ADAPTIVE RADIOTHERAPY (A.R): RISULTATI DOSIMETRICI IN 10 PAZIENTI CON CARCINOMA DEL RINOFARINGE E DELL'OROFARINGE TRATTATI CON TECNICA VMAT

S. Noulas, L. Loreggian, A. Roggio, M. Paiusco, L. Corti

UOC di Radioterapia e Medicina Nucleare

I.O.V – I.R.C.C.S.

PADOVA

I.O.V
Istituto Oncologico Veneto

Adaptive radiotherapy

"Adaptive radiotherapy" is defined as changing the radiation treatment plan delivered to a patient during a course of radiotherapy to account for

-Temporal changes in anatomy (e.g. tumor shrinkage, weight loss or internal motion)

- Changes in tumor biology/function (e.g. hypoxia).

Istituto Oncologico Veneto

Dong L. et al. Journal of Oncology 2011

Adaptive RT

ELSEVIER

Seminars in
RADIATION
ONCOLOGY

Adaptive Radiotherapy of Head and Neck Cancer

Pierre Castadot, MD, John A. Lee, Eng, PhD, Xavier Geets, MD, PhD, and
Vincent Grégoire, MD, PhD, FRCR

Intensity-modulated radiation therapy (IMRT) in head and neck (H&N) cancer has the capability to generate steep dose gradients, leading to an improved therapeutic index. IMRT plans are typically based on a pretreatment computed tomography scan that provides a snapshot of the patient's anatomy. Nevertheless, interfractional patient variations may occur because of setup error and anatomical modifications. Therefore, the accuracy of IMRT delivery for H&N cancer may be compromised during the treatment course, potentially affecting the therapeutic index. In this framework, adaptive radiotherapy is a potential solution, which consists of "the explicit inclusion of the temporal changes in anatomy during the imaging, planning, and delivery of radiotherapy." Adaptive radiotherapy has brought an additional dimension to the management of patients with H&N cancer and has the potential to counteract the effects of positioning errors and anatomical changes. This article reviews the causes and discusses potential solutions to circumvent the discrepancies between the planned dose and the actual dose received by patients treated for H&N malignancies.
Semin Radiat Oncol 20:84-93

I.O.V.
Istituto
Oncologico
Veneto

Castadot P. et al. Semin Radat.Oncol. 2010

Adaptive RT

-Buon controllo locale (no dose-escalation)

-Riduzione della dose agli OAR (parotidi)

Castadot P. et al. Semin Radat.Oncol. 2010

Adaptive RT-anatomical modifications

Table 1 Anatomical Modifications During Radiation Therapy

Author	No. of Patients	Per-Treatment Imaging	Image Registration	Volume Analysis	Shape and Positional Analysis
Barker et al (2004)[6]	14	In-room CT-on-rail 3 times/wk; no iv contrast	Rigid	Reduction of: • GTV: 1.8% per treatment day • PGs: 0.6%/treatment day	• GTV: COM displacement: 3.3 mm (asymmetric shrinkage) • PG: COM shift medially by 3.1 mm
Geets et al (2007)[50]	10	CT scan at mean doses of 14, 25, 35, and 45 Gy; iv contrast	Rigid	After a mean dose of 45 Gy: • GTV_T: mean decrease of 65.5% • High dose CTV_T: mean decrease of 50.9% • High dose PTV_T: mean decrease of 47.9%	NA
Han et al (2008)[43]	5	Daily helical MVCT	Rigid	At the end of treatment: PGs had decreased from 20.5 to 13.2 cm^3, ie, an average decrease of 0.21 cm^3/treatment day or 1.1%/treatment day	NA
Vasquez Osorio et al (2008)[51]	10	CT scan at 46 Gy; iv contrast	Deformable	Reduction after 46 Gy: • GTV: 25 ± 15% • Homolat PG: 17 ± 7% • Heterolat PG: 5 ± 4% • Homolat SMG: 20 ± 10% • Heterolat SMG: 11 ± 7%	After 46 Gy: • Lateral and inferior regions of homolat PG: medial and posterior shift (3 mm) • Homolat SMG: medial, cranial, and posterior shift (4 mm)
Hansen et al (2006)[52]	13	CT scan after a mean dose of 39 Gy	Rigid	Reduction: • GTV: no change • Right PG: 15.6% • Left PG: 21.5%	NA
Robar et al (2007)[53]	15	Weekly CT scans; no iv constrast	Rigid	Reduction of superficial regions of both PGs: 4.9%/wk	Superficial regions show medial translation of: left PGs: medial shift of 0.91 ± 0.9 mm/wk right PGs: medial shift of 0.79 ± 0.13 mm/wk
Castadot et al (2008)	10	CT scan at mean doses of 14, 25, 35, and 45 Gy; iv contrast	Deformable	Reduction of • GTV_T: 3.2%/treatment day • GTV_N: 2.1%/treatment day • Homolateral PG: 0.9%/treatment day • Heterolat PG: 1.0%/treatment day • Low dose homolat CTV_N: 0.5%/treatment day • low dose heterolat CTV_N: 0.4%/treatment day	After 5 treatment wks: • Homolat PG: medial shift of 3.4 mm • GTV_T: lateral shift of 1.3 mm • GTV_N: medial shift of 0.9 mm • Low dose homolat CTV_N: medial shift of 1.8 mm No shift for the heterolat PG and heterolat low dose CTV_N.

