotid glands (Gy RBE)	15.1 (10.1-28.1)	13.8 (7.8-27.5)	14.0 (8.1-27.4)
Dmean submandibular glands (Gy RBE)	45.6 (25.4-59.0)	46.5 (28.2-60.4)	46.1 (27.3-59.1)
Dmean oral cavity (Gy RBE)	29.7 (9.8-55.9)	29.9 (8.9-54.9)	29.2 (8.7-54.9)
Dmean PCM's (Gy RBE)	36.3 (18.9-55.8)	35.8 (18.8-55.4)	35.6 (18.4-55.1)
Dmean esophagus (Gy RBE)	10.4 (0.7-32.3)	16.7 (0.8-36.1)	13.0 (2.8-32.7)
Dmean thyroid (Gy RBE)	43.7 (34.2-51.0)	46.8 (37.8-52.2)	45.4 (37.3-52.7)
NTCP			
Sum grade 2	51.7 (32.8-101.6)	50.7 (32.7-99.1)	50.5 (33.0-100.6)
Sum grade 3	13.2 (7.8-32.4)	12.8 (7.8-30.7)	12.8 (7.6-31.9)

Results – toxicities

Retrospective study



Prospective study

