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Frameless SRS Using the Varian Linac Platform

Richard Popple

Disclosures

- Research support from Varian Medical Systems
- Intellectual property licensed to Varian Medical Systems through The University of Alabama at Birmingham
- Speaking honoraria from Varian Medical Systems

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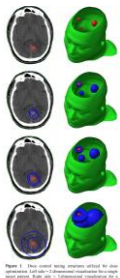
VMAT Radiosurgery
Planning Challenges

- Many ways to get a sub-optimal plan
  - Metrics of plan quality not in the cost function
  - Relevance on default NTO to define dose falloff
  - Forced homogeneity
  - Restrictive treatment geometry (e.g. axial only)
  - Report gradient index when plans differ in conformity
  - Poorly considered normalization
  - Sequential optimization of multiple isocenters
- "Ring recipe" devised to place all surrogates for plan quality in the cost function
  - Conformity
  - Gradient
  - normal brain dose



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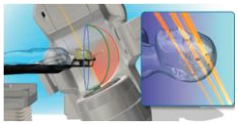
Clark GM et al. *Pract Radiat Oncol.* 2012; 2:306-313
PMIDs: 27612917, 26596814, 27603198, 24748269, 25434937, 28477798, 27614790, 26894335, 26699547, 28297536

Automating Treatment Planning and Delivery
HyperArc™

- Treatment planning software component in Eclipse treatment planning system
- Treatment delivery software on TrueBeam® system or Edge® radiosurgery system
- Process is defined and prescriptive to **ensure high quality even if planner is less experienced**



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HyperArc™ components

- TrueBeam linear accelerator
- Millenium 120 or HDMLC
- Qfix Encompass mask system
- Eclipse TPS
- ARIA ROIS

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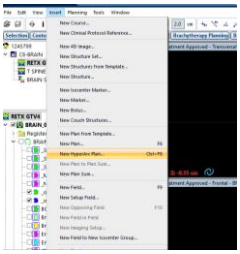
HyperArc™ Treatment Planning



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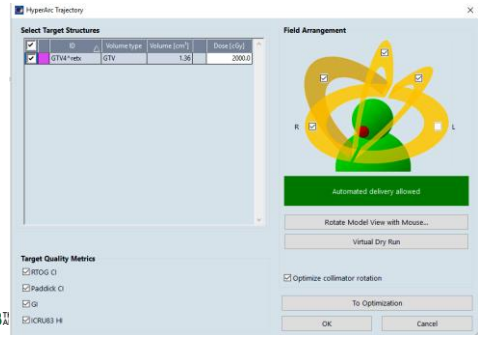
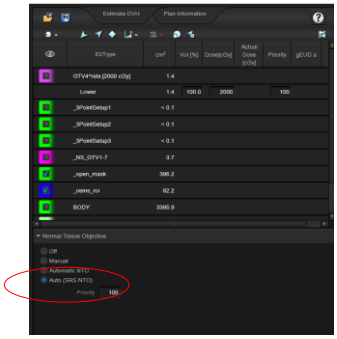
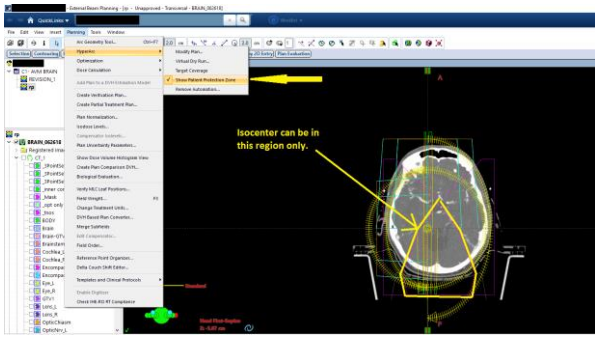


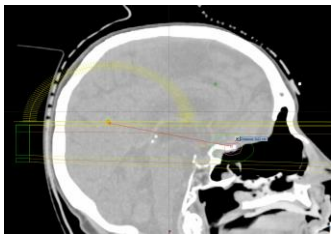
SRS normal tissue objective

- –Includes parameters for rapid dose falloff around targets
- –Designed for multiple targets
- –Designed for radiosurgery



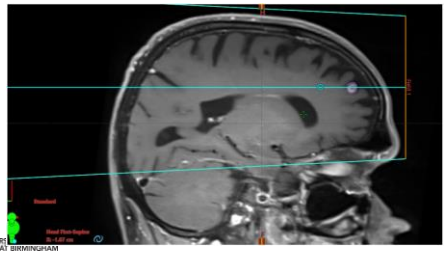


Automated Isocenter Placement Far from Anterior Target



- Placed in center of protection zone
- Increased risk of alignment error due to small rotational error
- Lower resolution MLC leaves used for more of treatment
- Planner needs to manually move it closer

Manual Placement of Isocenter Within Protection Zone as Close as Possible to Target



MLC leaf width

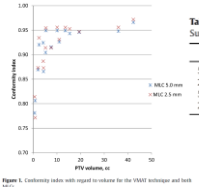


Figure 1. Conformity index with regard to volume for the VMAT technique and both MLCs.