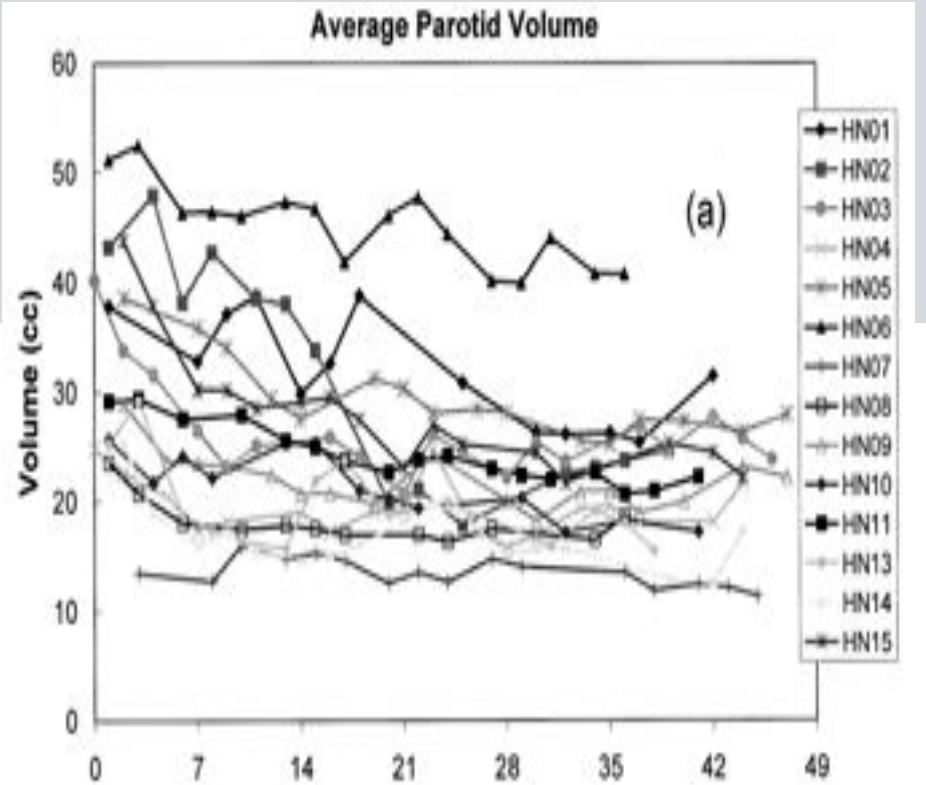
ISTITUTO ONCOLOGICO VENETO

Castadot P. et al. Semin Radat.Oncol. 2010

Adaptive RT-anatomical modifications

Riduzione media del volume parotideo del 28%

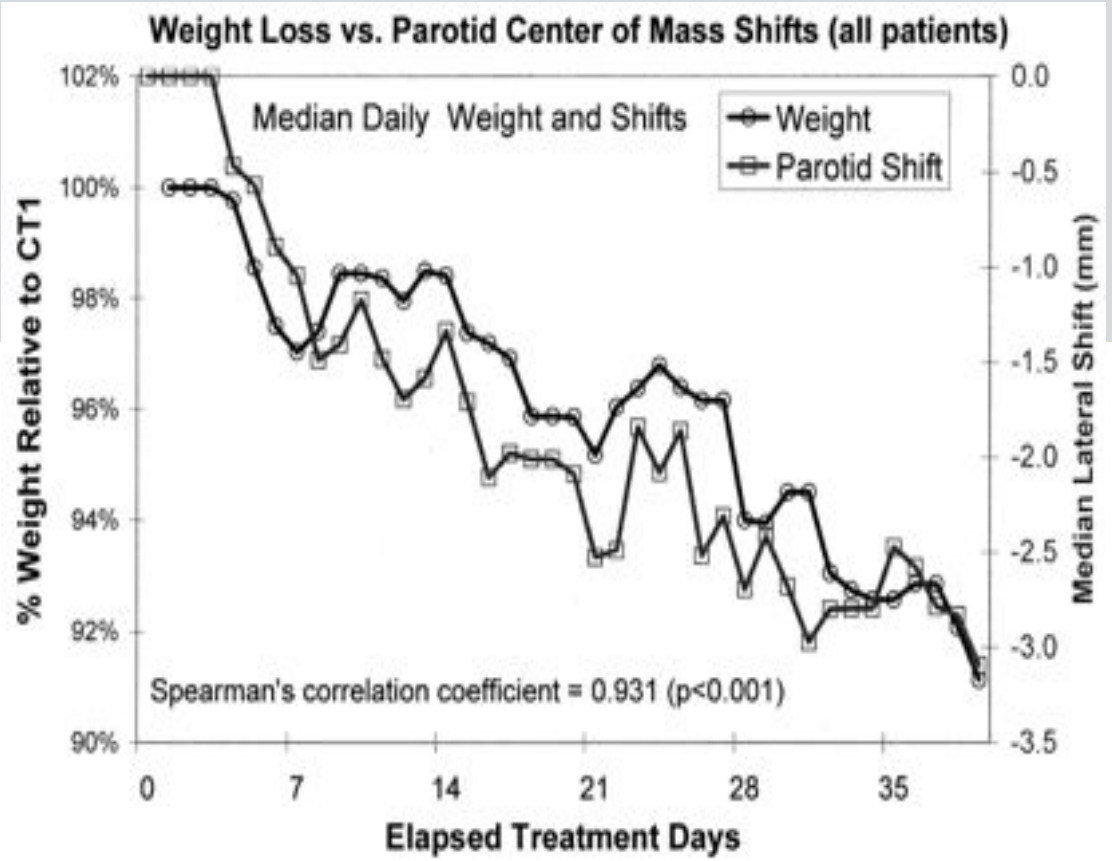
Cambiamenti anatomici significativi dopo 3-4 sett.



Barker JR. et al. Int. J. Radiation Oncology Biol. Phys 2004

Adaptive RT-anatomical modifications

Shift mediale delle parotidi altamente correlato al calo ponderale



Barker JR. et al. Int. J. Radiation Oncology Biol. Phys 2004

Adaptive RT-anatomical modifications and Dosimetric effects

Table 2 Dosimetric Effect of Anatomical Modifications During Radiation Therapy

Author	No. of Patients	Per-Treatment Imaging	Image Registration	Results	Comments
O'Daniel et al (2007)[44]	11	In-room CT-on-rail scans twice/wk; no iv contrast	Deformable	Cumulative PG dose greater than planned; median dose increase: 1 Gy No impact on tumor dose coverage	If no image-guidance for daily setup error correction, cumulative PG dose greater than planned; median dose increase: 3 Gy for homolat PG and 1 Gy for heterolat PG
Hansen et al (2006)[52]	13	CT scan after a mean dose of 39 Gy	Rigid	decreased by 12.1, 12.2 Gy, and 7%, respectively • Low dose PTV D_{98}, D_{95}, $V_{80\%}$ decreased by 12.6, 11.3 Gy, and 9.2%, respectively • Right PG V_{20Gy} increased by 10.9% • Mandible V_{60Gy} increased by 7.2%	If replanning: significant improvement of: • Low and high dose PTVs D_{98} D_{95} and $V_{80\%}$ • Spinal cord D_{max}, D_{1cc} • Brainstem D_{max} • Right parotid PG D_{mean}, D_{50}, and V_{20Gy} • Mandible D_{max} and V_{60Gy}
Robar et al (2007)[53]	15	Weekly CT scan; no iv contrast	NA	• Left PG D_{mean} increased by 2.6 ± 4.3%, V_{20Gy} increased by 3.5 ± 5.2% • Right PG D_{mean} increased by 0.2 ± 4.0%, V_{20Gy} increased by 0.3 ± 4.7%	
Han et al (2008)[43]	5	Daily helical MVCT	Rigid	PG D_{median} increased from 0.83 to 1.42 Gy with an average increase rate of 0.17 Gy/treatment day corresponding to an average increase of 2.2%/treatment day	Strong correlation between the volume and the median parotid dose during the treatment (correlation coefficient, −0.95)
Lee et al (2008)[54]	10	Daily helical MVCT	Deformable	• PG daily D_{mean} differed from the planned dose by an average of 15% • PG cumulative D_{mean}: planned: 29.7 Gy actual: 32.7 Gy (110% of planned dose)	• Changes in the distance between the COMs of the left and right PGs correlated strongly with the mean parotid dose changes (R^2 = 0.89) • Correlation between the relative weight loss and higher parotid mean doses (R^2 = 0.58)
Castadot et al (2009)	10	CT scan at mean doses of 14, 25, 35, and 45 Gy; iv contrast	Deformable	PGs D_{mean}: planned: 17.9 Gy, actual 18.7 Gy SMGs D_{mean}: planned 51.9 Gy actual: 52.8 Gy OC D_{mean}: planned 26.0 Gy, actual 26.7 Gy SC D_2: planned 40.1 Gy, actual: 41.0 Gy Skin V_{60}: planned 17.2 Gy, actual 18.3 Gy No difference in PTV or CTV coverage	

I.O.V. Istituto Oncologico Veneto

Castadot P. et al. Semin Radat.Oncol. 2010

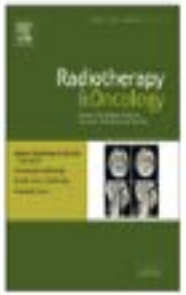
Adaptive RT

Radiotherapy and Oncology 101 (2011) 343–350

Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com



Adaptive RT in head and neck cancer

Adaptive functional image-guided IMRT in pharyngo-laryngeal squamous cell carcinoma: Is the gain in dose distribution worth the effort?

Pierre Castadot, Xavier Geets, John Aldo Lee, Vincent Grégoire *

Department of Radiation Oncology, Université catholique de Louvain, Brussels, Belgium

Castadot P. et al. Radiotherapy and Onclolgy. 2011

Adaptive RT

-Clinical benefit of adaptive strategy will have to be evaluated both in terms of patients outcome and cost-effectiveness

-In the mean-time, owing to the complexity of the procedure, ART should not be used in routine clinical base

I.O.V.
Istituto Oncologico Veneto

Castadot P. et al. Radiotherapy and Onclology. 2011

Adaptive RT-Padova

I.O.V.
ISTITUTO ONCOLOGICO VENETO

MATERIALI E METODI

-10 pazienti tra 2013-2014

-III-IV stadio rinofaringe e orofaringe

ID pz	Istologia	Sesso	Eta	Stadio	CT concomitante	Kg.persi	N* TC
1	SCC	M	70	T3N2c	NO	16	5
2	NPC	M	70	T3N1	SI	7	6
3	SCC	F	67	T3N0	SI	7	5
4	SCC	M	58	T2N2b	SI	14	5
5	NPC	M	36	T2N1	SI	6	6
6	NPC	M	63	T2N1	SI	5	6
7	NPC	M	68	T3N2	SI	9	6
8	NPC	F	69	T1N2	SI	4	6
9	NPC	F	59	T2N2	SI	6	6
10	NPC	M	40	T2N2	SI	10	6

MATERIALI E METODI

-VMAT a 2 archi(360 gradi)

Varian Unique

-Pianificazione con Eclipse TPS

-5mm di margine per il PTV

66Gy-60-54/30f SIB per Orofaringe

69.9Gy-60-54/33f SIB per Rinofaringe

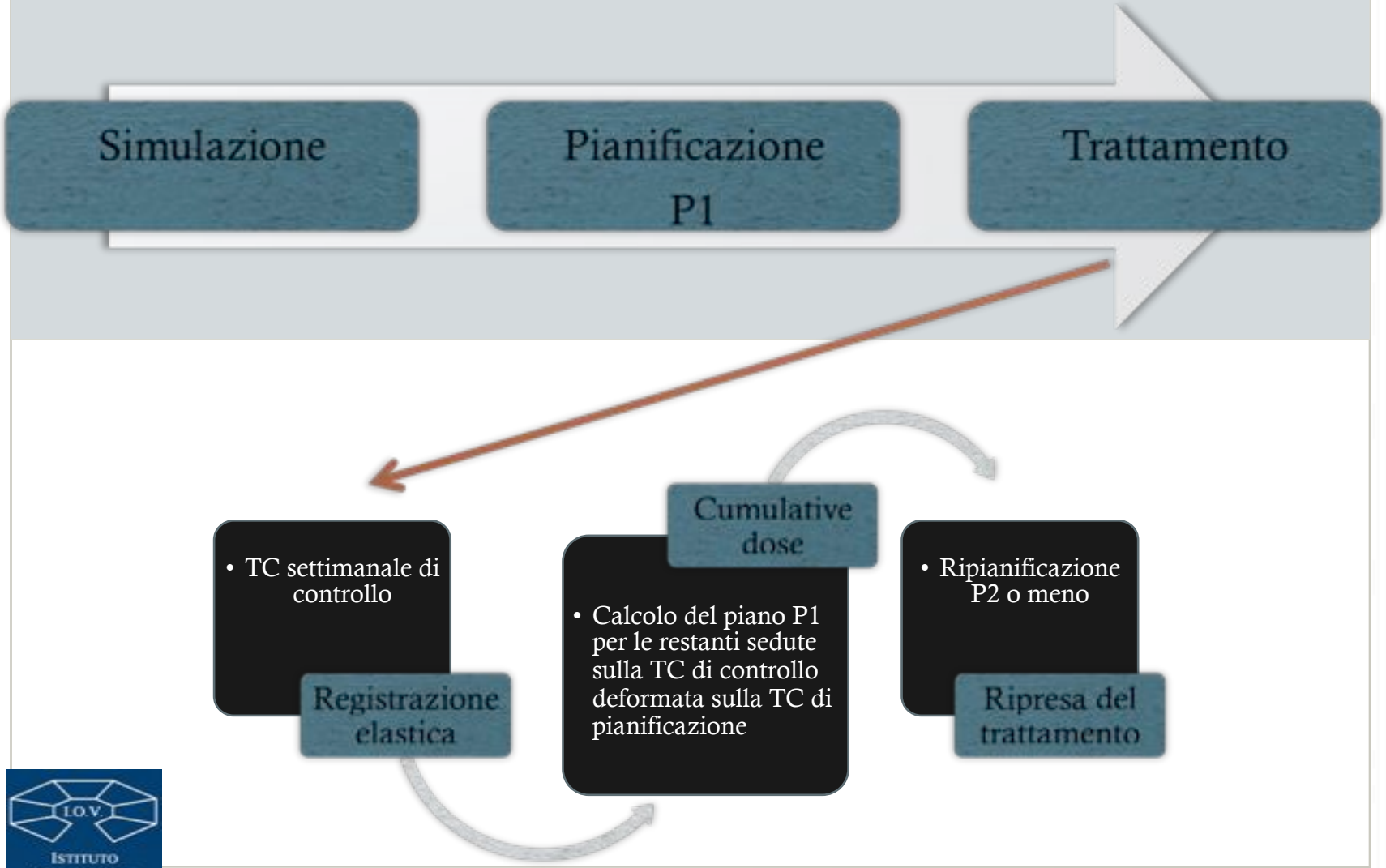
-TC settimanale di controllo

-Registrazione elastica con la TC di pianificazione

(Raystation TPS)