Serna A, Puchades V, Mata F, Ramos D, Alcaraz M. Influence of multi-leaf collimator leaf width in radiosurgery via volumetric modulated arc therapy and 3D dynamic conformal arc therapy. Phys Med. 2015 May;31(3):283-6. doi:10.1016/j.ejmp.2015.01.011

Table 2
Summary of dosimetric and radiobiological indices.

	Conformity index	Gradient index	NTCP
5 mm VMAT	0.91 ± 0.05	3.7 ± 1.1	7 ± 9
2.5 mm VMAT	0.91 ± 0.05	3.2 ± 0.8	6 ± 8
5 mm 3D-DCA	0.72 ± 0.06	3.7 ± 0.9	9 ± 12
2.5 mm 3D-DCA	0.74 ± 0.05	3.4 ± 0.7	10 ± 11

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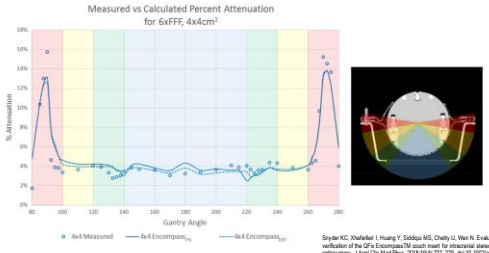
Encompass™ SRS Immobilization System

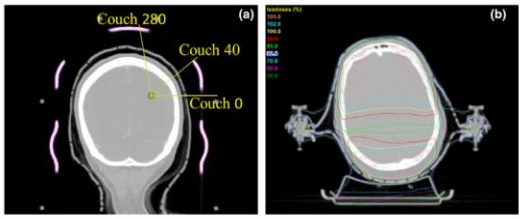
Other mask systems compatible with OSMS are not compatible with HyperArc™

Encompass attenuation



Snyder KC, Xhaferllari I, Huang Y, Siddiqui MS, Chetty IJ, Wen N. Evaluation and verification of the QFix Encompass™ couch insert for intracranial stereotactic radiosurgery. J Appl Clin Med Phys. 2016;19(4):222–229. doi:10.1002/acm2.12387

Encompass attenuation



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Encompass attenuation

- Significant attenuation (up to 17%) where the mask attaches to the insert.
- Should be included in the TPS model
- Small uncertainties in couch placement do not significantly perturb the dose calculation. However, larger differences can be seen when using few static beams compared to rotational treatment techniques.

Snyder KC, Xhafkollari I, Huang Y, Siddiqui MS, Chetty IJ, Wen N. Evaluation and verification of the CIVo Encompass™ couch insert for intracranial stereotactic radiosurgery. J Appl Clin Med Phys. 2018;19(4):222–229. doi:10.1002/acm2.12387

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HyperArc - QA

Same as other MLC based SRS

Quality and Safety Considerations in Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy

Timothy D. Solberg, Ph.D.[1], James M. Balter, Ph.D.[2], Stanley H. Benedict, Ph.D.[3], Benedick A. Fraass, Ph.D.2, Brian Kavanagh, M.D.[4], Curtis Miyamoto, M.D.[5], Todd Pawlicki, Ph.D.[6], Louis Potters, M.D.[7], Yoshiya Yamada, M.D.[8]

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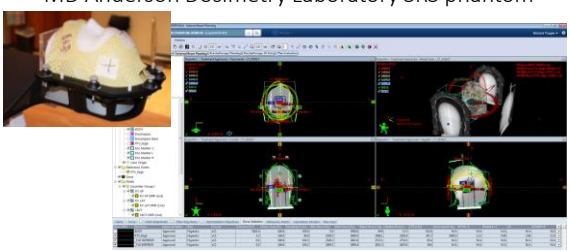
End-to-end
MD Anderson Dosimetry Laboratory SRS phantom