I.O.V.
ISTITUTO ONCOLOGICO VENETO

Workflow



I.O.V.
Istituto Oncologico Veneto

MATERIALI E METODI

-9 pazienti sono andati incontro ad ART1

-Tempo medio tra TC e ART1 :1.8 giorni

-Media 1^ ripianificazione: 16^frazione

-2 patienti(orofaringe) ART2

-Media 2^ripianificazione:22^frazione

I.O.V.
ISTITUTO ONCOLOGICO VENETO

RISULTATI

-Volume del GTV diminuisce del ordine del 35% durante le prime 3 settimane di trattamento

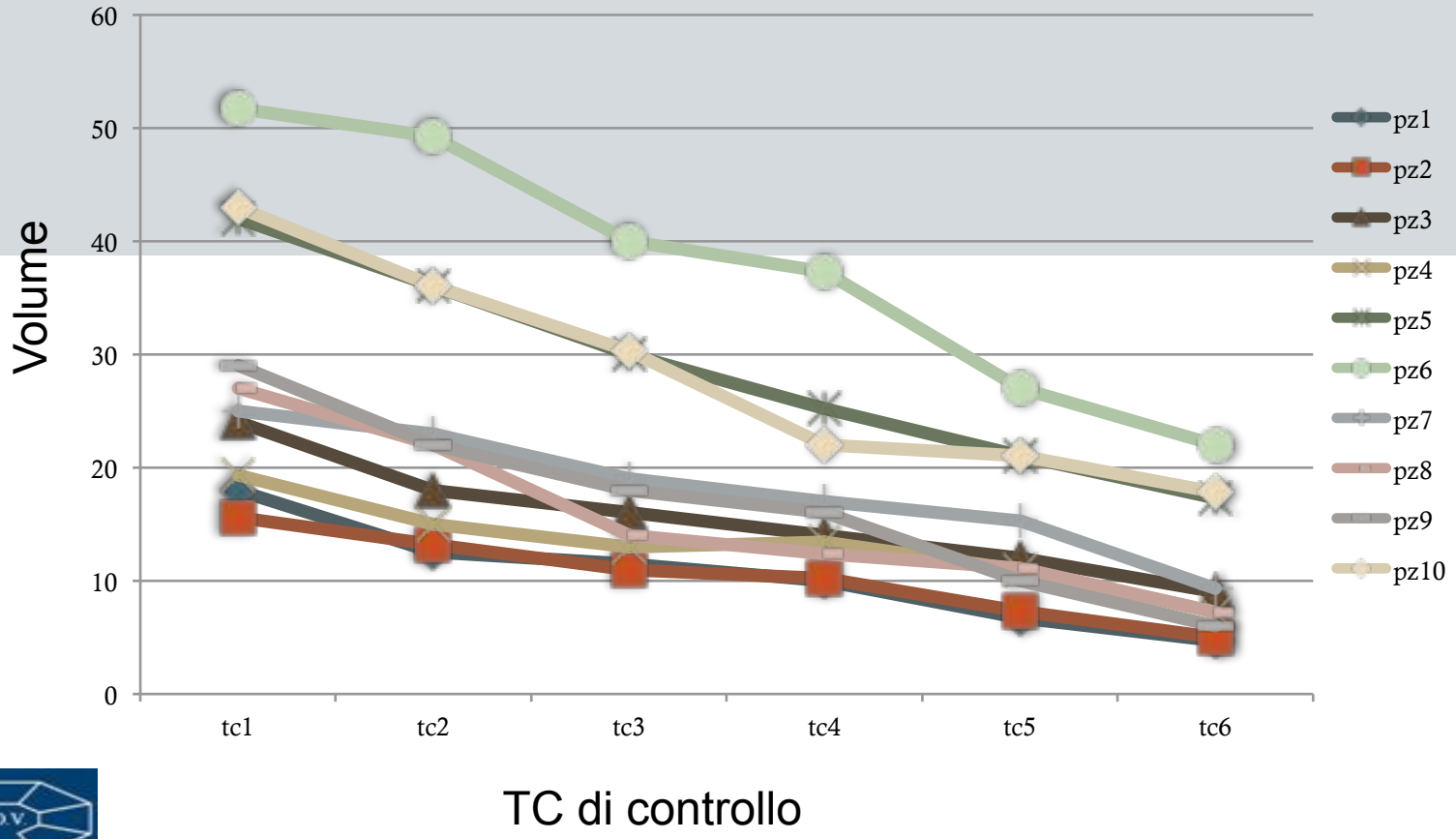
-Volume medio parotideo diminuito dell 11%

-ART 1 riduce la dose media alle parotidi di 1,1 Gy e al tronco di 0,8 Gy

-ART 2 nei casi Ca orofaringe riduce la dose media alla parotide vicina al GTV di circa 3 Gy

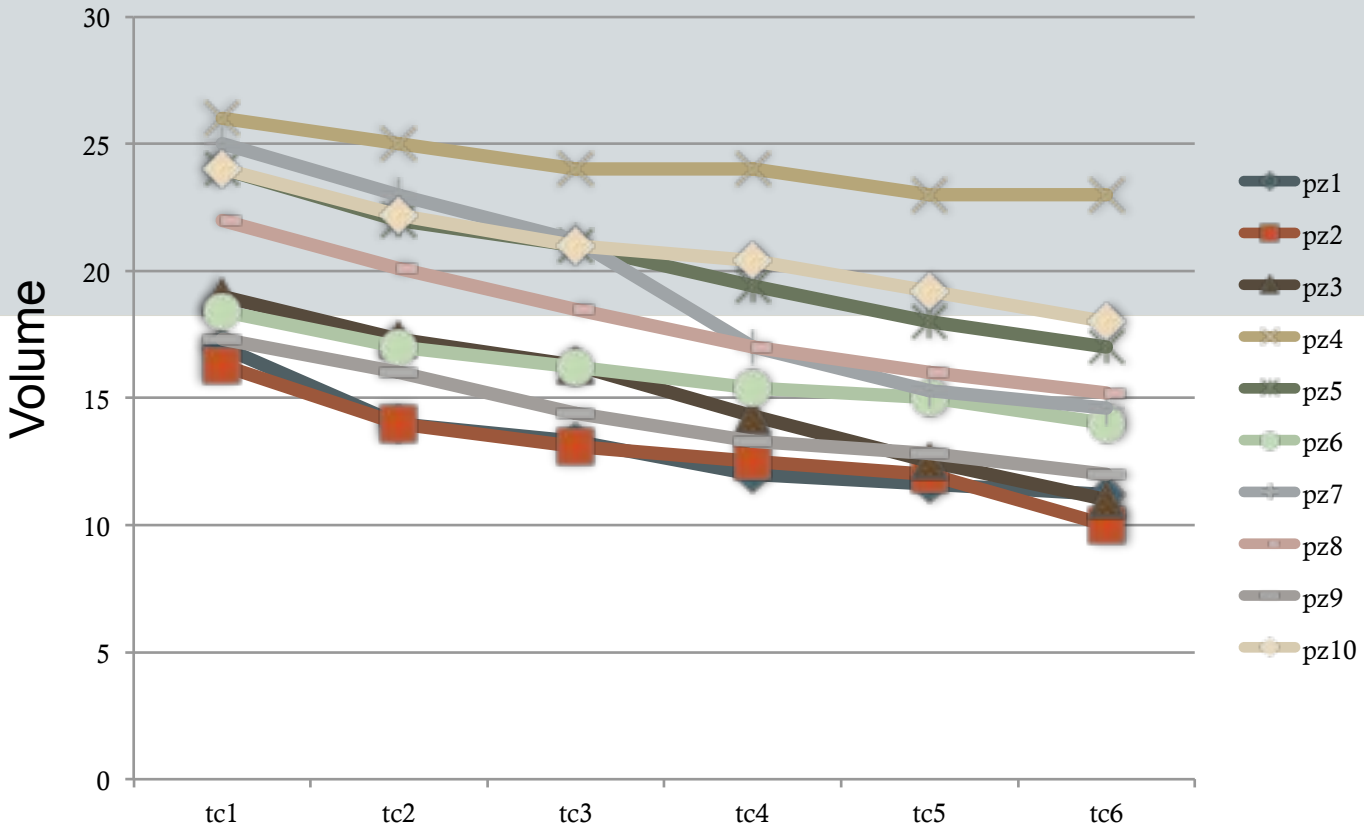
I.O.V.
ISTITUTO ONCOLOGICO VENETO

Modifica del GTV



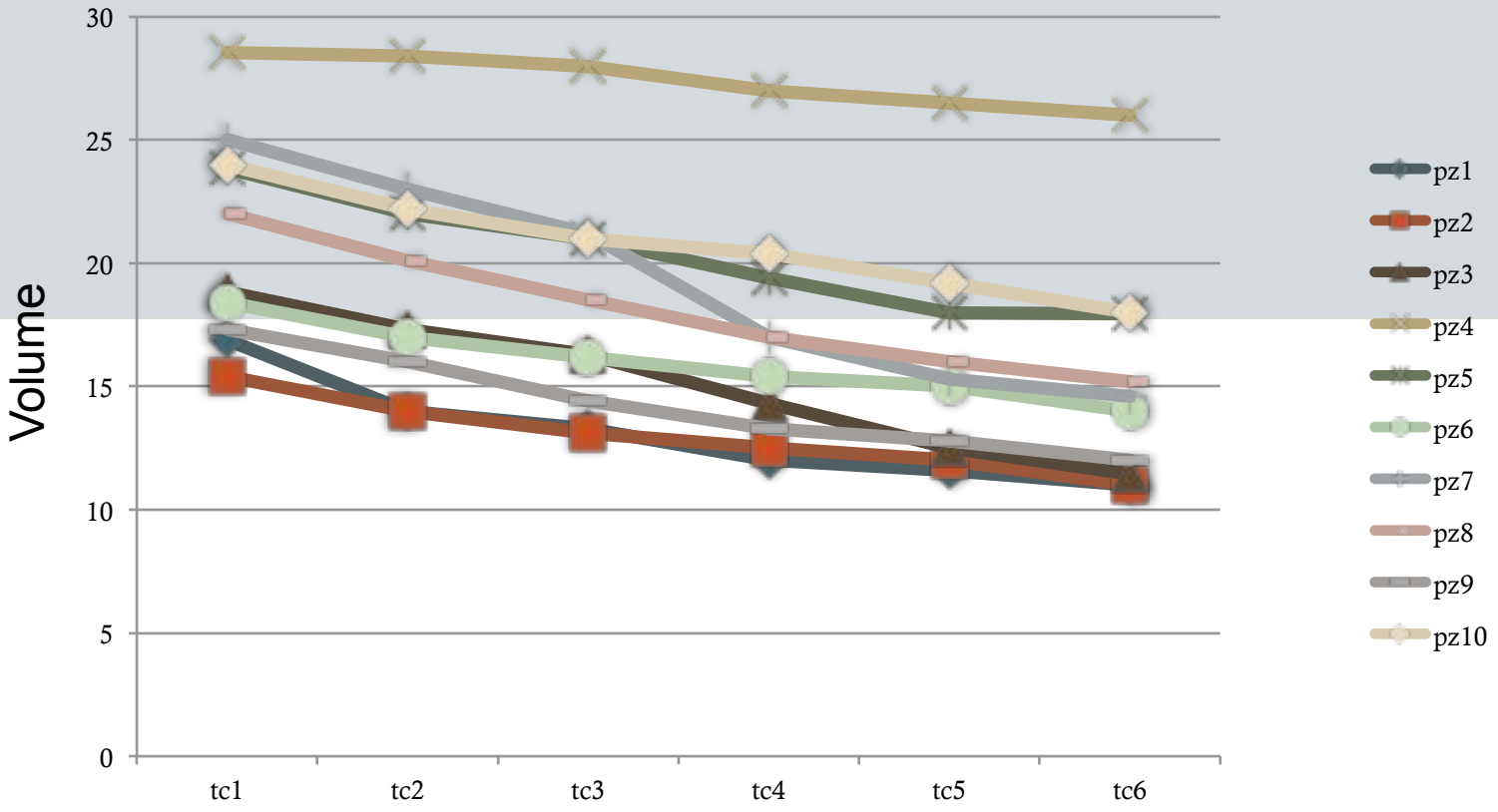
I.O.V.
Istituto Oncologico Veneto

Volume parotideo sx



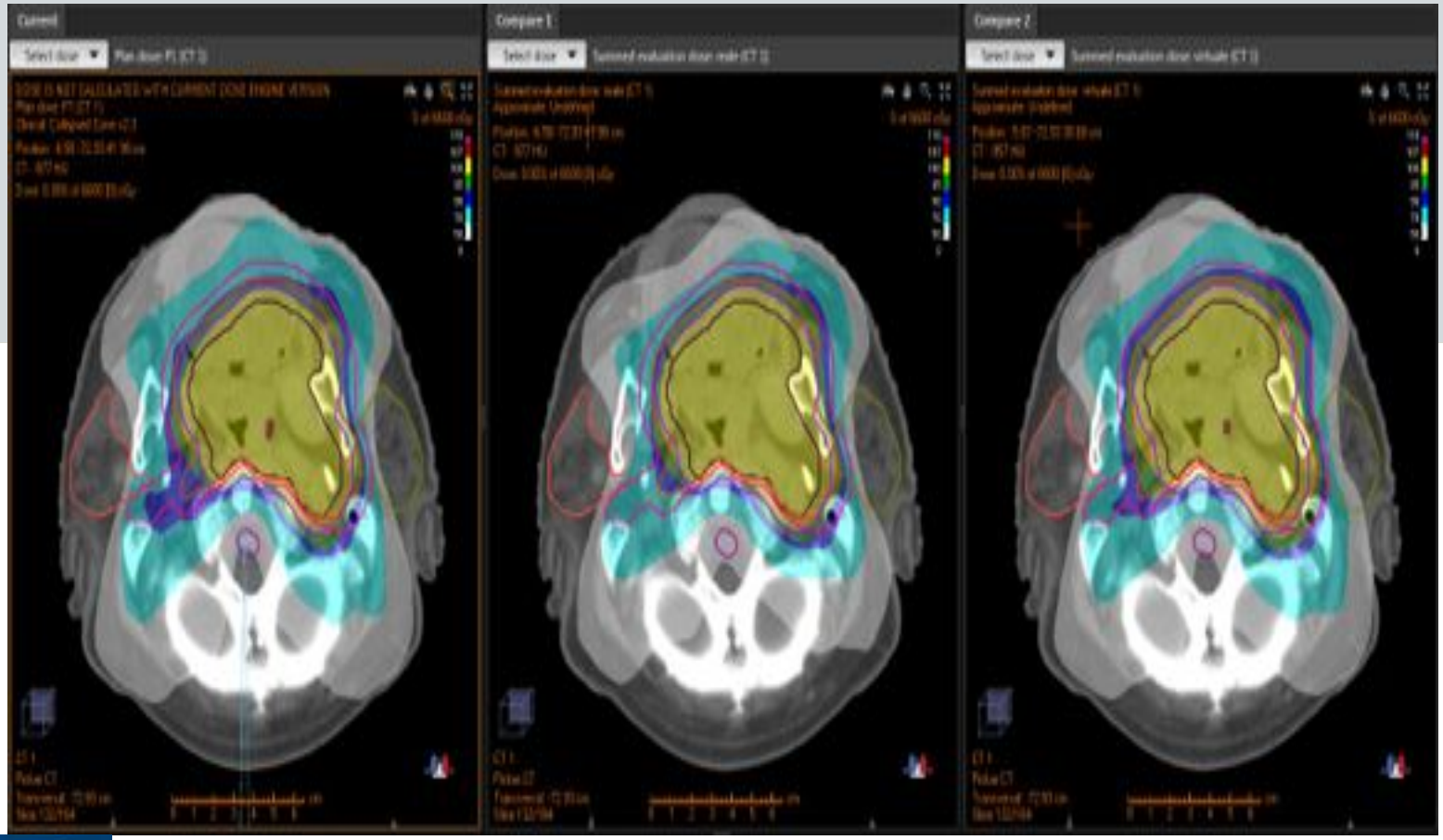
I.O.V.
Istituto Oncologico Veneto

Volume parotideo sx



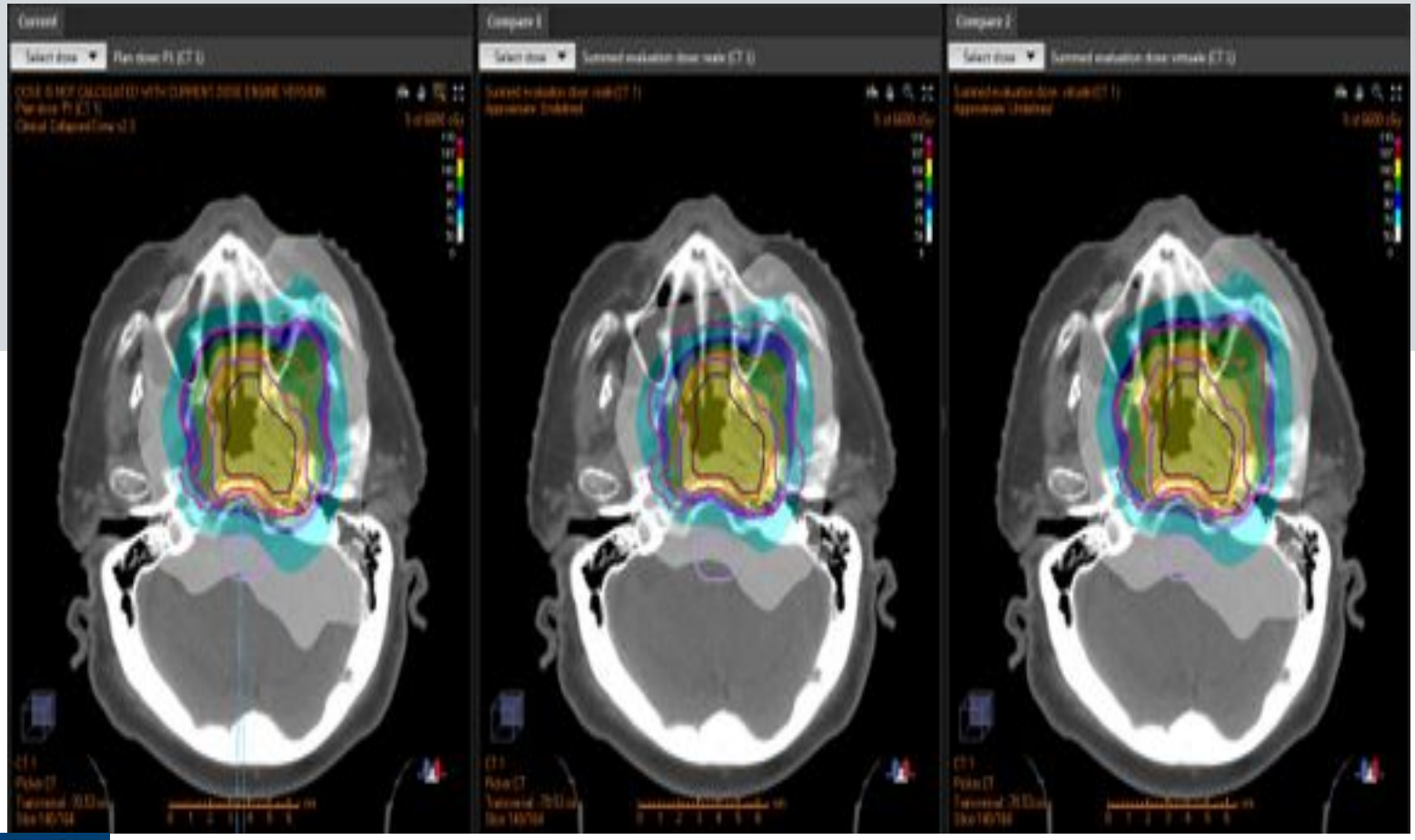