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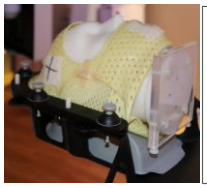
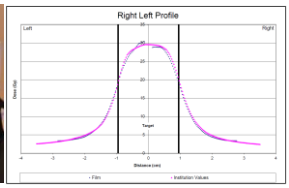
MDADL SRS Head Phantom





TLD Results:

Dose to TLD Capsules (cGy)		Institution Dose (cGy)		Average Ratio Measured/Institution
Upper	Lower	Upper	Lower	
2810	2911	2727	2832	1.03

Daily tests

Table 5. SRS / SBRT-specific linac-related quality assurance requirements, to be performed in addition to the standard linear accelerator tests described in the AAPM Task Group 142 report.

Daily Tests	
Procedure	**Tolerance**
Laser localization	1 mm
Distance indicator (ODI)	2 mm, if available
Collimator size indicator – both jaws and MLC	1 mm
Winston-Lutz test	≤ 0.75 mm average
IGRT positioning / repositioning	≤ 1 mm
Imaging subsystem interlocks	Functional
Stereotactic interlocks – cone size, backup jaws	Functional

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Imaging subsystem interlocks	Functional
~~Stereotactic interlocks – cone size, backup jaws~~	Functional

Monthly tests

Monthly Tests – in addition to tests listed above	
Procedure	Tolerance
Winston-Lutz test – both cones and MLC, covering complete range of gantry, couch, collimator positions	≤ 0.75 mm average
≤ 1 mm maximum	
Hidden target test using SRS frame and/or IGRT system	≤ 1 mm
Treatment couch position indicators	1 mm / 0.5 degrees
Output constancy at relevant dose rates	2%

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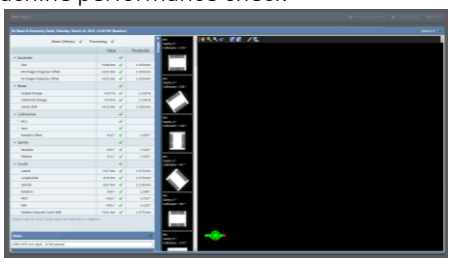
Machine performance check

Machine performance check



EPID-Based Quality Assurance of Linear Accelerators (TG330)

Charge

- To provide comprehensive review of characteristics of EPID as a time-resolved measurement device and dosimeter.
- To summarize the application of EPID for linac QA.
- To provide recommendations on efficient and effective implementations of EPID-based QA techniques.
- To describe hazards associated with use of EPIDs for linac QA and to provide examples how hazard analysis can be used to ensure safe use of EPIDs for linac QA.

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Verification of Vendor Provided Data, Tools and Test Procedures (TG332)

Charge

- To define "closed" and "black box" systems in a radiation oncology setting and to provide examples of self-integrated or pre-configured delivery devices, test procedures or data that fall into these categories.
- To provide guidance on the critical evaluation and independent validation of these types of systems. This includes but is not limited to independently validating:
- Pre-configured devices, tools, and test procedures developed by vendors and provided to the customer that are utilized during acceptance, commissioning or routine QA;
- Data that is acquired by vendors and provided to the customer and utilized during acceptance, commissioning or routine QA;
- To provide guidance to the medical physicist on how to approach QA of a system that is selfintegrated or pre-configured and falls outside of the realm of a traditional radiation delivery device to which guidance documents already exist.
- To provide guidance to the medical physicist and vendors on a collaborative relationship between the two parties to achieve a mutual and shared responsibility for the performance of equipment and quality of the data in use.
- To provide guidance on analyzing the risks associated with implementation of "closed" or "black box" systems.

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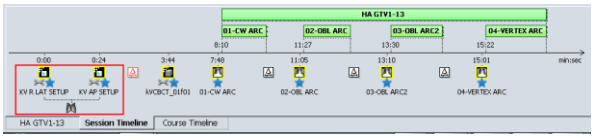
Treatment delivery



Most cases 12-15 minutes

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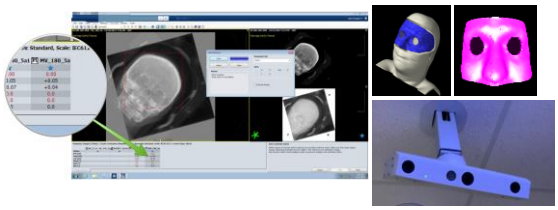
Motion monitoring for frameless radiosurgery



OSMS includes three pods each with two cameras and a projector to monitor the surface

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Thanks

John B. Fiveash, MD
Radiation Oncology

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