I.O.V.
ISTITUTO ONCOLOGICO VENETO

Risultati-caso1



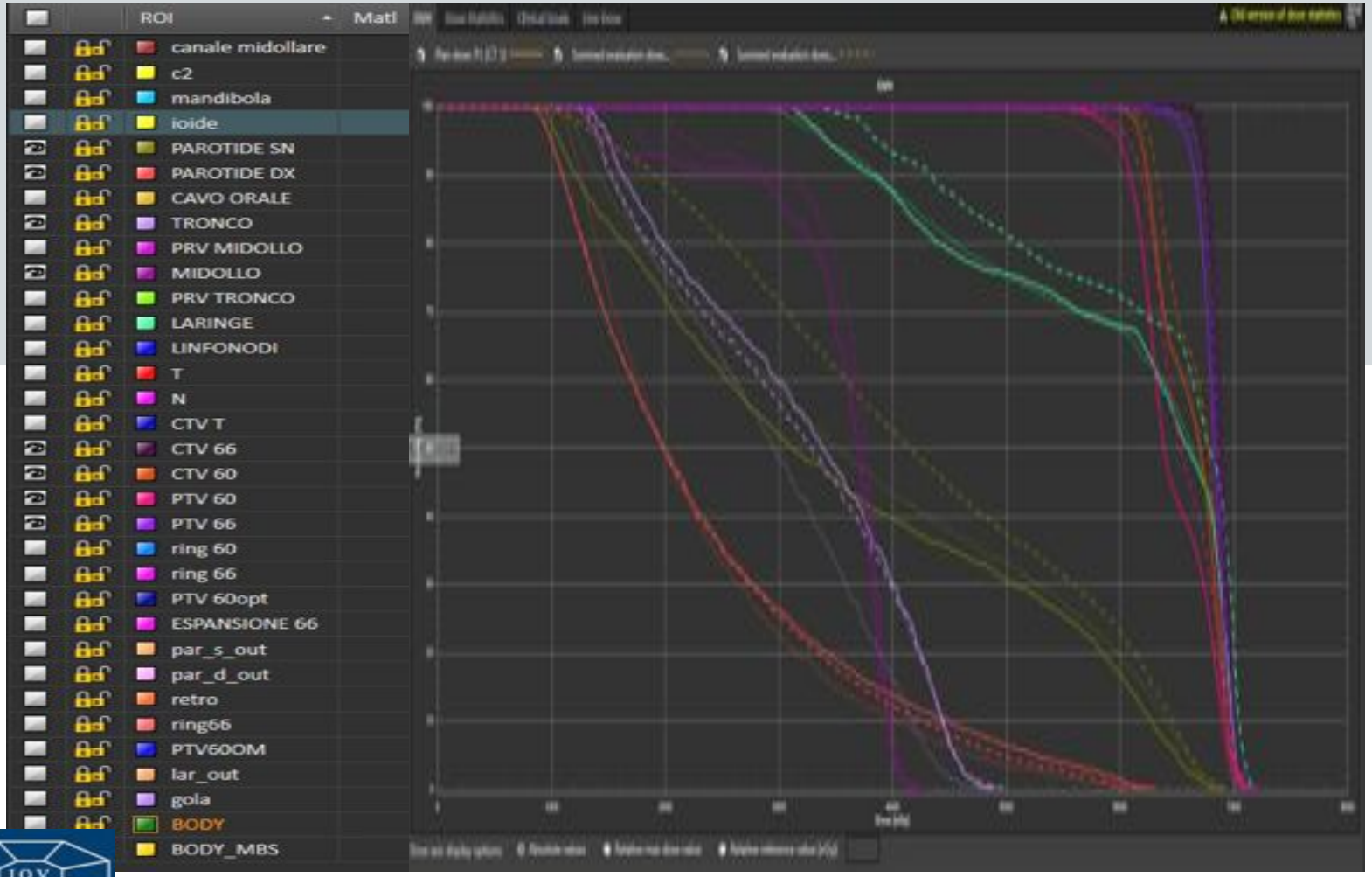
I.O.V.
ISTITUTO ONCOLOGICO VENETO

Risultati-caso1



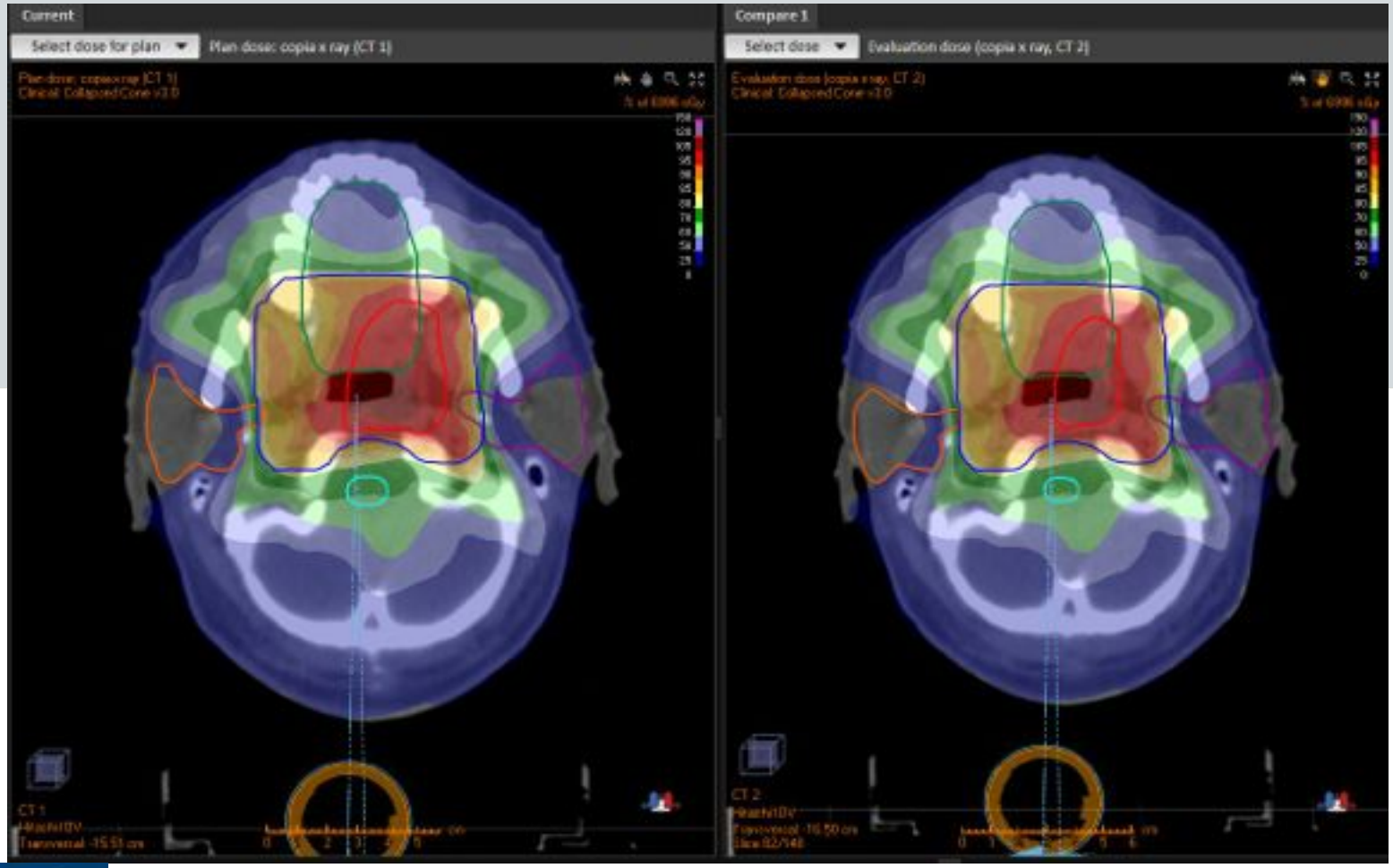
I.O.V.
ISTITUTO ONCOLOGICO VENETO

Risultati-caso1



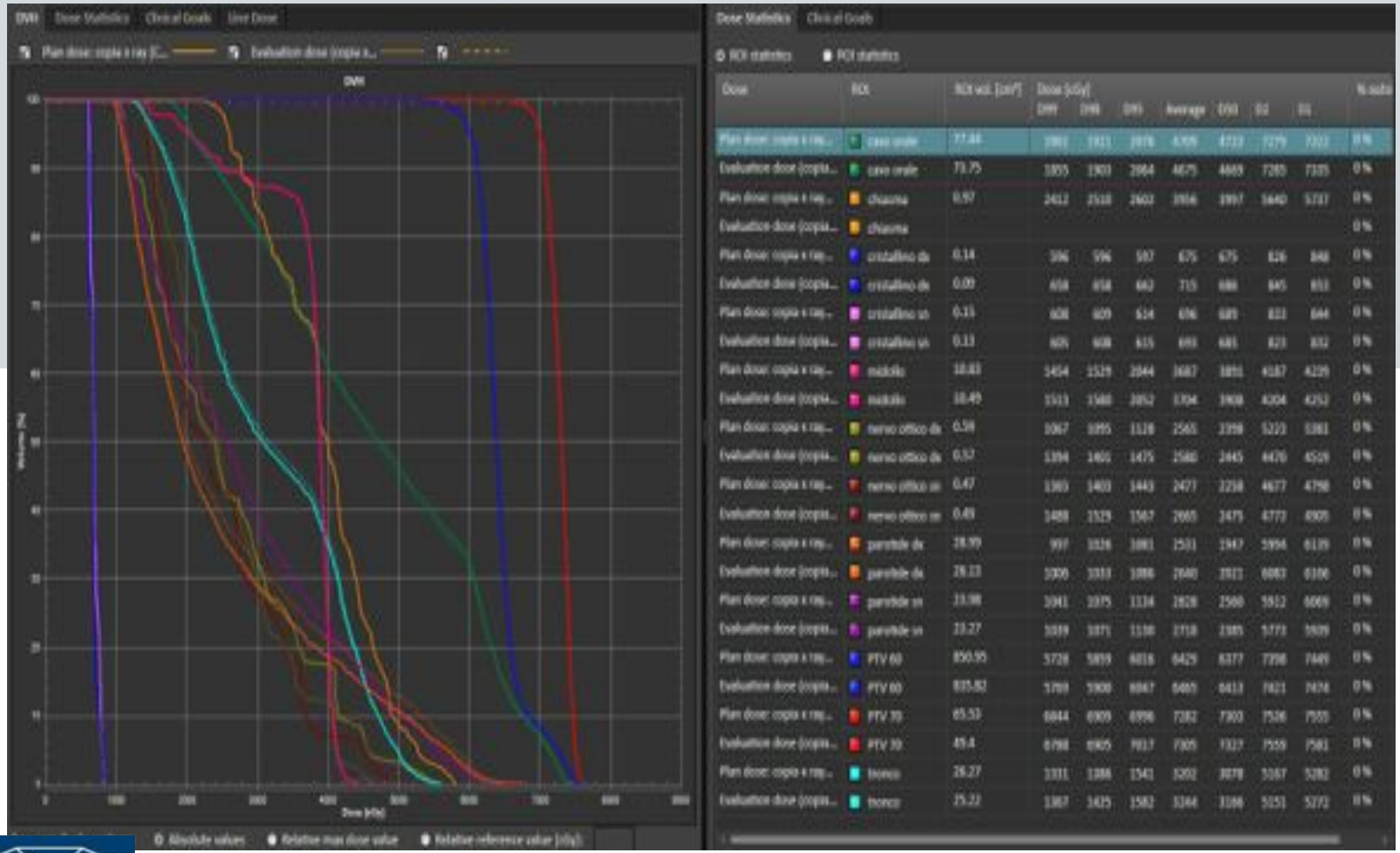
I.O.V.
Istituto Oncologico Veneto

Risultati-caso 2



I.O.V.
ISTITUTO ONCOLOGICO VENETO

Risultati-caso 2



I.O.V.
ISTITUTO ONCOLOGICO VENETO

CONCLUSIONI

-L’ ART e’ fattibile

-Grande impegno di tempo e risorse umane

-Una migliore conoscenza degli algoritmi di registrazione elastica e dei loro limiti è necessaria prima che ‘A.R. possa essere introdotta con sicurezza nella pratica clinica giornaliera

-Nel nostro studio, modesto beneficio nella ripianificazione adaptive in pazienti non selezionati.

-L’impatto clinico di questa tecnica deve essere ancora confermato da futuri trials.

I.O.V.
ISTITUTO ONCOLOGICO VENETO

GRAZIE !!!

I.O.V.
ISTITUTO ONCOLOGICO VENETO